Exploring the Relationship between Road Infrastructure and Agricultural Productivity: Evaluating Empirical Evidence of Pakistan Economy

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Abstract

The present study investigates of the relationship between quality-road infrastructure and agricultural output by using time series data from 1980 to 2020. Present research has three main goals first, the study analyzed the impact of road infrastructure on output of agricultural sector of Pakistan by using time series data from 1980-2020. Secondly, study evaluates the impact of quality roads on output of three main selected crops like wheat, rice, and cotton of Pakistan. The third objective is to analyze the effect of road infrastructures on agricultural productivity at aggregate and disaggregate level of Pakistan. In methodology, two different unit root tests are used to find the order of integration of each series of all models of the study and these two tests are Augmented Dickey Fuller and Phillips-Perron tests. Both tests indicate that some variables are non-stationary at levels while some are stationary at first difference. These findings suggest that there may be cointegration among the variables. In such circumstances Auto Regressive Distributed Lag bound testing approach i is regarded as the most appropriate technique for obtaining short and long run outcomes. Our finding is indicated the test of hypothesis that road infrastructure is not significant impact on agricultural production at both the aggregate and disaggregate levels (rice) except the wheat and cotton production. Accordingly, from the long run result is suggested that quality of road has insignificant impact on total output as well as in short run it is also insignificant. In the form of wheat production, the quality of road has significant impact in long run but in short run effect it is insignificant. But in the form of 2nd food crop rice, the quality of road has not significant effect in long term along with in short term. Lastly, the form of cash crop, quality of road has significant influence on long run but in short run it effect is insignificant. Present study of policy recommendations suggests that there should be more focus on the improvement of rural infrastructure instead of the road infrastructure, also, in future, if more work is done on the farm technology, skilled labor force and capital input, Pakistan's agricultural sector and overall economy will experience a great improvement.

Keywords: Road infrastructure, Agricultural Productivity & Road connectivity, Economic growth

CHAPTER 1

1.1 Introduction

Production is a process to convert the inputs into outputs (Parkinson and Bates, 2010). The core objective of production is to meet the demand or create supply of transformed resources. While on the other side, productivity is the efficient use of resources in the production process of goods and services. Productivity is getting same with low resources (inputs) or achieving more output in terms of volume and quality with same level of inputs. Productivity and production are considered key sources for economic growth[1] and these show the competitiveness among economies, sectors, industries, and firms. Productivity is a measure of scale to assess the economic performance of an economy overtime. According to (Saglio,1985), productivity reveals an efficient relationship between output and input during a given period of time (Sumanth et al., 1990). In the same vein (Wilson & Jantrania, 1994), conclude that productivity is the increasing ratio of output to the input that are utilized in production process. Productivity is a source to achieve the goals of medium to long term economic growth. Similar, the productivity via technological advancements is also a source of economic growth but there are many social and demographic bottlenecks that create hurdle in beautification of technological-led productivity (Nakamura et al., (2018). These bottlenecks are working style, managerial style, and capacity of resources like capital, labor force and intellectual property rights. The difference between productivity and efficiency is that productivity is proactive, and efficiency is reactive.

Production and productivity are two different concepts. The former is ex-post condition for the later one. While the later one (productivity) is ex-ant condition of production. The role of productivity is now universally recognized as a source of welfare. All human activities get benefit from improved productivity and it is source of improvement in gross national product (GNP) (Hubert, 1981). Therefore, productivity improvements are a source to increase in living standard but it conditional that improved productivity gains are dividing according to the contribution of factors of production. Productivity improvements have significant effects on social and economic indicators, including economic growth, higher living standard, and country's balance of payment (Guzzo et al., 2019). Moreover, productivity changes influence

[1] Paul Krugman said, "Productivity isn't everything, but, in the long run, it is almost everything".

wage levels, cost or price relationships, capital investment needs and employment (Bennett et al., 1989).

Since 1980s to onward, there is stream of research about the role of productivity and its determinants in different economies and sectors. Majority of developing nations try to opt dual-sector growth strategy or balanced growth strategy for traditional sector as well modern sector. At the same time road infrastructure is also considered a source that brings simultaneous growth in both traditional and modern sectors of an economy. Pakistan being a developing economy also opts the same road (paved-road or quality road) to achieve the goal of balanced growth. Road infrastructure continuously gets the major junk of budgetary allocation from public sector development program (PSDP) of Pakistan. It is supposed that road infrastructure plays a bridging role between agriculture sector and industrial sector of Pakistan economy. At the same time planers ignore the separate-policy measures for both sectors especially in case of agriculture sector.

1.2 Overview and Importance of Road Infrastructure of Pakistan

Roads boost economic activities directly and indirectly. The enlargement in road infrastructure is to extend the access of more resources and short to lead times, increasing economic efficiency. Roads also provide the access to goods and services and create opportunities of employment.

The main purposes of National Highway Board (NHB) are to development of interprovincial road infrastructure and monitors maintenance. In 1991, the NHB became the National Highway Administration (NHA) and provided additional independence, including the planning, development, repair, and maintenance of strategic and commercially significant federal and local infrastructure. When the mass transportation system (basically named as the motorways of Pakistan) launched in 1992, roads development began. As a result, NHA entrusted with the management of both Pakistan's highways and motorways.

Broadly, road infrastructure is categorized into two classes in Pakistan that are paved and unpaved roads. The public sector maintains and controls the road infrastructure sector in Pakistan. The NHA is charge of federal highways. Pakistan currently ranks 22nd in the World for the length of its road network, which spans 263,775 kilometers (thirteen thousand km of national highways and motorways, ninety-three thousand km of provincial highways and rest are District and village roads). The state’s ranking is likely upgrade importantly as latest

project of economic connectivity are built, particularly under the China Pakistan Economic Corridor (CPEC).

1.3 Overview of Agriculture Sector of Pakistan

Agriculture is an important sector of Pakistan. As this sector is the third largest sector that supports the Pakistan's economy. Pakistan's agricultural sector is contributed to gross domestic product (GDP) about twenty one percent with a yearly growth rate of about two and half to three percent. Pakistan's agricultural sector is established on major crops like wheat, rice and cotton which is accounted in overall agriculture for almost 24% of value added 4.67% of GDP (Rehman et al., 2019). Ahmad et al.,(2012) describe economic contributions of agriculture sector of Pakistan. First, agricultural sector meets almost all national food needs and try to make Pakistan food secure. Secondly, agriculture sector also functions as an industrial product market that uses industrial products such as machinery, fertilizers, and pesticides. Thirdly, it also serves as a constant source of foreign exchange income and containing almost one-fifth of exported agri-products. It accounts for two-thirds of the total export value. Fourthly, agricultural growth helps raises farmers and villagers income and it try to reduce poverty rate in rural areas. Fifthly, promoting agricultural growth can limit migration to rural urban areas and helps overcome the problems created by overpopulation. Lastly, agriculture provides important raw materials for industry, as growth of agricultural sector leads to growth in the industrial sector.

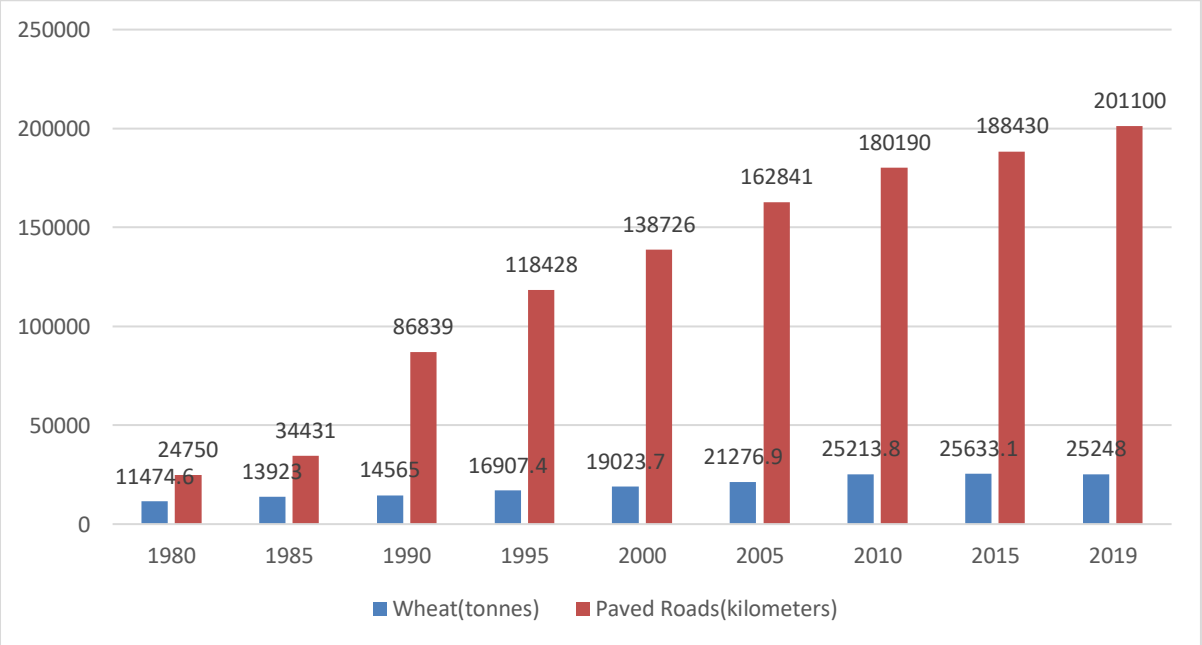
Agricultural sector provides 44% employment to workforce and 62% of Pakistan's rural population is depending upon this sector. It is focused on multiple roles in national economics with included poverty decrease, the industrial revolution and economic development particularly in developing countries (Azam and Shafique, 2017). The growth rate of agricultural sector in 2020-21 is 2.77%. Growth of essential crops (wheat, rice, sugarcane, corn, and cotton) year-round is 4.65%. The major crops of production (Kharif), such as corn and rice has shown significant improvements compared to the last years. However, the cotton crop is mainly decreased by 22.8% to 7.064 million bales from 9.148 million bales. While the most important crop wheat (Rabi) is indicated a growth of 8.1% and record is reached high production level of 27.293 million tonnes as compared to last year 25.248 million tonnes .

In following subsections, study compares the improvements in output of three main crops and quality roads overtime. It is trying to investigate the role the roads in improvements of agriculture as well as crops.

1.3.1 Wheat

Pakistan is 10th largest wheat producer in the world in terms of total area under cultivation. In Pakistan, the average person weighs 125 kg per year, which is on average 60% of daily required diet of an individual. Wheat is the staple food of the population, and it is enjoying a central position in planning and policies of authorities. Wheat is contributed 8.7% to the added value of agriculture sector and about 1.7 % in overall GDP of Pakistan. Wheat production is increased 2.5% from 24349 million tonnes last year to 24946 million tonnes in present fiscal year. The wheat area is increased by 1.7% that is about 8,825,000 hectares as compared to last year's 8,678,000 hectares.

Figure 1 Road Infrastructure and Wheat over time

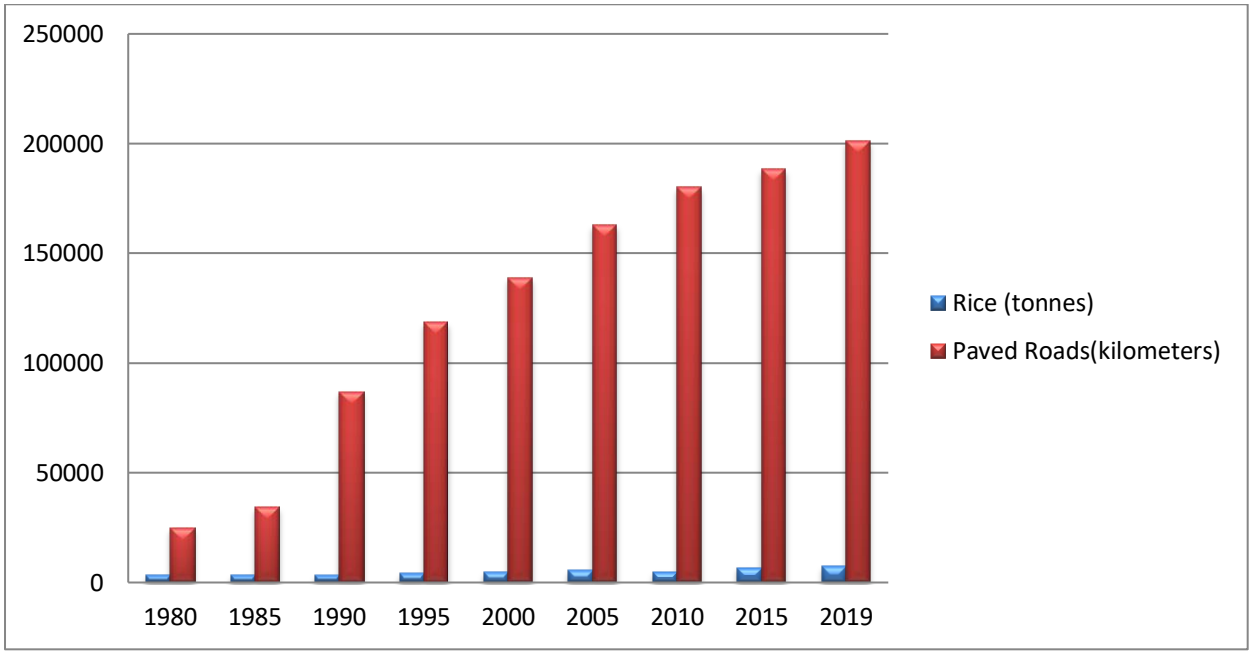


The increasing trend in production of wheat can be observed from above Figure 1. Acreage, healthy grain formation, and more covered area promote the production of wheat as a food crop. Wheat is cultivated in a very vast area of Punjab. But if the figure above in analyzed, the increase in wheat production (in tonnes) is more as compared road infrastructure (in kilometers) over the time. But there hasn't been any significant change in the results. Following sub section contains the role of rice food crop in Pakistan economy and an overview of rice crop.

1.3.2 Rice

Rice is the second most important crop in Pakistan after Wheat and prevalent supply in economy. Rice has a proportion of 0.6% in GDP and debts for 3.1% with inside the fee introduced in agriculture. Rice is grown below mixed climate and higher soil situations in Pakistan, it is cultivated in the northeast Punjab. Pakistan is also well-known for basmati and non-basmati with lengthy ounce rice that's divided into 4 ecological zones.

Figure 2 Road Infrastructure and Rice over time

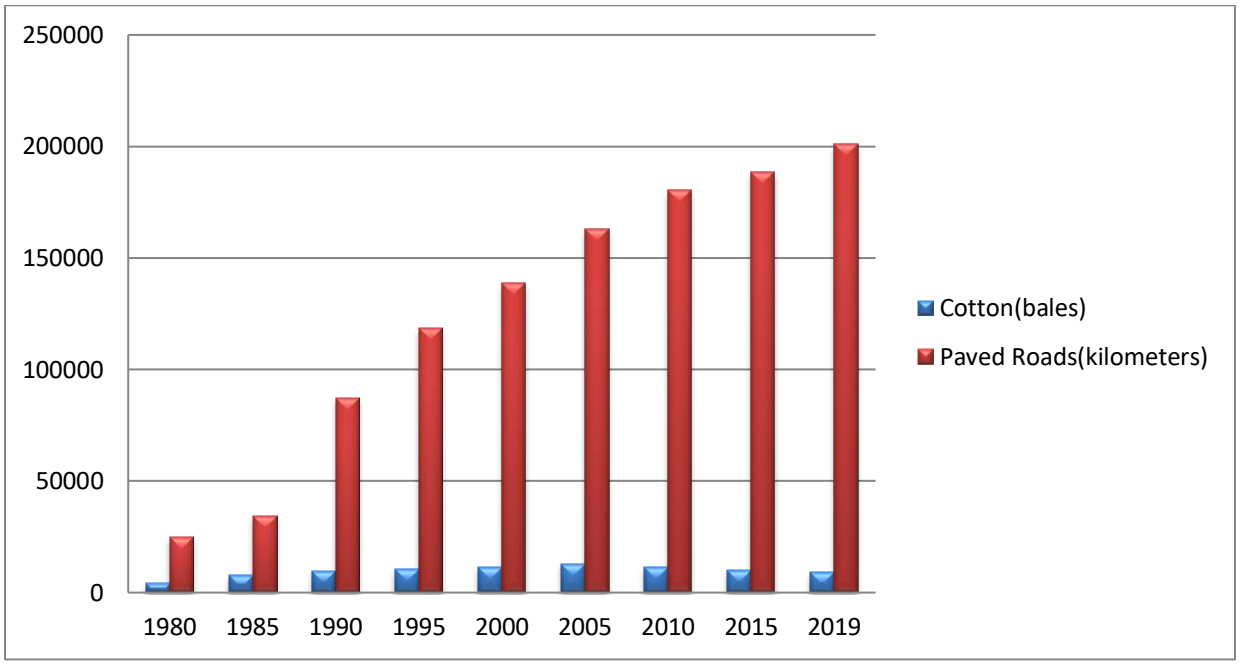


Rice is an important crop in Pakistan's agriculture because it is both a food and a cash crop. It is the second most important exportable commodity after cotton. While on the other side, rice production in tonnes is more raised as compared roads infrastructure in kilometers over time. After discussing the food crop, we will move to the next point, which is the cash crop of Pakistan, cotton.

1.3.3 Cotton

Cotton in Pakistan is most necessary cash and textile crop. In the World, Pakistan is the fourth largest producer and the third largest consumer of cotton. Pakistan's cotton industry is an important part of the economy and develops the growth rate. It is played an important role in the country's foreign exchange revenues. It is accounted for 55% of self-sufficiency, 8.2% of added value, and 2% of the country's GDP. Cotton is based on textiles and fabrics, accounting for 46% of total production and 40% of employment of labor. Pakistan is the third largest exporter of raw cotton, accounting for 9% of the world's textile industry.

Figure 3 Road Infrastructure and Cotton over time



In 2019-20, cotton crop strew on a zone of 2527 KHA expended by 6.5% over last year's territory of 2373 KHA. The production of cotton crop is expected to be about 9.178 million bales, down 6.9% from the previous year's total of 9.861 million bales. Although on the other side, the cotton crop production in bales is more upraised as compared road infrastructure over time. The bar graph illustrates that like in the cases of the food crops we discussed, there hasn't been any grave change in the production of crop due to the road infrastructure.

1.4 Objectives of Study

- The core objective of present study is to analyze the impact of road infrastructure on agriculture sector of Pakistan by analyzing the time series data from 1980-2020.
- The second objective of present study is to critically evaluate the impact of quality-roads on output of three main crops of Pakistan by analyzing the same time span as in above objective.
- Third and last objective of is this study is to investigate the impact of road infrastructures on agricultural productivity at aggregate and disaggregate level of Pakistan.

1.5 Significance of Study

Previous studies observed specific factors that contribute to the sectorial-growth of agriculture. This study is operating to investigate the effect of modernization of infrastructure

on growth of agriculture sector and contributions of road infrastructure in form of productivity in case of Pakistan.

1.6 Research Questions

- Is there a significant impact of road infrastructure to influence the output of agriculture sector and productivity during the time of 1980 to 2020?
- Does road infrastructure influence the output and productivity of agriculture sector at disaggregate level during the time period of 1980 to 2020?

1.7 Research Gap

Numerous research had claimed on the topic of exploring the relationship between road infrastructure and agricultural productivity by using different variables (Nadeem et al., 2011) and (Oyakhilomen & Zibah, 2014). Few researches referred to the relationship while the others deserted them in many ways like in the context of the long run as well as in the short run. The growth strategy of Pakistan is based on Haq/HAG mind set. This mind set is considered that infrastructure development is a vital source of econpmic growth. The contempranous study intends to critically investigate the impact of infrastructure-led growth startgy on agriculture sector at aggregate and disaggregate level. Further, disaggrgate analysis is based upon cash and food crops. It will have supported to the exploration of the true association of the variables like GNP, food crops (wheat & rice) and cash crop (cotton) as a dependent variable and road infrastructure, farm technology, capital, R&D, energy consumption and labor as independent variables by using data extended to 2020 in the case of Pakistan.

1.8 Organization of the Study

The study organizes into five chapters. The first chapter discusses introduction, issues and challenges, research objective, research question and importance of the research. The second chapter provides an overview of literature review on road infrastructure such as growth strategy and agricultural productivity situation in Pakistan. The third chapter describes the research methodology, theoretical framework, and the model use to perform the research objective. The forth chapter focuses on the data estimation of the result and discussion about the study. The last chapter contains the conclusion and policy recommendations. It also provides the recommendations for administrations and concerns with interventions to consider though develop the roads infrastructure in future and agricultural productivity in Pakistan.

CHAPTER 2

Literature Review

2.1 Introduction

The literature review contains an in-depth analysis of literature that informs agricultural productivity. It provides a review of the factors affecting agricultural productivity. The primary goal of this research is to examine how infrastructure affects agricultural productivity in Pakistan.

This chapter refers to four parts. The first part discusses the introduction, and the second part conveys detail about the whole chapter summery. The last three sections describe the review of panel data, review of time series data and review of cross-section data.

2.2 Theoretical review

Agricultural productivity divides the value of output and the value of inputs that are used. Several empirical studies which investigated the relationship between agricultural productivity and economic growth found several different results that describe this relationship.

2.3 Empirical review

The empirical studies regarding the subject area highlighted that one of the major development constraints are the lack of infrastructural development. Brattberg,(2017) in his studies highlighted that poor infrastructure and lack of investment for infrastructural development causes major blow to the growth and development of any nation and sometime even stops the growth at all. The perceived competitiveness and attractiveness of the Philippines as an investment destination are severely harmed by poor infrastructure, a substantial contributor to rising business costs.

Causation experiments demonstrating that the direction of causation flows from infrastructure to economic growth and that regional imbalance in infrastructure availability hurts a region's prospects for economic growth have shown that there is a crucial relationship between infrastructure and regional growth. (Moreno, 1997). Ludmer is of the view that infrastructure plays a pivotal role in attaining regional convergence and there are plenty of evidences to prove it (Ludmer, 2010). While researchers' opinions on the relationship between infrastructure and growth vary, there is a preponderance of evidence that suggests that a lack

of infrastructure or unreliable infrastructure services may limit investments in productive capital and result in a limitation or reduction of output.

2.4 Review of Panel Data

Alhassan, (2021) in his work had highlighted the implication of the agricultural productivity on environmental degradation in Sub-Saharan African nations. Study use panel data in which period is from 1981 to 2016. In methodology, first different types of Panel unit root tests apply then based on unit root results, the Fully Modifies Ordinary Least Square (FMOLS) technique is used to estimate the model. Except for Sub-Saharan National economic growth, the unit root test outcomes show that all variables are stationary at the level in three-panel unit root tests. So, economic growth becomes stationary after the first difference. The Wester-lund panel test of co-integration confirms that there exists co-integrating among the variables of the models. The results of FMOLS validate the long run relationship between the economic growth, trade, agriculture total factor productivity and urbanization.

Gong, (2018) examines the impact of China's agricultural reforms and productive output; he further highlighted changes that occurred in the productivity and function of provincial production. Thirty-one provinces' inputs and outputs from 1978 to 2015 were employed as the study's source of data. The model for this study's technique consists of two pivotal steps. First, the production function and total factor productivity are assessed using a changing coefficient stochastic frontier model. Second, while holding everything else constant, the increase of the estimated input elasticity and TFP are regressed on the dummy variables for each reform era in accordance with another variable to represent the accomplishments and variances in each of the six reform periods. The result of the study shows that there is a relative decrease in the labor elasticity, at the same time the elasticity of fertilizer and machinery is elevating, and the elasticity of land has a U-shaped time-series curve. Technology and inputs have a significant role in periods of growth as opposed to times of changes and reforms.

Ahmed & Mustafa, (2016) find out the effect of CPEC projects on the agricultural sector through the linkages between infrastructure and agriculture production in Pakistan. The study uses panel data from 1970 to 1980. In methodology, (SEM) Simultaneous Equation Model on Production Function used to estimate the infrastructure and agricultural output. The results show that for China investment in irrigation, road, electricity, and telephone has an insignificant positive association with agriculture output. For Indonesia development of both

road and irrigation infrastructure has a strong positive association with agriculture GDP. In the case of Philippine investment in irrigation has a strong positive relationship with GDP driven from the agriculture sector. For Vietnam investment in irrigation and road has an insignificant positive association with agricultural output. Similarly, Thailand represent a supportive trend where it has been witnessed that the investments made in the sectors like irrigation, road development and electricity production have a strong, positive and long lasting relationship in fact strong impact on the Agricultural GDP.

Adepoju & K.K., (2013) define the role of infrastructure and its effect on agricultural productivity in Surulere and Ife East Local Government Areas (LGAs) of Oyo and Osun States of Nigeria. Moreover, study discusses the role of instructions in determining the agricultural productivity. Study uses micro level data and collects the data from one hundred and sixty respondents through multistage sampling method. In this study, farm size, household employment and number of years spent in schools are taken as proxies of socioeconomic factors. It is pertinent to mention here that all these factors are very important having great statistical significance and have positive impact on productivity in the two LGAs. However, memberships of farmer cooperative are not significant in the case Surulere LGA, but it positively affects the productivity in Ife East LGA. The total factor productivity model shows that farm size and labors positively and statistically significantly effects on productivity at 5% and 1% levels of probability correspondingly.

Nadeem & Mushtaq, (2012) is stated that the function of agricultural extension is improving agricultural productiveness in Punjab, Pakistan. Study uses data range from 1970 to 2005 for analysis. In methodology, there exists a long-time relationship t between TFP and agriculture research. The Granger-causality tests reveal a dual link between them. For investigation, marginal internal rate of return to research (MIRR) has been set to 73%, indicating that the Punjab agricultural research machine continues to produce. The effects indicated that the long-run hyper-link amongst TFP and agricultural research is point out that agricultural research has a critical and high-quality effected on TFP. So, the coefficient is estimated of research is 0.571 and considerable at a 1% level of significance.

Benin et al., (2012) describe the relationship between state spending and rising agricultural output in Ghana. Although the study used data from 2001 to 2006, public agricultural spending is made up of two parts: district- and regional-level disaggregated data on Agriculture Services Sector Investment Program (ASSIP) expenditures and regional-level

disaggregated data on Ministry of Food and Agriculture expenditures (MOFA). It is observed while finding the results of the study that the impacts and consequences of the estimated marginal effect and the result in return vary for all the four agro-ecological zones. According to the findings, agricultural production was significantly impacted by the supply of numerous public goods and services in the fields of agriculture, education, health, and rural roads. In addition to that a 0.15 percent increase in the productivity of the workers working in the agricultural sector is correlated with a 1% increase in public investment on agriculture (with a benefit-price ratio of 16.8). Agriculture production was altered to be adversely correlated with official education. As a result, it has been suggested that emphasize should be given on the generation of additional or future public resources.

Headey et al., (2010) evaluate the role of agricultural productivity as an engine of economic growth. Study uses panel data for the year 1970 to 2000. Study uses, the multi-input-output procedure, stochastic frontier analysis (SFA) and data envelopment analysis (DEA). The results show that SFA is relatively more attractive than DEA. The study examines that the (TFP) in the low-income countries improves. The study finds that TFP growth rates in across countries shows the performance in wide range fluctuation. Among the LDCs of TFP growth gap due to lack of transferability of agricultural technology, high transport cost and adverse climate factors are more than the Organization for Economic Co-operation of Development OECD nations. So, the instability in political and welfare is significantly negative correlates with the TFP growth.

Self & Grabowski, (2007) discuss the economic growth of 89 cross-country analyses and its impact on agricultural technologies. According to a study, increased agricultural output is a result of improved agricultural technology. The average rise of real per capita GDP is a key factor in determining long-term growth; the factor is highlighted on the basis of the data gathered between the years 1960 and 1995. Agriculture technology is divided into two categories in this study: biochemical and mechanical. Therefore, whereas mechanical advances demand increased fertiliser consumption of equipment like tractors, biochemical innovations necessitate intensified fertiliser usage. The results demonstrate the beneficial effects of agricultural development on both the stages of economic growth and human development.

Park & Koo, (2005) find the impact of the development of infrastructure on agricultural and non-agricultural trade among OECD countries. The study uses panel data for OECD nations

from 1997 to 2001. Telecommunication infrastructure is uses as a proxy of infrastructure. For analysis, the study uses traditional gravity model to estimate the influence of telecommunication on the bilateral trade of agricultural and non-agricultural goods. The results show that in both exporting and importing countries GDP per capita, geographical size and telecommunication investment has significant impact on bilateral trade between the OECD nations. Investment in telecommunication is relatively more effective in importing countries as compared to the exporting countries in terms of agricultural trade.

Fulginiti et al., (2004) made efforts to analyze that how the institutions impact the agricultural productivity of the Sub- Saharan African countries. From 1960 to 1999, information was gathered for this study from approximately 41 Sub-Saharan African (SSA) nations. In terms of technique, we found that the predicted rate of productivity change over four decades was 0.83 percent per year by estimating a semi-nonparametric Fourier production frontier. Despite this, the average rate from 1985 to 1999 was a robust 1.90 percent annually. The findings showed that former British colonies had much better productivity improvements than other countries, whereas Liberia and those that had been Portuguese or Belgian colonies experienced net productivity declines. Thus, measurements suggest a much lower rate of productivity during political upheaval and war, and a significantly higher rate of productivity among nations that enjoy a certain level of political freedom.

Coelli et al., (2003) evaluate the total factor growth of the state in the production sector and also highlighted its effects to change technical efficiency in Bangladesh crops by using a stochastic frontier approach. Study uses panel data of agriculture crops of the thirty-one observations from 1960-61 to 1991-92 of sixteen regions. The study's methodology takes into account technological effectiveness, technical advancement, and TFP growth in Bangladeshi crop agriculture. This method avoids the need for pricing data, which is difficult for underdeveloped nations to get, and instead creates a TFP catalogue. The results show that wide range expenditure and improvement in technical efficiency occurred by adopting the Green Revolution Technology. It is concluded that cost of the research moves in different and opposing directions. However, contrary to that, by adopting this technology of technical progress rises as infrastructure, education and wide range expenditure to break technical performance meanwhile curtailing and limiting the growth of the TFP. So, change in TFP shows frequently dependency on the green revolution technology and agricultural research expenditures.

T. J. Coelli & Rao, (2003) gathered data from more or less ninety three countries in order to compare the trend of agricultural productivity which was prevailing in both developed as well as underdeveloped countries. Study uses panel data from 1980 to 2000. At the time of conducting the research, the researcher built the piece-wise linear production frontier while using the data envelopment analysis (DEA) technique and Malmquist index approach. The findings indicate that the rise in total factor productivity is 2.1 percent annually, efficiency changes are 0.95 percent annually, and technical boundary modifications are 1.2 percent annually. The findings point to a positive reversal in the negative production trends and technological regression observed in several earlier research between 1961 and 1985 over the years 1980 to 2000. China's most notable accomplishment in terms of the overall performance of the nation was its 6.0% yearly compound growth rate for TFP within a certain time period. While the United States has a TFP growth rate of 2.6 percent and India has produced a TFP growth rate of only 1.4 percent, other countries with outstanding performance include Cambodia, Nigeria, and Algeria.

Nkamlue & Blaise, (2003) define the impact of agricultural productivity, technological progress, and change in the efficiency of African agriculture from sixteen countries. Study uses panel data from 1970 to 2001. In methodology, the study discusses about Tobit model which is not very informative because many of the explanatory variables are country-specific and do not change with time. Consequently, these variables do not change efficiency and productivity with the passage of time. The results find that technical change in the sub-Saharan African nations has been the major limitation to attain the high levels of total factor productivity. However, in Maghreb countries, technological change has played an important role in developing productivity of agricultural growth. Lastly, the study shows that in addition to agro-ecological factors, institutional factors are essential elements of agricultural productivity increase.

Hsu et al., (2003) evaluate the impact of TFP growth on the agricultural sector in China. Study uses panel data from 1984 to 1999 of twenty-seven provinces. Study discusses the procedure of estimation through two stages. In the first stage, non-parametric DEA technique is used to calculate the output-orientated Malmquist productivity indexes. While in the second stage, major elements of TFP growth are identified through the Tobit regression model. The results indicate that TFP growth is inactive in China’s agricultural sector because government tax policies and investing in the research and development (R&D) have not yet been very effective in promoting productivity, efficiency and technical progress. On the other

hand, the regional factor appears to be very determinants on technical innovation and regional inequalities.

Nayak, (1999) evaluates North-East India's infrastructure, its growth, and its effects on the agricultural sector. The study uses data and information available for the North-Eastern region of India for a time period of approximately ten-year that was between 1983–1984 and 1993–1994. Investment in irrigation and flood control are regarded as the proxy variables for infrastructure in the study, while total food grain production and their productivity are regarded as the proxy variables for agricultural development. This is because the study examines the relationship between infrastructure and agricultural development. The findings demonstrated that there is an imbalanced approach to the development of various infrastructures and that the correlation coefficients are too small and statistically insignificant. The study shows that some infrastructures (such as roads, trains, power, health, and irrigation) are mostly neglected, but that significant improvement has been made in the areas of education and a number of other amenities (post, telecommunication, and banking). Therefore, for the development of multiple facilities that are mostly underutilised, all state governments in the North-Eastern areas should work together.

Wu et al., (1998) define the role of agricultural growth and its factors of productivity after reforms in China. Study uses data from 1980 to 1995 for thirty one provincial-level units. In methodology, efficiency degradation, which declined 1.2 percent yearly, is the main cause of TFP regression. The government was encouraged to expand economic reforms to urban areas in 1985 by the success of rural reforms in the late 1970s and early 1980s. A flow of labour, notably young and educated farmers, from the agricultural sector to the industrial sector resulted from the quick expansion of township and village businesses. The findings suggest a 2.4 percent annual rise in total factor productivity, with technological change rising by 3.8 percent and efficiency change decreasing productivity growth by 1.3 percent. Therefore, the delay in efficiency and the increase in technical performance affect the lack of adoption of the current agricultural technology.

Felloni et al., (1996) discuss the role of infrastructure in determine the output and productivity of eighty-three countries. Moreover, study also checks the impact of infrastructure on productivity as well as production of thirty provinces of China. In this study road infrastructure and energy consumption are used as proxy variables of infrastructure. Different models along with various selected independent variables are estimated theory use

econometrics techniques. Study finds the significant impact of agriculture infrastructure on productivity in all nations and selected province of China. On the other hand, the significance of infrastructure varies from nation to nation. It is due the heterogeneity among the selected nation that depends upon other factors.

2.5 Review of Time series Data

Fuglie, (2021) estimates the role of agricultural productivity in Sub-Saharan Africa. Study uses data from 1961-1970 to 2006-2008. In this study, both production function and index number methods while incorporating natural resource quality variables to find patterns of agricultural productivity growth in sub-Saharan Africa. The results reveal that the maximum of the rise in agricultural productivity has been due to resource enlargement that can be clarified in part by developed macroeconomic and political environments. The increase in global commodity prices since 2006 has also better-quality agriculture's terms of trade. Furthermore, if there's continuous subdivision in economic development, poverty reduction can be experienced but there is the suggestion that total factor productivity growth improves in some countries.

Awan & Aroosa, (2020) examine agriculture productivity and its impact on the economic growth of Pakistan. Additionally, study also examines the influence of economic growth on agricultural production by using secondary data from1994 to 2017. In this study, firstly uses the Augmented Dickey Fuller (ADF) test to find out the level of stationarity of all model variables. After that ARDL technique is used to estimate the model that provides the long-term and short-term relations among the economic growth and agricultural productivity. The results of the study show that whereas all other factors have positive relationships with economic development over the long and short terms, the gross capital formation (GCF) and inflation rate have negative relationships. According to the study's findings, the government should increase its investments in the agriculture industry and implement new technologies to boost production.

Välilä, (2020) examines the macroeconomic element of the relationship between infrastructure and growth in the UK's capital, London. Late 1980s secondary data are used in the investigation. The Generic Aggregate Production Function is analysed using the OLS method in methodology to estimate the empirical model. The empirical findings support a consensus that public capital has a favourable influence on growth, maybe similar to that of private capital, while there is some disagreement regarding the size of that benefit. At least

temporarily, it is substantially higher in emerging than in industrialised nations. The total amount mostly relates to public capital, which is a subpar substitute for infrastructure.

Osabohien et al., (2019) in his study take Nigeria's case study and explain the how the economic growth of a state impacts the agricultural production and exports of that countries. Furthermore, the study uses the ARDL econometric approach to examine the long-term association between agricultural export and economic growth. Economic growth, which is the dependent variable in this study, is defined by real gross domestic product. Agriculture exports, foreign direct investment, the rate of inflation, and the labour force make up the other explanatory factors. According to the findings of the ARDL method, Nigeria's economic growth is heavily impacted by agricultural exports. Therefore, it implies that a 1% rise in agricultural exports has increased Nigeria's economic development by almost 25%. The report notes that in order to improve agricultural export, agricultural production must be increased.

Daud et al. (2018) analyze the effect of rural infrastructure and the benefits of food crop production in Oyo state of Nigeria. Study uses multi-stage sampling technique to collect the data of 20 farmers from two agricultural zones. Study uses simple OLS regression technique to estimate the model. Moreover, study also presents the descriptive results of present study. The results confirm that rural framework is important for the agricultural production. So, rural infrastructure development is considered as a booster source of agricultural production across different regions of Nigeria.

Terdal, (2017) define the impact on the development of transportation and communication infrastructure of Bagalkot District. Study utilizes the secondary data from 2010 to 2013. In this research, there are two circumstances; the first one is transportation infrastructures displays (road length, railway length, No. of vehicles and bridges) and the second is communication infrastructures (No. of post offices, No. of telephone exchange and No. of telephones). The results indicate that in the study area, the development is insufficient in both transportation and communications infrastructures. Accordingly, in the Bagalkot district, the resident government is taking some compulsory arrangements and creating development rules on the way to developing basic infrastructures. The basic infrastructures establishment is strong; development is not easily achievable but also continuous, stable, quantitative, and qualitative.

Anik et al., (2017) examine the progress of agriculture growth and its effect on capital in South Asian nations. Study uses data from 1980 to 2013. The total factor of productivity (TFP) index, which includes technical change, technical scale, mix-efficiency changes, residual scale, and residual mix-efficiency changes, was estimated in this study. The findings show that all countries continued to have varying growth in agricultural production, with Bangladesh seeing the highest growth at 1.05 percent, followed by India at 0.52 percent, Pakistan at 0.38 percent, and Nepal at 0.06 percent. While financial capital and crop diversification have the opposite impacts, natural resources, human capital, and technology endowments are the most significant drivers of agricultural TFP growth. The study also shows that investments in education recover human capital, agricultural research and development (R&D), and advancement in technological capital boost agricultural productivity growth in South Asia. Land reform and resilience also include the size of farm operations and the effectiveness of the land rental market.

Islamabad et al., (2016) evaluate the analysis of infrastructure investment and institutional quality on living standards of Pakistan. The study uses secondary data from 1984 to 2013. In methodology, the Unit root test, Johansen cointegration, Granger Causality test, and ADF test were used to analyze the GDPC, CIM, DEXP, OP, and POP to estimate the model. The results show that VAR analysis shows that the coefficients of only Institutional Quality and the living standard of people are significant in affecting the living standards of the people. The Granger Causality shows bi-directional and uni-directional relationships among variables. These results discussed the Bi-directional relationship of the living standards of people (GDPC) with institutional quality (CIM). CIM and infrastructure investment are having uni-directional relationships, while the population and institutional quality are having a uni-directional relationship. So, GDPC and infrastructure investment carry uni-directional relationships.

Kakar et al., (2016) define determines of economy wide total productivity that enhances the productivity of agriculture sector of Pakistan. Additionally, study also checks the impact of economic growth on agricultural productivity by analyzing the time series data from 1990 to 2017. In this study ARDL technique is used to estimate the short run and long run forms of the model. The study finds that in the long run, cultivated area, fertilizer use, agricultural credit, and rainfall all have a positively effect on agricultural productivity. On the other hand, employment and pesticide use in agriculture have shown a positive effect on Pakistan's agricultural productivity but not statistically significant. Even though in the short-run all-

determining factor have positive and significant effects on total agriculture productivity moreover shows the convergence toward equilibrium as the value of error correction term is about 0.829.

Awan & Alam, (2015) discuss the impact of Pakistan's agricultural production on national economic development. Study uses secondary data from 1972 to 2012. The auto regressive distributed lags approach (ARDL) is used in this work to estimate the model. Other independent variables used in regression analysis include real GDP per person, gross capital creation, labour force participation, inflation rate, trade openness, and agricultural added value. The inflation rate negative effects on economic growth while all other variables positively affects to economic growth of Pakistan. The study finds the significant role of agriculture in economic growth of Pakistan. Therefore, they suggest that the industrial sector productivity promotes due to agricultural productivity and also improves the employment opportunity in a nation.

Goswami & Chatterjee, (2009) examines how infrastructure and technology affect agriculture productivity in the Indian state of Uttar Pradesh. One of India's agriculture states is Uttar Pradesh. Study uses secondary data from 1989 to 2006. In terms of technique, the effect of infrastructure and technology on agricultural production is examined using multivariate regression analysis on Cobb-Douglas form. This study's construction of a composite infrastructure index is appealing. The findings indicate that infrastructure, fertiliser, and HYVs have a considerable influence on agricultural productivity. As a result, it has been determined through study of the impact of each particular infrastructure indicator that electrified villages, fertiliser, and HYVs all have positive and substantial effects, whereas rural roads have a little or no effect..

(Li & Liu, 2009) evaluate the influence of rural infrastructure development on agricultural production technical efficiency of China. In this study data is taken from second national agricultural survey of 2006 of China. Study uses Tobit model for analysis as OLS method provide biased estimators in case of binary dependent variable. Study finds that four other types of rural infrastructure (excluding telecommunication) have positively associated with agricultural production technical efficiency. Interestingly transportation infrastructure contributes more than of other remaining types to agriculture production technical efficiency. In addition, other possible factors that contribute to agriculture production technical

efficiency are regional industrial structure, mechanical intensity, the quality of labor, and geographical locations.

Ali et al., (2008) explain the growth of total factor productivity (TFP) in the agricultural field of Pakistan. Study utilizes data from the annual time series from 1971 to 2006. This research is using the Tornqvist-Theil indexes methodology in order to estimate output, input and TFP of Pakistan's agricultural productivity. During various time horizon study observed the TFP growth rates are changed due to fluctuation of different factors like macroeconomic factors, institutional factors and weather conditions. The study shows that improvement in TFP of agriculture sector occurred due to government intervention and policies. The results find that development in TFP growth in agricultural productivity and input is not a significantly contributed except for the 70s decade. In the last six years study discuss that average annual TFP growth rate is highest at 2.86 percent and the lowest 0.96 percent of Pakistan's agriculture sector.

Narayanamoorthy & Hanjra, (2006) evaluate the aspect of rural infrastructure and agriculture output linkage among a study of 256 districts of Indian. The study uses secondary data from 1970 to 1991. In methodology, multivariate regression model and D-W test used to estimate both infrastructure and coefficient of regression suggest that all other infrastructural variables do significantly influence the value of output except rural electrification variable at all three-time points. The result shows that though the coefficient of fertilizer is also highly significant in determining the output and its magnitude is relatively small than the infrastructure variables in all three-time points. So, the increase in agriculture output and infrastructure variables in determining the output increases over time.

2.6 Review of Cross-section Data

Bordoloi, (2020) analyzes the role of inter-linkage between rural infrastructure and Agriculture Land Productivity in the Assam state of India. Assam is among the Agrarian state of India. The study uses cross-section data the district level data from 2016. To estimate the linear regression model and examine the relationship between rural infrastructure and agricultural land production, the ordinary least square (OLS) approach is employed in methodology. The findings indicate that just three indicators—road infrastructure, banking, and HYV—show a positive and substantial effect on agricultural land productivity among the seven infrastructures and two additional factors. The institutional infrastructure is positive and statistically significant at the 5% level, and the calculated coefficient of the availability of

road infrastructure is statistically significant at the 10% level. So, the other variables like irrigation, electricity, education, health, agriculture credit, and fertilizer consumption are not significant in the model.

Further research needs to be done on economic growth determinants of agricultural productivity to have an in-depth understanding of the contribution of individual factors without aggregating them in a study.

2.7 Literature Gap

According to the literature review is reported in the previous section that in order to incorporate the sustainability idea into the agricultural productivity analysis and roads infrastructure must pay attention to two critical aspects. Firstly, the link between roads infrastructure and agricultural productivity to improve the long-term decision making for the Pakistan's economy and they must need to understand the changing that is involved in demands and challenges. Secondly, in the previous studies used the factors (variables) which are totally changed from this research factors (variables). While this research contains such factors (variables) like labor force, real GFCF (Gross Fixed Capital Formation), farm technology (No's of tractors and tube-wells), total agricultural energy consumption (TOE), research & development (R&D) and paved roads are independent variables impact on the dependent variables like total agricultural output as real GNP (Gross National Product), Food crops (wheat & cotton) and Cash crop (cotton) in long run positive and significant links is shown on the Pakistan's economy. So, the long run relationships among the factors (variables) is more appreciated and promoted the economy growth rate higher as compare than the short run associations. Consequently, these factors (variables) are not used in the previous research and the agricultural sector is supported through these factors (variables). These two main difficulties are interrelated and are examined in greater depth in the sub section.

2.8 Concluding Remarks

This chapter is summarized the finding of the literature review completed as part of the research framework's first stage**.** The extensive material reviewed in this chapter is demonstrated that the influence of roads infrastructures on agricultural productivity was positive and supports the economic growth of Pakistan. It is observed that there was not agreement on the relationship between the agricultural productivity and roads infrastructures

to develop Pakistan economy. In some studies, empirical literature is different for the reason that some researchers is agreed or disagreed with others.

The study of Nadeem et al., (2011) is analyzed that the rural infrastructure and agricultural productivity in Pakistan has a positive impact on the economy and is very important for the economic development of the country. As a same result Oyakhilomen & Zibah, (2014) is founded that agricultural production has a huge effect on the economic growth. The economic development depends on the agricultural sector growth and agriculture is also extremely important for economic development. (Faridi et al., 2012) has shown that exports of agricultural products have a negative correlation with economic growth, but exports of non-agricultural products have a positive correlation. However, (Simasiku & Sheefeni, 2017) are not agreed more because they found that the relationship between agricultural exports and economic growth is positive and insignificant effect on economy. As a similar study of Ali et al., (2008) is explained that the total factor of productivity in agricultural sector of Pakistan is not significant influenced on the economy.

Many studies have founded a one way causal relationship but some have not founded a causal relationship. Some studies are related exactly linked to this study. However, the current study is alike to that of (Bonsu, 2014) the positive impact of roads access on subsistence agriculture in northern Ghana. In spite of rain is a major determinant of subsistence agriculture in the northern region but road access is an easy and timely access to agricultural factors (variables) that is allowed to use rain for the benefit of the production.

In order to achieve economic growth, it must bring about higher rate of production in agricultural sector through the roads infrastructure. Theoretically, the agricultural sector and roads infrastructure plays an important role in Pakistan to stimulate economic growth through its backward and forward connections.

CHAPTER 3

Theoretical Framework, Model and Methods

3.1 Introduction

This chapter contains theoretical framework, model, and methods to estimate the models of present study. Moreover, data descriptions and sources of data are also discussed. The chapter is divided into seven sections. First section contains the discussions about the theoretical framework of this study. Section three point two is related to conceptual framework that brings the theoretical relationships among the variables of model of study. While model and methodology of present study are defined in the third section of this chapter. Next, the study contains the data and variables and same section provides the details of data sources in the third section. In the fifth section description of variables and measurement issues are discussed. In second last section of chapter, the unit root test and its types are discussed. Then the last section of this chapter discusses ARDL cointegration test and its various steps.

3.2 Theoretical Framework

In theoretical framework, theories are demonstrated in ideas and concepts that are related to the broader fields of knowledge. It provides the explanation or interpretation of statements that are observed in research (Bryman & Cramer, 2001). In similar vein, the theoretical framework facilitates the researchers to understand the state of knowledge and how theory is evolved over the time (Arora et al., 2008; Rajasekar et al., 2006). To conduct an effective research, theoretical framework and methods are two integral parts of research.

There are many factors that determine the path of economic growth of any society (e.g., natural resources, capital formation, technology, physical capital, and infrastructure etc.). No doubt all these factors have a direct impact on economic growth with different rates whether these factors are determined endogenously or exogenously. Pakistan's economic growth path is also determined through the agriculture growth and agriculture productivity. An increase in economic growth is due to the better performance of agriculture sector. In this way, higher rate of agriculture productivity indicates a higher growth rate in manufacturing and services sector through the backward and forward linkages among manufacturing, services, and agriculture sectors. Being the third-largest sector of Pakistan's economy, growth of agriculture sector is reflected into the growth trends of the economy.

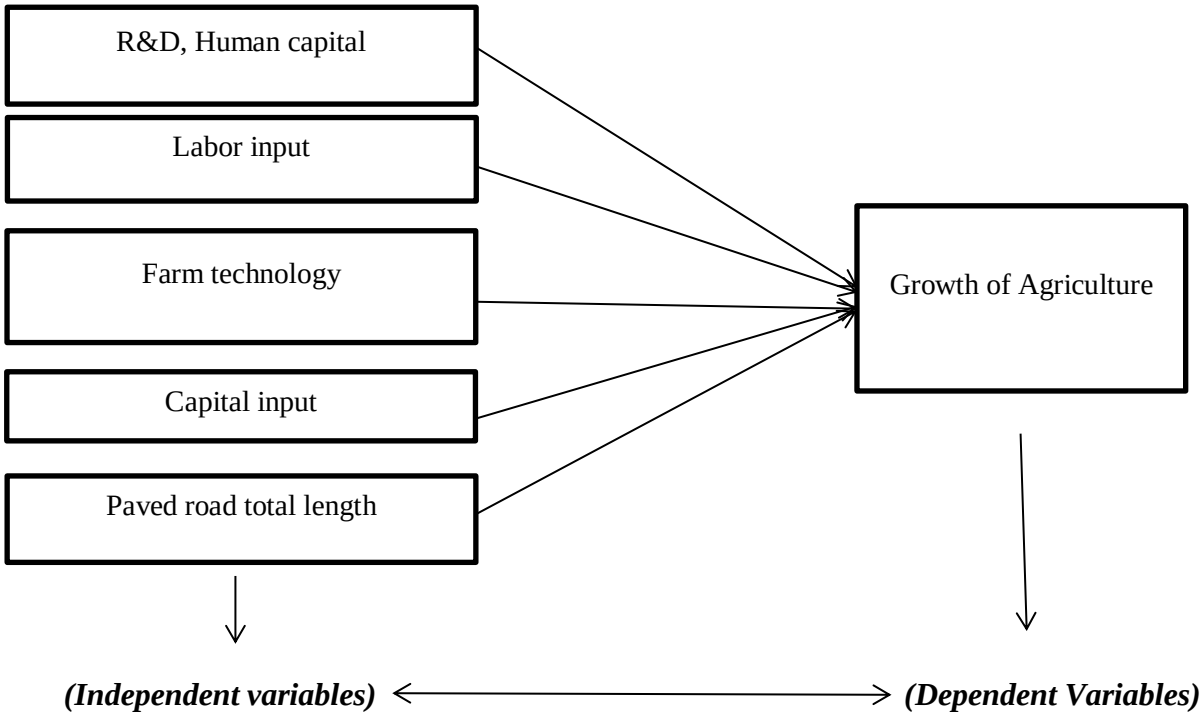
Structure theory is given by (Robey & Markus, 1988) and according to this theory that how can a farmer uses available resources in his agricultural activities to enhance the agricultural output. Road infrastructure is basically to facilitate and mobilize the agricultural activities (Madou et al., 2004). In another study, duality theory of economic growth is a performance process in which infrastructure is considered as a medium source to boost the economic activities (Kivunja, 2018). As in rainy seasons, farmers require roads to access modern inputs such as fertilizers while after harvesting farmers need roads to access markets (D. S. Lee et al., 2009).At global level output of agriculture sector is increased many times due to research and development (R&D). But in case of Pakistan, it is supposed that the agricultural productivity improved through road infrastructure. That's why; paved roads in rural areas are considered as solid source of agricultural productivity.

The quality roads or paved roads are source of physical integration of economic sources, and it is concluded that agriculture output easily mobilize to urban markets. Roads in good condition provide economic opportunities. Roads provide opportunities for obtaining comparatively less expensive inputs as well as marketing and selling. In a fishing community in the Philippine's, a study of (Olsson et al., 2009) revealed that improvement in roads lead to change in investment, production system, employment, transportation service of supply and demand. According to (Markusen & Venables, 1999) farmers are exposed to modern agricultural approaches because to improved communication and the inability given by improved roads network. Improvements in infrastructure are source of expansions in markets, economics of scale and improvements in factors market. The enlargement of rural infrastructure is supposed to expand markets of factors of production (Rehman & Hussain, 1994). In agriculture and rural sector the process of commercialization is linked with infrastructure (Jaffee & Morton, 1995). It is increased trade of scale too and owing to economies of scale to reduce the trading costs.

The role of infrastructure in agriculture sector is most important and well-documented of rural development (Bank, 1985). Modern rural infrastructure is headed towards lower production cost in which expansion of agriculture output and community income. The development of roads is directly affected on agriculture productivity by extending the area under cultivation. The road development and increased in agriculture products have bidirectional causality (Mazrekaj, 2020).

The endogenous growth theory by (Romer, P. M. 1986) has made a significant contribution to the study of the determinants of long-term growth. According to the HAQ/HAG , the development of road infrastructure is critical for economic growth. Intutively, owing to road infrastructure investment is raised in agriculture sector as well as economic growth for instance as transportation, telecommunications, and power facilitates the production process by lowering trade and transaction costs and gaining access to markets. It can also boost up the marginal productivity of output and other additional inputs, thereby encouraging long-run economic growth (Sabir, 2018).

3.3 Conceptual Framework



The conceptual framework is shown the relationship among the variables (dependent variable, independent variables) which are used in the study. The infrastructure investment is directly effect on Pakistan's agricultural productivity. When roads infrastructure is improved then it is reduced in both agricultural outputs and inputs transaction costs, but the social infrastructure developed the quality of human capital (health & education). Consequently, the capital, labor force, research & development, human capital, paved roads, farm technology (numbers of tractors and tub-wells) and total energy consumption especially electricity in agricultural are most important requirement for processing and production. All variables in the production function have positive affect on Pakistan's agricultural productivity.

The impact mechanism of road infrastructure for agriculture productivity is that infrastructure increased the agriculture growth rate. Basically, there are two types of infrastructure like soft infrastructure (internet) and hard infrastructure (roads). Hard infrastructure like road impact the agriculture sector which is supported to riase the agricultural productivity.

3.4 Model and Methods

3.4.1 Model

The Cobb-Douglas production function frequently uses in the analysis of agricultural related studies (Douglas, 1967). First time in the history, Cobb-Douglas production function was used for the industrial sector of USA by (Cobb & Douglas, 1989). In agriculture sector, the production function procedures in which the agriculture resources are transformed into such form that provide the maximum output (Nucci et al., 2014).

Here is the C-D production function.

$$Y_t = AL_t^{\alpha} K_t^{\beta} R_t^{\gamma} X_t^{\theta} e^{ut} \quad (3.1)$$

Where:

Y_t is output of agriculture sector.

A is total factor productivity

L_t is total labor employed as an input in agriculture sector.

K_t is total capital as an input in agriculture sector.

R_t^{γ} is economy wide total paved road length and it is used a proxy of quality road as well.

Xt is vector of variable that contains farm technology in agriculture sector, R & D overall in Pakistan economy and total energy consumption by agriculture sector.

Now take the natural log of above C-D production function (Samoilova & Rodionov, 2022). As the above production function is not linear in terms of parameters. Because raw data is used to analysis the model and make the linear to take the natural log.

$$lnY_t = lnA + \alpha ln L_t + \beta ln K_t + \gamma ln R_t + \theta ln X_t + u_t \quad (3.2)$$

Let, ln (Zt) = z_t for all variables of model except the error term.

$$y_t = \beta_\circ + \alpha l_t + \beta k_t + \gamma r_t + \theta x_t + u_t \quad (3.3)$$

$$y_t = \beta_\circ + \beta_1 l_t + \beta_2 k_t + \beta_3 r_t + \beta_4 x_t + u_t \quad (3.4)$$

Following model (3.5) is capturing the impact of roads infrastructure on agriculture output of Pakistan over time.

$$y_t = \beta_\circ + \beta_1 l_t + \beta_2 k_t + \beta_3 r_t + \beta_4 f t_t + \beta_5 e c_t + \beta_6 r\&d_t + u_t \quad (3.5)$$

Here, y_t agriculture output or gross national product (GNP) of agriculture sector that is a function of labor force, gross fixed capital formation, paved roads, farm technology, agriculture energy consumption and research & development.

In following model try to investigate the road infrastructure influence on food crop (wheat) of Pakistan and it is disaggregated analysis (R.M.,Skrynkovskyy et al., 2019).

$$wy_t = \alpha_\circ + \alpha_1 l_t + \alpha_2 k_t + \alpha_3 r_t + \alpha_4 f t_t + \alpha_5 e c_t + \alpha_6 r\&d_t + v_t \quad (3.6)$$

In this model wy_t is output of wheat crop overtime and it is function of labor force, gross fixed capital formation as real, paved roads, farm technology, agriculture energy consumption and research & development.

On same token following model (3.7) is developed that captures the effect of roads infrastructure on rice (food crop) in Pakistan overtime.

$$ry_t = \gamma_\circ + \gamma_1 l_t + \gamma_2 k_t + \gamma_3 r_t + \gamma_4 f t_t + \gamma_5 e c_t + \gamma_6 r\&d_t + \vartheta_t \quad (3.7)$$

In this third model, output of rice is a function of labor force, gross fixed capital formation , paved roads, farm technology, agriculture energy consumption and research & development.

The intuition of following model (3.8) is to discover the effect of road infrastructure on a cash crop of Pakistan which is cotton.

$$cy_t = \theta_\circ + \theta_1 l_t + \theta_2 k_t + \theta_3 r_t + \theta_4 f t_t + \theta_5 e c_t + \theta_6 r\&d_t + \mu_t \quad (3.8)$$

In this last model of present study, output of cotton is a function of labor force, gross fixed capital formation as real, paved roads, farm technology, agriculture energy consumption and research & development. As study are constructed four models and each through different endogenous variable and identical exogenous variables. In following section, data description and data sources are going to discuss.

3.4.2 Data and Variables

The data is taken from 1980 to 2020. As we discussed in previous section that several factor are affecting the agricultural production and its productivity. The main factors are roads infrastructure (paved road total length), capital (gross fixed capital formation), labor, and farm technology. The research covered seven variables which are related to agriculture production. The dependent variable (endogenous) is agriculture output, and the other variables are used as independents (exogenous) like paved road total length, gross fixed capital formation, research & development (R&D), farm technology, total agriculture energy consumption ton of oil equivalence (TOE) and labor force in million.

Gross national product (GNP) of agriculture sector is used as proxy of output which is dependent variable. It is assumed that real gross national product expands by nation's economy over a specific period and the economy will grow (Faridi & Murtaza, 2013). The labor force is proxy of productive population overtime. The relationship between the labor force and agricultural output is expected to be positive in short run. But the same relationship may invers in long run when total crop area approaches to saturation point. This is due to the pressure on the agricultural land as increase in urbanization. Capital stock is an integral source of agriculture production, and capital accumulation is the key to agricultural growth and development processes. Capital is used as an input to the agricultural sector provided by mechanical and technological advances. Capital formation serves as an instrument of production. It is fundamentally net investment and the parts of expenditure in which follow the methods by calculating the GDP. So, gross fixed capital formation in agriculture sector is involved the spending on improvements of land, plant, machinery Mclaren, (2017).

The total length of paved roads is used to represent the development of infrastructure in the country. A positive relationship is expected between agriculture output and paved roads.

Agriculture or farm technology is included the machinery like production of total numbers of tractors and numbers of total tub-wells connection. In other study the total number of harvester machine are used as a proxy of farm technology by Rehman & Hussain, (2016).

Agriculture research and development is included all an extremely wide range of positional innovations and activities. Boost-up the income of farmers due to allowed higher yield seeds for the production of large quantity of agricultural output at a minimum cost (Moris, 2018). Here in this study, overall economy wide expenditures of R&D are taken as a proxy.

This research is using secondary data for analysis. The data is collected from the most reliable sources of Pakistan like Pakistan Statistical Yearly Book (various issues), Pakistan

Economic Survey and various Energy Books that are published by Hydrocarbon Development Institute of Pakistan (HDIP).

3.4.3 Description of Variables

With the description of variables, data is easily understood and measured (Abiodun-Oyebanji, (2017).

a) a quantity in which any set of values
b) representing a symbol of variables

Table 3.1 Variable Description

Factors	Variables	Abbreviation	Measurement	Data source
		Explained(Dependent) Variables		
Total agriculture output	GNP(Real)	Y	Million Pakistani Rupees	Pakistan Economic Survey
		Explanatory(Independent) variables		
Paved road total length	Paved road	Roads	Thousand Kilometers	Pakistan Economic Survey
Gross Fixed Capital Formation (Real)	GFCF	GFCF	Million Rupees	Do
Labor Force in Agriculture sector	Labor force	LF	Million	Do
Research and Development	Research& Development	R&D	% of GDP	World Development Indicator (WDI)
Farm Technology	No's of tractors& tub-well	FT	Normalized	Pakistan Economic Survey
Total agriculture	Agri energy	EC	Ton of Oil	Hydrocarbon

Energy consumption	consumption		Equivalent (TOE)	Development Institute of Pakistan
Agriculture crops	Wheat	W	Million. Tones	Pakistan Statistical Yearly Book
	Rice	R	Million. Tones	=
	Cotton	**C**	**Million. Bales**	**=**

Table 3.1 describes the list of variables that are used in present study. Paved roads total length is as independent variable. Theoretically it is supposed that improvement of infrastructure has positive impact on economic growth. A better road network provides the distribution of agricultural goods as well as improved the agricultural trade opportunities. It is leaded to large economic scale, market expansion and enlargement in factor market operations (Shamdasani, 2021).

While on the other side, cotton yield is measured by the numbers of total million bales. The cash crops in Pakistan like cotton which is the world's major producer of raw cotton. In the global market Pakistan's yarn 26.1 % and 14.3 % is contributed of export. Pakistan's total cotton export is counted by 46% and provided the labor force employment of 35% (Donelan, 2019).

3.4.4 Methods to Estimate the Models

In methodology, it is referred to provide such technique in which to analyzing and systemizing the data by (Polit & Beck, 2005). It is explained that the research is a completed structure like methods of size and sample, utilize the practice and technique to collect data and the data analysis process by (Bowling, 2010). The main purpose of this research is to analyze the impact of road infrastructure on agriculture output and agriculture productivity in Pakistan as moderation exploration. Thus, to estimate the model by using the dynamic modeling's approach. In the dynamic modeling's approach, it is examined that the economic variables in long-run equilibrium and hypothesis testing. This approach is supported the study to examine the long-run and short-run relationships between the variables. The role and significance of road infrastructure and agriculture productivity in Pakistan is based on

conceptual understanding. Following section proceeds with stationarity tests and move forward for ARDL analysis.

3.4.5 Unit Root Test

According to Nelson & Plosser (1988), macroeconomic series have stochastic trend instead of deterministic. All types of stochastic trends are not source of unit root, but the deterministic trend is a source of non-stationarity. There are three other sources that may also cause the unit root. The first one is seasonality, irregularity, and presence of inertia in time series data. A unit root test is a statistical test for the preposition that in a time series of an autoregressive model, and autoregressive parameter is equal to one. A time series to be stationarity when the properties of statistic such as mean, variance and covariance of distribution are same over time or when there is no trend showed in the time series (Rahayu et al., 2019). As a time series is not stationarity as its mean, variance and covariance are time invariant. There are two types of stationarity weak stationarity and strong stationarity.

A weak stationary is a series if its value of mean and variance are remained same or constant over time, but the covariance value is only determined by the distance or lags between two periods. In time series analysis stationarity play an important role with tremendous influence on how to data predict and perceive (Granger & Newbold, 1974). Sometimes a nonstationary series can convert into stationary series by certain transformation.

Unit root test for time series is indicated that there is no distinction between unit root and stable processes by Cochrane, (1991). There is various aspect of unit root test that's supported the time series analysis. Firstly, unit root test is solved the econometric problems. Unit root test helped to detect the source of non-stationarity and the solution to restore stationarity in consequence (Sainz-Escudero et al., 2021). In simple words, under analysis the features of the process depend on the way to restore stationarity. Secondly, if supposes that two series (Yt & Xt) have unit root process. Regression analysis of such series may lead to spurious regression.

Following random walk model is used to test the stationarity of a time series.

$$Yt = \rho Y_{t-1} + U_t \qquad (3.9)$$

Where $-1 \leq \rho \leq 1$

If the value of rho is equal to one, then there is a unit root in above series or series in nonstationary. Here u_t is pure white noise. Let subtract lag value of variable ($Y_{t-1)}$ from both sides of above equation.

$$Yt - Yt\text{-}1 = \rho Yt\text{-}1 - Yt\text{-}1 + ut \quad (3.10)$$

$$\Delta Yt = (\rho\text{-}1)\, Yt\text{-}1 + ut \qquad \text{where } \delta = (\rho\text{-}1) \quad (3.11)$$

Now the null hypothesis of Dicky Fuller test is that $\delta = 0$. If $\delta = 0$ then ρ = 1 that is again an issue of unit root. It means the time series is non-stationarity under consideration.

$$\Delta\, Yt = (Yt - Yt\text{-}1) = ut \quad (3.12)$$

If take the first difference, then difference of dependent variable is equal to white noise error term, and which is stationary. In simple words, above time series is stationary at 1st differences.

3.4.6 Test of Stationarity

In unit root test, testing of stationarity has get to importance as the whole result of the regression might be misguided in presence of nonstationarity(Granger & Newbold, 1974).

There are two tests that is used for analysis and finding out the stationarity of time series data. So, there are two types of unit root test to analyze the time series which are Augmented Dickey-Fuller (ADF) and Phillip-Perron tests.

3.4.7 Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) test

Dickey & Fuller, (1979) formulate a procedure that is categorized as Dicky Fuller (DF) test for testing stationarity of a series. In earlier days, DF test is the most prominent and it is broadly used for unit root testing. It is established on the model of first order autoregressive procedure (Box & Jenkins, 1989).

$$y_t = a + \emptyset_1 y_{t-1} + u_t \quad (3.13)$$

$$t = 1,2,3, \dots \dots T$$

Where $\emptyset_1$ is coefficient of partial autocorrelation and it is also parameter of autoregressive. For the time series investigation, the AR model is also included one or more lagged values which is included both the endogenous variables with exogenous variables is known as autoregressive model Ng & Perron, (2001).

Only constant: $$\Delta Y_t = \alpha + \gamma Y_{t-1} + \mu \quad (3.17)$$

Time trend and constant: $\Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \mu$ (3.18)

A unit root test is contained a null hypothesis and it is non-stationary while unit root test does consist of alternative hypothesis that series is stationary.

Ho: $\gamma = 0$

H1: $\gamma < 0$

To test the data for stationarity DF test with intercept is applied on both series. So, the null hypothesis is tested through t-statistics formula:

$$t = \frac{\gamma^{\wedge} - \gamma \, \mathrm{Ho}}{\mathrm{SE}(\gamma^{\wedge})}$$

Now if t value is more than critical value, then the null hypothesis is not rejected. In such condition, the variable under examination is not stationary and it have unit root. But on the other side, if the value of t is less than critical value then the null hypothesis is rejected. In such condition, underlying variable is stationary and do not have a unit root. As DF test equation is consisted a non-systematic component, so known as Augmented Dickey-Fuller test is constructed by (Dickey & Fuller, 1979). The ADF test is based on the regression equations below, without drift and trend.

$$y_t = \rho y_{t-1} + \sum_{i=1}^{k} \gamma_i y_{t-1-i} + e_t \quad (3.19)$$

With drift but no trend

$$y_t = \alpha + \rho y_{t-1} + \sum_{i=1}^{k} \gamma_i y_{t-1-i} + e_t \quad (3.20)$$

With drift and trend

$$y_t = \alpha + \beta t + \rho y_{t-1} + \sum_{i=1}^{k} \gamma_i y_{t-i-1} + e_t \quad (3.21)$$

The critical values of ADF test is given by Mackinnon, (2012) that are computed through Monte Carlo simulation.

3.4.8 Phillips–Perron (PP) Test

Phillips-Perron tests the null hypothesis that a time series has unit root at level along with deterministic trend (Phillips & Perron, 1988). PP test in an advancement of unit root theory. PP test is alike to Augmented Dickey Fuller test, but it includes an involuntary adjustment to the Dickey Fuller method to enable for autocorrelated residuals. So, PP tests are mostly assembling the same marks as ADF test. Here is equation of PP test that is almost identical to ADF test. But the here e_t is hetero and auto corrected error term of PP test.

$$\Delta y_t = c + \beta t + \gamma y_{t-1} + \sum_{i=1}^{k} \gamma_i y_{t-i-1} + e_t \quad (3.22)$$

Here again estimated coefficient (γ) is treated as it is treated in case of ADF. Because the null hypothesis of ADF and PP test is identical. However, the critical value of PP test is relatively robust as compared to "tau" critical values of ADF. The (γ) coefficient of PP is relatively best as compared to coefficient of ADF due to the non-presence of hetero and autocorrelation in residuals of 3.22 equation.

3.4.9 Test of Cointegration

Cointegration analysis is basically subpart of dynamic econometric analysis. It is basically a inferential-statistical method to test the steady state or long run relationship between (among) two (more than two) non-stationary time series (Campbell & Perron, 1991). It is leaded to identify long run parameters and is determined the scenarios in which two or more stationary time series are co-integrated in such a way that in long run they cannot depart from their equilibrium path. It is a concept of econometric in which is simulated the existence between economic time series for a long run equilibrium. If two series are non-stationary at level or both series are integrated at first difference but the linear combination of both nonstationary series is stationary at level then it means there is cointegration between two series (Hillmer & Wei, 2006). In cointegration test variables are generally integrated at order one or I(1) or one variable is cointegrated at level while other is cointegrated at first difference. The cointegrated variables are never move separately or independently (Ssekuma & Commerce, 2011). Engle and Granger theorem is considered as a pioneer cointegration test for bivariate analysis. It is also known as two step procedure of cointegration. In the same par, Johansen cointegration approach for multivariate is developed. Both Engle Granger and Johansen cointegration tests are subjected to order of unit root of variables of the model. In empirical literature, it is supposed that all variables of model should be stationary at first difference for Engle Granger and Johansen cointegration.

In the same vein, Pesaran et al., (2000) give auto regressive distribution lags **(**ARDL) technique to estimate the model when model contains few variables are stationary at level and other are at first difference. ARDL technique is customized to identify the cointegrating vectors in case of mix order of integration. If one cointegrating vectors is identified, then the ARDL approach of the cointegrating vectors is re-parameterized in ECM. In the single model, the re-parameterized results are provided short-run and long-run dynamic relationship among or between the variables.

3.4.10 Auto Regressive Distribution Lags (ARDL) of Estimation Technique /Bound Cointegration Testing Approach

ARDL is a method of cointegration among dependent and explanatory variables of the model. The major advantage of this approach is identified the co-integrating vectors when multiple cointegrating vectors. Here are some general forms of ARDL equations for agriculture sector as well as for three selected crops.

$$\Delta(GNP)_t = \beta_{o1} + \sum_{i=1}^{n1} \beta_{11\Delta \ln GNP_{t-i}} + \sum_{i=0}^{n2} \beta_{12\Delta \ln GFCF_{t-i}} + \sum_{i=0}^{n3} \beta_{13\Delta \ln F.T_{t-i}} + \sum_{i=0}^{n4} \beta_{14\Delta \ln E.C_{t-i}} + \sum_{i=0}^{n5} \beta_{15\Delta \ln L.F_{t-i}} + \pi \sum_{i=0}^{n6} \beta_{16\Delta \ln R\&D_{t-i}} + \sum_{i=0}^{n7} \beta_{17\Delta \ln P.Roads_{t-i}} + \delta_{11 \ln GNP_{t-1}} + \delta_{12 \ln GFCF_{t-1}} + \delta_{13 \ln F.T_{t-1}} + \delta_{14 \ln E.C_{t-1}} + \delta_{15 \ln L.F_{t-1}} + \delta_{16 \ln R\&D_{t-1}} + \delta_{17 P.Roads_{t-1}} + \varepsilon_{t1} \quad (3.23)$$

Long run equation

$$(GNP)_t = \beta_{o1} + \sum_{i=1}^{n1} \beta_{11\Delta \ln GNP_{t-i}} + \sum_{i=0}^{n2} \beta_{12\Delta \ln GFCF_{t-i}} + \sum_{i=0}^{n3} \beta_{13\Delta \ln F.T_{t-i}} + \sum_{i=0}^{n4} \beta_{14\Delta \ln E.C_{t-i}} + \sum_{i=0}^{n5} \beta_{15\Delta \ln L.F_{t-i}} + \pi \sum_{i=0}^{n6} \beta_{16\Delta \ln R\&D_{t-i}} + \sum_{i=0}^{n7} \beta_{17\Delta \ln P.Roads_{t-i}} + \varepsilon_{t1} \quad (3.24)$$

Short run equation

$$\Delta GNP_t = \beta_{o1} + \sum_{i=1}^{n1} \beta_{11} \Delta \ln GNP_{t-i} + \sum_{i=0}^{n2} \beta_{12} \Delta \ln GFCF_{t-i} + \sum_{i=0}^{n3} \beta_{13} \Delta \ln F.T_{t-i} + \sum_{i=0}^{n4} \beta_{14} \Delta \ln E.C_{t-i} + \sum_{i=0}^{n5} \beta_{15} \Delta \ln L.F_{t-i} + \sum_{i=0}^{n6} \beta_{16} \Delta \ln R\&D_{t-i} + \sum_{i=0}^{n7} \beta_{17} \Delta \ln P.Roads_{t-i} + \alpha ECM_{t-1} + \varepsilon_{t1} \quad (3.25)$$

Equation (3.23) is generic form of ARDL model that contains both short and long run relationship. Parameters that are attached with small delta operator are basically long run parameters of model. In equations β_{o1} is intercept while from β_{11} to β_{17} signify the short run coefficient and δ11 to δ17 are coefficients of long term. n_1 to n_7 identify the lag of length of variables of the model and at the last ε_{t1} is an error term. The F-test which is including the equations of the joint significance of the lagged variables of coefficient to confirm that there is a linkage among the variables in the long run. So, there exists a long run cointegration relationship among the

dependent variable and independent variables. For this the null hypothesis is as follows

Ho:$\beta_1=\beta_2=\beta_3=\beta_4=\beta_5=\beta_6=\beta_7=0$

H1: $\beta_1\neq\beta_2\neq\beta_3\neq\beta_4\neq\beta_5\neq\beta_6\neq\beta_7\neq0$ or at least one beta is not equal to zero. This F-test is developed by Pesaran et al., (2000). The ECM model is identifying the short run equations for estimation the linkage among the variables. The negative sign of ECM_{t-1} should be statistically significant and the coefficient (α) that implies the long-run equilibrium among the dependent variables and the long-run equilibrium association is converge back to the long run equilibrium. Here are following steps of ARDL technique that are going to be discussed by one by one.

Step 1: Existence of a Long-Run Relationship (Bound testing)

The first step of ARDL is to test the existence of long-term relationships between the variables under investigation by calculating the bound F-statistic (cointegration bound test). This bound F-statistic is calculated as per variable because variables are considered endogenous and other variables are considered exogenous. In fact, testing the relationships between coercive variables in the ARDL model tests the hypothesis of long-term relationships between the underlying variables.

Step 2: Choosing an Appropriate Lag Length

If it is confirmed that there is cointegration among the underlying variables or the null hypothesis of F test is failed to accept, then there is long-term relationship. Since we need a Gaussian error term (that is, a standard normal error term that is unaffected by non-normality, autocorrelation, non-uniform variance, etc.), the problem of finding out an appropriate lag for each variable underlying the ARDL model is too high. It is important. To find the appropriate model for the underlying long-term equation, one need to determine the optimal lag lengths (k). There are various lag length selection criterions such as: Akaike's Information Criterion (AIC), Schwartz-Bayesian Criterion (SBC), or Hannan-Quin Criterion (HQC), R square and adjusted R square. The next step is to find the long run and short forms of ARDL technique.

Step 3: Long run and Error Correction Model

Unsteady variables can be regressed in the model with erroneous results. One way to achieve variable stationarity is to resolve this difference in data (because most data have a difference stationary process). In this situation, the parameter estimation from the regression model is correct and may solve the problem of confounding equations. However, the regression equation shows only the short-term relationships between the variables. No information is provided on the long-term behavior of the parameters in the model. This causes problems because researchers are primarily interested in the long-term relationships between the variables under consideration and ECM is essential to solve the concept of co-integration. The ECM specification has integrated both long-term and short-term information.

3.4 Growth Accounting Method

Solow, (1956) introduced the concept of growth exogenous growth theory. Later on, growth accounting tool is widely used to break down how specific factors are contributed to economic growth. It is also focused on the three key factors like labor, capital, and technology. Although Kuznets suggests about an index of growth accounting, which he is provided an informal analysis of the sources of long-term growth in developed countries since the dawn of modern economic growth. Kuznets, (1973) concluded that rather than about a quarter of per capita income growth. So, the Solow model is focused on the supply side economy and it is assumed that supply of goods are increased imply the economic growth (Ball & Mankiw, 2002). It is designed to demonstrations that how rise in capital and labor force and technology advancement is effected total output of goods and services of a nation. However, the Solow growth model is indicated that higher savings rate causes higher stock of capital and thus large number of output per effective worker. As a similar point of views (Gordon et al., 2005) is showed that the economic growth theory is developed from internal process such as improvement in human capital and its impact on long run economic growth. In short, it is concluded that growth theory suggested the following points. First, technological advancement is not considered as exogenous effects. Second, higher capital investment is leaded to higher returns. Third, technological progress is acquired to investment in research and development. Finally, key concept of growth is that to investment in human capital like labor training and education.

In economic history, growth accounting's potential significance is accumulated in numerous ways (Crafts & Woltjer, 2021). Firstly, it is a method of benchmarking such as is provided a valuable diagnostic of growth performance strengths and shortcomings. A growth-

accounting approach is provided essential explanation for deeper investigations of the growth process by laying out the proximate drivers of growth. Secondly, an extension to the fundamental methodology is allowed for the quantification of certain sectors' or new technologies' contributions to growth. This provided a useful reality checked on too optimistic assertions made in the literature, as well as a perspective on productivity 'puzzles' like the Solow paradox. Thirdly, the basic of Solow residuals is thoughtful and thus attempting to clearly counter "our level of ignorance" that is provided valuable insights into the nature of productivity progress and the large disparities in TFP levels across the country.

In this study time serious data is utilized for empirical analysis. As time series analysis is coupled with the data properties of all variables of model. So, after collecting the data, the first task will be found out the integration level of each variable then based on integration, study will opt suitable technique to estimate the model. The linear form of the Cobb-Douglas production function is estimated in dynamic form in which the effect of infrastructure development on productivity and production of agriculture sector of Pakistan. After estimating the model, the following equations for Solow residual will be estimated to get the growth drag of infrastructure. Here is the simplest form of neoclassical production to obtain the growth,

Y= F (A, K, L)

In the growth accounting model is expressed that aggregate output (Y) is a function of level of technology (A), inputs factors of capital (K) and labor (L) by Healey, (1991).

The growth accounting equation is facilitated to analyze economic growth at the minutest level by Nanayakkara, (2001). Growth accounting equations is like as;

$$Productivity = g_y - g_k - g_l$$

In this equation,

g_y = GDP growth

g_k= capital stock growth

g_l= labor force growth

Growth accounting equations which are used in this study. The difference between productivity equation and productivity (A) equation is basically growth drag from road infrastructure and so on.

$$Productivity\ (A) = g_y - g_k - g_l - g_p$$

$$Productivity(A) = g_{GNP,real} - g_k - g_l - g_p$$

$$Productivity(B) = g_{wheat} - g_k - g_l - g_p$$

$$Productivity(C) = g_{rice} - g_k - g_l - g_p$$

$$Productivity(D) = g_{cotton} - g_k - g_l - g_p$$

In this research, we are calculated the four various productivity's growth rates like growth rate of GNP, food crops (wheat & rice), cash crop (cotton), labor force, capital and paved roads.

3.5 Concluding Remarks

This chapter contains theoretical justifications, conceptual framework, and model of the study. Then construction of variables of various models and their descriptions are also discussed. Later, estimation procedure of study is also explained step by step. In upcoming chapter, results will be presented along with discussion.

CHAPTER 4

Results and Discussion

4 Introduction

In this chapter, results are explained in six segments along with relevant discussion. These six segments are descriptive statistics, correlation analysis, unit root tests (Augmented Dickey Fuller & Phillips Perron) of all variables of all models. Hereafter the bound testing, long run form of ARDL and short-run (ECM) parameters of agriculture sector with some diagnostics tests are discussed. At disaggregate level three selected crops (one cash and two food crops) are selected and same process of estimation is used.

4.1 Descriptive Statistics

Descriptive statistics gives a simple summary about the sample and provides the basic features of data (Ciuiu, 2014). So, in this descriptive analysis raw data of all variables are used.

Following Table 4.1 contains the descriptive analysis of variables. The mean value of GNP is 910126.7 which show the average value from 1980 to 2019. There are some fluctuations in magnitude of GNP. As it is time series data, so the median value doesn't make rational to explain. The standard deviation of GNP is 883517.0 and its distribution is positively skewed. The p-value of GNP is more than 0.05 thus the null hypothesis of Jarque Bera cannot reject. The mean value of paved roads is 124543.2 that indicate the average value of 40 years. The standard deviation value of paved roads is 59784.7 correspondingly. The distribution is negatively skewed and leptokurtic curve of paved roads. The p-value of data is more than 0.05 so the null hypothesis do not rejected of Jarque Bera. The mean value of output of cash crop (cotton) and standard deviation of cotton is 2630.0 respectively. The distribution is negatively skewed and mesokurtic curve of cotton. The p-value of Jarque Bera test is greater than 0.05. The mean value of (food crop) wheat is 18907.4 which indicate the average value. The distribution is negatively skewed and leptokurtic curve of wheat. Then the mean value of rice is 4794.1 and the standard deviation is 1478.8. The distribution is normally skewed and leptokurtic curve of rice. Additionly, the mean value of labor force is 18.51 and standard deviation is 4.27 correspondingly. Its distribution is positively skewed and p-value of jarque Bera test is greater than 0.05. So, the null hypothesis do not rejected. Along with the mean value of gross fixed capital formation is 151274.9 and its p-value is also greater than 0.05. Its

distribution is positively skewed and the null hypothesis do not rejected. More, the mean value of farm technology is 146.3 which shows the average value of it. The p-value of Jarque Bera test is less than 0.05 and the distribution is positively skewed. Thus, the platykurtic curve of farm technology. As the p-value of value of energy consumption is less than 0.05 and the null hypothesis is rejected of Jarque Bera. The distribution is negatively skewed and leptokurtic curve of energy consumption. Lastly, the mean value of research & development is 0.17 and its p-value of Jarque Bera test is also less than 0.05. Therefore, the null hypothesis is rejected. The distribution is positively skewed and the platykurtic curve of research & development. Descriptive statistics is presentation of statistical properties of univariate while correlation and regression analysis of bivariate phenomenon.

Table 4.1 of Descriptive Analysis

	Real GNP	**GFCF**	**L.F**	**R&D**	**Paved Road**	**Cotton**	**Wheat**	**F.T**	**Rice**	**Agri.E.C**
Mean	910126.7	151274.9	18.51	0.17	124543.2	9927.5	18907.4	146.3	4794.1	735668.2
Median	903966.0	214899.0	16.72	0.14	138463.0	9889.1	18858.8	105.1	4576.1	733351.0
Maximum	2434850.	353310.0	25.14	0.44	201100.0	14265.2	26673.6	1622.6	7449.8	857193.0
Minimum	76399.00	5169.50	13.01	0.10	24750.00	2907.7	10881.9	1.312	2918.9	488964.0
Std. Dev.	883517.0	142023.6	4.27	0.03	59784.78	2630.0	4977.6	252.4	1478.8	76570.89
Skewness	0.53	0.05	0.36	1.74	-0.50	-0.54	-0.05	5.141	0.45	-1.02
Kurtoses	1.69	1.19	1.47	6.12	1.81	3.14	1.66	30.77	1.81	4.81
Jarque-Bera	4.73	5.44	4.79	36.5	4.06	2.03	2.96	1461.9	3.75	12.55
Probability	0.093	0.06	0.09	0.00	0.13	0.36	0.22	0.00	0.15	0.00
Sum	364050	6050995.	740.5	7.04	4981728.	397102.8	756299.5	5854.3	191766.5	2942672
Sum Sq. Dev.	3040	7870	711.5	0.20	1390	270	9660	24859.	852896.	2290
N	40	40	40	40	40	40	40	40	40	40

Table 4.2 Correlation Analyses

	GNP	Labor force	Energy use	GFCF	Farm tech	R &D	P. Road

GNP	1.00						
Labor force	0.95	1.00					
Energy use	0.21	0.25	1.00				
GFCF	0.95	0.91	0.18	1.00			
Farm Tech	0.48	0.52	0.08	0.44	1.00		
R&D	0.76	0.73	0.21	0.64	0.64	1.00	
P. Road	0.85	0.87	0.39	0.87	0.75	0.57	1.00

As present study is using time series data so, the main issue of time series data is non-stationarity in nature. The non-stationarity of time series data is also called unit root. If a time series contains unit root, then it implies that the mean or variance or both vary with respect to time. While in descriptive analysis, the mean and standard deviation are treated as static and discuss the behavior only single reported value. The following section of study contains the unit root test.

4.2 Correlation Analysis

It is technique of statistics to examine the linear relation among the two variables. It provides a good understanding of data analysis (Senthilnathan, (2019). It indicates the change in one variable bring how much change in the other variable. If a strong correlation between two variables, then it is concluded that one variable is being observed in a particular way while the other variable is being affected in a similar manner. High magnitude of correlation between the two variables is showed a strong linear relationship, while the low value of correlation coefficient implies weak linear relationship. The value of coefficient of correlation of varies from negative one to positive one. If the value is near to positive one, then its shows that both variables are increased in same manners. However, if magnitude of coefficient of correlation approaches to negative one then it implies that as one variable rises the other one falls vice versa. When the correlation coefficient is near to zero, it is shown that both variables are independent.

Following Table 4.2 reveals the correlation values in a matrix format. Correlation between labor force and GNP is about 0.95 which indicates the positive linear relationship between real GNP of agriculture sector and labor force utilized in labor sector. As the agriculture

sector of Pakistan is labor abundant so study finds high correlation between labor and GNP of this sector. On the same pattern, the correlation between energy consumption in agriculture sector and GNP of this sector has also positive. On other hand, agriculture sector in Pakistan is suffering from low availability of energy service. So, study finds low value of correlation coefficient between energy and GNP of agriculture. The GFCF and GNP are highly positive correlated with each other. The magnitude of correlation coefficient is 95 % which indicates the intensity of linear relationship between these two variables. Farm technology and GNP have a positive correlation and correlation coefficient is 0.86 which indicates the positive linear relationship between the farm technology and agricultural GNP. Economy wide research and development and GNP of agricultural sector of Pakistan have also positive correlation with the magnitude of coefficient of correlation about 0.76. The last coefficient of correlation is about 0.85 between paved roads and GNP. So, all variables labor force, energy consumption, GFCF, farm technology, research & development and paved road have positive correlation with GNP with different magnitudes.

4.3 Unit Root Test

Data visualization is very good source to identify whether series is stationary or non-stationary. On the other hand, when data is small then it is better to use some scientific tests to find out the stationarity level. In literature, the order of integration of a series to find that various types of unit root tests are used. While each test of unit root requires some prior information about the data generation process. Augmented Dickey Fuller (ADF) is used to find the stationarity level of each series. Furthermore, economic and financial indicators are frequently claimed that two non-stationary time series may have long-run equilibrium relationships (Herranz, (2017b).

Table 4.3 Augmented Dickey Fuller Test of Unit Root

Variable	Level		1st Difference		Remarks
	Intercept	Intercept and trend	Intercept	Intercept and trend	
Labor force	-0.62	-1.68	-6.37*	-6.64*	I(1)
GFCF(Real)	-0.38	-2.28	-6.33*	-6.27*	I(1)
Wheat	-0.98	-5.62*	-11.433*	-11.349*	I(0)

Rice	-0.21	-4.404*	-8.98*	-8.98*	I(0)
Cotton	-2.709	-2.933	-6.27*	-6.975*	I(1)
P. Road	-1.92	-1.005	-3.56*	-3.733*	I(1)
Total Energy use	-2.68	-2.85	-5.14*	-5.075*	I(1)
GNP(Real)	0.354	-2.19	-6.37*	-6.53*	I(1)
Farm Technology	-5.13*	-6.27*	-7.15*	-7.05*	I(0)
R&D	-1.49	-4.71*	-12.06*	-11.91*	I(0)

Note: *Indicate variable is stationary

From above Table 4.3 it is observed that labor force, GFCF, paved road, total energy use, GNP, research & development and output of cotton crop have a unit root at level. While, farm technology, research & development, two food crops (wheat and rice) are stationary at level I (0). So, the null hypothesis is not rejected of unit root for all of these variables at level. The advance is examined whether the variables are cointegrated or not, given that all of them are stationary at least at I (1).

In literature it is reported that Phillips-Perron (PP) test of unit root relatively performs well in case of small data as compared to ADF test (Phillips & Perron, 1988). This test is involved a more comprehensive theory of unsteady unit root tests. The PP tests have the same procedure of construction of null and alternative hypotheses. The only difference between these two tests is on the side of simulation of critical values.

The following Table 4.4 contains the outcome of PP test of unit root. In this test again all variables like labor force, GNP, research & development, GFCF, farm technology, total agriculture energy consumption and crops (wheat, rice and cotton) same behavior as in case of ADF test. It is also indicated that some variables are resting at 1st difference I (1) while the other variables are resting at level I (0).

Additionly, ADF test is used for large data and PP test is used for small data. So, our data is small thus can used the PP test.

Table 4.4 Phillips-Perron Test of Unit Root

Variables	Level	1stDifference	Remarks

	Intercept	Intercept and trend	Intercept	Intercept and trend	
Labor force	-0.65	-1.88	-6.71*	-6.62*	I(1)
GFCF	-0.36	-2.30	-6.33*	-6.27*	I(1)
Wheat	-0.81	-5.62*	15.26*	-15.32*	I(0)
Rice	-0.17	-4.35*	-12.38*	-19.93*	I(0)
Cotton	-2.57	-2.84	-8.98*	-20.46*	I(1)
P.Road	-1.26	-0.91	-3.50*	-3.49*	I(1)
Energy use	-2.53	-2.50	-8.96*	-8.88*	I(1)
GNP	0.51	-2.14	-6.38*	-6.62*	I(1)
Farm Tech	-5.20*	-6.28*	-35.75*	-36.09*	I(0)
R&D	-3.14*	-4.83*	-15.68*	-15.78*	I(0)

Note: *Indicate variable is stationary

Whenever one or more time series are non-stationary at level then there may exist cointegration or long run relationship between two are more than two variables of model. In same vein, Engle & Granger, (1987) presented a theorem that if linear combination of two non-stationary series is stationary then it implies that there is co-integration between the two series. The same theorem extends for more than two variables by (Johansen & Juselius, 1990).

The approach of cointegration of Johansen requires that all variables of model should be stationary at first difference. While autoregressive distributed lag (ARDL) technique provides more robust results when there is mixed order integration in a model. It is necessary condition for ARDL that not a single variable of the model should be stationary or integrated at two or I(2). This technique is developed by (Pesaran et al., 2000). As present study finds the mix order of integration, so ARDL technique is going to apply in upcoming section.

4.4 Auto Regressive Distributed Lag Estimation Technique

ARDL is used to determine long-term relationships between series with different integration order (Pesaran et al., 2000). It is assumed that in ARDL approach there is long-run relationship exist in single reduce form of equation that contains dependent and explanatory

variables. There are various steps are involved in estimation the model through ARDL technique. After confirmation the order of integration (unit root level), the next step is bound testing which conforms whether there is cointegration exist or not. If calculated of F-test of bound test is greater than the critical value, then it is concluded that there exists long-run relationship. After this confirmation, next task is to get long run and short run parameters of model. While the last step of ARDL model is involved diagnostics and stability test of model.

4.5 Bound Testing

The F-statistic of bound test is key to confirm the cointegration. If calculated value is more than the upper critical value, cointegration exists. If F statistic value is less than the upper critical value, then there is no long-term relationship or cointegration. So, study must accept the null hypothesis.

Table 4.5 is indicated that the value of F-Statistic is 14.36 which are higher than the critical value of both lower and upper bound. So, study fails to accept the null hypothesis even at 1% significant level. It is clear evidence of existing of cointegration.

Table 4.5 ARDL Bound Testing of Cointegration:

Variables	**F-Statistic**	**Decision**
6	14.36	Cointegration Exist
Critical Value Bounds	**Lower Bound**	**Upper Bound**
(Significance)	**(I0)**	**(I1)**
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

In following Table 4.6, results of long run forms of model are presented. Long run results show that capital and R&D have significant and positive impact on agriculture output while the farm technology has significant but negative impact on output of agriculture sector. Interestingly, the quality road has insignificant impact on output of agriculture sector. The output of agriculture is positively linked with the independent variables like labor force,

capital, R&D, and energy consumption. The value of coefficient of labor force is statistically insignificant. Pakistan is a developing country, here agriculture sector is considered a traditional sector with huge surplus labor. This surplus labor is almost disguised unemployment with near to zero marginal products. So, any change in labor stock may not be proven productive as compared to capital. So, if the positive role of labor and capital in shaping of the output path of agriculture sector confirms the neo-classical theory. In addition, the coefficient value of capital is significant and plays an important role in determines the output path of agriculture sector. More, the coefficient value of energy consumption is insignificant. The coefficient value of R&D is positive and significant. Consequently, the coefficient value of farm technology is positive, and t-value is statistically insignificant.

Here study uses the average of normalized value of total number of tractors and tube wells as proxy of farm technology but interestingly the impact of farm technology is not up to the mark on agriculture sector because the significance level 7%. It might be due to biasedness of technology towards big land holders instead of small farmers. In recent years the electrification rate of this sector is increasing as the number of installed tube-wells and tractors production also increasing many times. At the same time tractors and tube-wells are using big share of energy consumption of this sector (Mannava et al., 2020). Now talk about the coefficient value of paved road which is high but at same time it is statistically insignificant. The insignificant impact of paved road on agriculture output is discussed by (Kaupa, 2015). Findings of present study are compatible with another attempt in case South Sumatera state of Indonesia in which the role of paved road has insignificant impact on agriculture output (Kaupa, 2015). In simple words, the strategy of growth of agriculture via infrastructure is proven statistically weak. It is common belief among the development economists that the road infrastructure is biased towards car holders instead of cart-holders especially in case of dual economy. Additionly, the actual stance of present study is that our infrastructure and growth strategy is not working in case of agriculture sector. The findings in term of insignificant parameters of paved road clearly justified our stance of present study.

Table 4.6 Results of Long-Run

	Labor Force	GFCF	Agri-Energy Consumption	Research & Development	Farm Technology	Paved Road	C
Coefficient	9599.6	2.45	0.93	11368710.	493.0	0.91	-2338010.

Std. Error	(47516.1)	(1.07)	(0.76)	(3790613.)	(269.9)	(2.21)	(700325.1)
t-Statistics	[0.20]	[2.29]	[1.22]	[2.99]	[1.82]	[0.41]	[-3.33]
Prob.	0.84	0.03	0.23	0.00	0.07	0.68	0.00

Note. Standard error in ( ) & t-statistics in [ ]

Table 4.7 Results of Standarized Long-Run

	Labor Force	GFCF	Agri-Energy Consumption	Research & Development	Farm Technology	Paved Road	C
Coefficient	0.20	0.51	0.05	0.62	-0.11	-0.02	0.04
Std. Error	(0.14)	(0.13)	(0.05)	(0.12)	(0.07)	(0.10)	(0.04)
t-Statistics	[0.20]	[2.29]	[1.22]	[2.99]	[1.82]	[0.41]	[-3.33]
Prob.	0.84	0.03	0.23	0.00	0.07	0.68	0.00

Note. Standard error in ( ) & t-statistics in [ ]

The above Table 4.7 shows the results of standardized long run forms of model. Due to standardized, now coefficients are low. Actually the measurement of scale of variables are different so the coefficients are seemingly high in magnitude.

4.5.1 Error Correction Mechanism (ECM)

In a recent study Banerjee, (2020) points out that an important error correction term is requires a long-term stable relationship. Basically, ECM is estimated the rate at which one endogenous variable returns to full equilibrium path due to an exogenous shock. In the short run, the value of ECM is -0.16 which indicated the statistically significant at the 5% level. So, the value of ECM is negative and lies between zero and one. The short run value of coefficient is also indicating that the stable long run relationships among independent variables and agriculture output. In short run, labor force and R&D have statistically significant impact on agriculture output. The role of farm technology is statically negative and insignificant in short run. So, it is concluded that the paved road is not performing better in the long run plus in the short run. After checking the short and long effect of independent variables on a dependent variable, the next task is to check the qualification of overall model.

Table 4.8 Results of Short-Run

Variables	Coefficient	Std. Error	t-statistic	Prob.	Significance at 5% level
ECM(-1)	-0.16	0.04	-3.39	0.00	✓
D(L.F)	28571.4	10818.5	2.64	0.01	✓
D(L.F(-1))	26614.0	12186.3	2.18	0.03	✓
D(F.T)	-83.57	35.84	-2.33	0.02	✓
D(GFCF)	3.78	0.24	15.18	0.00	✓
D(R&D)	1926979.	184217.0	10.46	0.00	✓
D(Agri.E.C)	0.158	0.11	1.36	0.18	○
D(road)	0.154	0.36	0.42	0.67	○

Note. Standard error in ( ) & t-statistics in [ ]

4.5.2 Model Diagnostics

Model Diagnostics are a set of processes used to evaluate the numerical outcomes of a regression analysis (Von Davier, 2008). The magnitude of calculated value of serial correlation LM test tells about the serial correlation's intensity. From the following Table 4.8, it is shown that the probability value of LM test is 0.78 which indicates that there is no problem of serial correlation in this mode. ARDL is also considering as way-out of autocorrelation.

Table 4.9 Model Diagnostics

R-Squared	0.99	Sum sq. residual	5.54000
Adj-R-Squared	0.99	S.E. equation	45292.8
F-Statistic	1410.2	Mean dependent	953912.1
Log-likelihood	-454.8	S.D. dependent	885108.6
Serial correlation (LM-Stat)	Lags (2)	1.17	P-value(0.78)

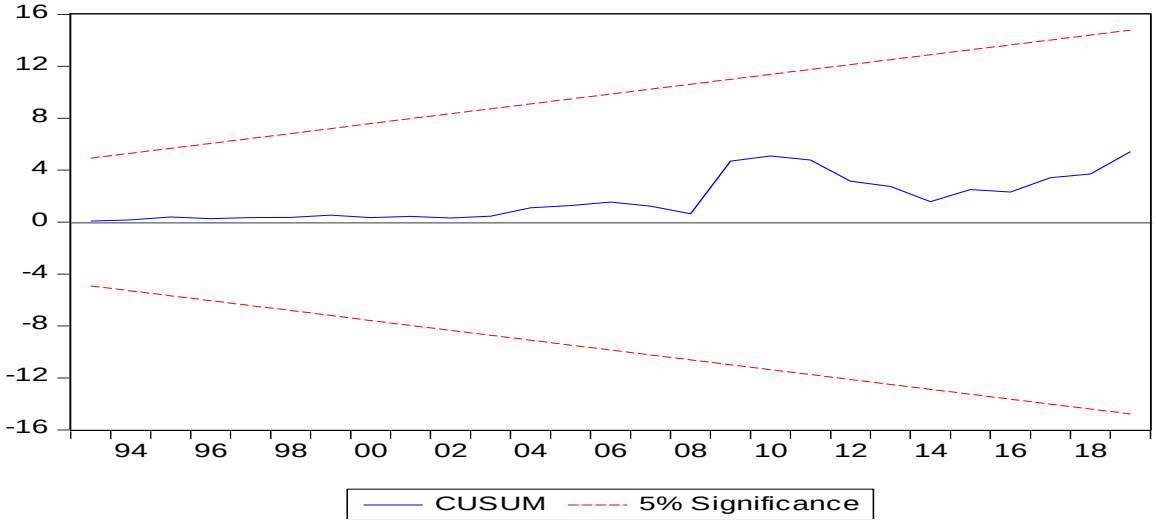
A higher value of R-Square is better for the model. The value of R-Square is 0.99 which indicated that the deviation in endogenous variable is explained by exogenous variables. The higher Adjusted R-Squared value is also confirms the goodness of fit. The high value of F-Statistic ensures the jointly significance of explanatory variables. The negative value of log-likelihood is -454.8 in the model indicate the best fitting of model. The value of mean dependent is 953912.1 that indicate the average value of GNP. So**,** the value of S.D. Dependent is 885108.6 that indicate the deviation from the average value of GNP.

4.5.3 Stability Test

Finally, Brown et al., (1975) devised the cumulative sum of recursive residuals (CUSUM) and the CUSUM square (CUSUMSQ) tests to assess stability of model. To test the long-term coefficient estimation ARDL model and the stability of the short-term coefficient between paved roads and total agricultural output, this study uses the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares (CUSUQ). If the lines plots lies within the range of 5% significance level than the coefficients of the error correction model (ECM) is stable (K. Lee, 2015). In the following Figure 1 and Figure 2, the CUSUM and CUSUMSQ lines are plotted, and lines do not break the boundaries which are implying that the coefficients are stable.

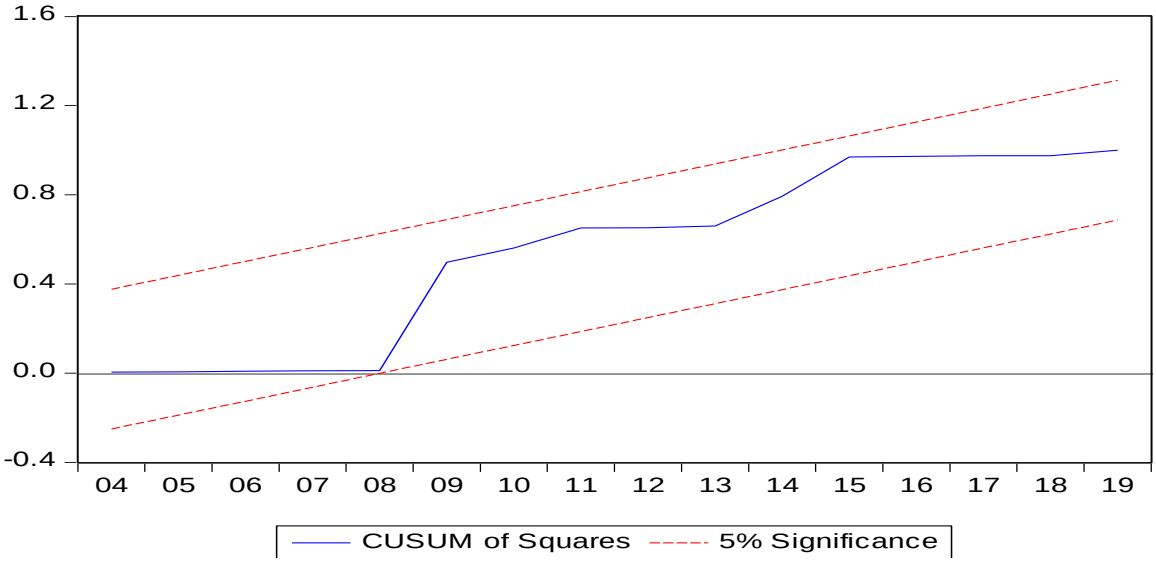
CUSUM Test

Figure 4: CUSUM Test



CUSUM of Squares

Figure 5: CUSUM of Squares



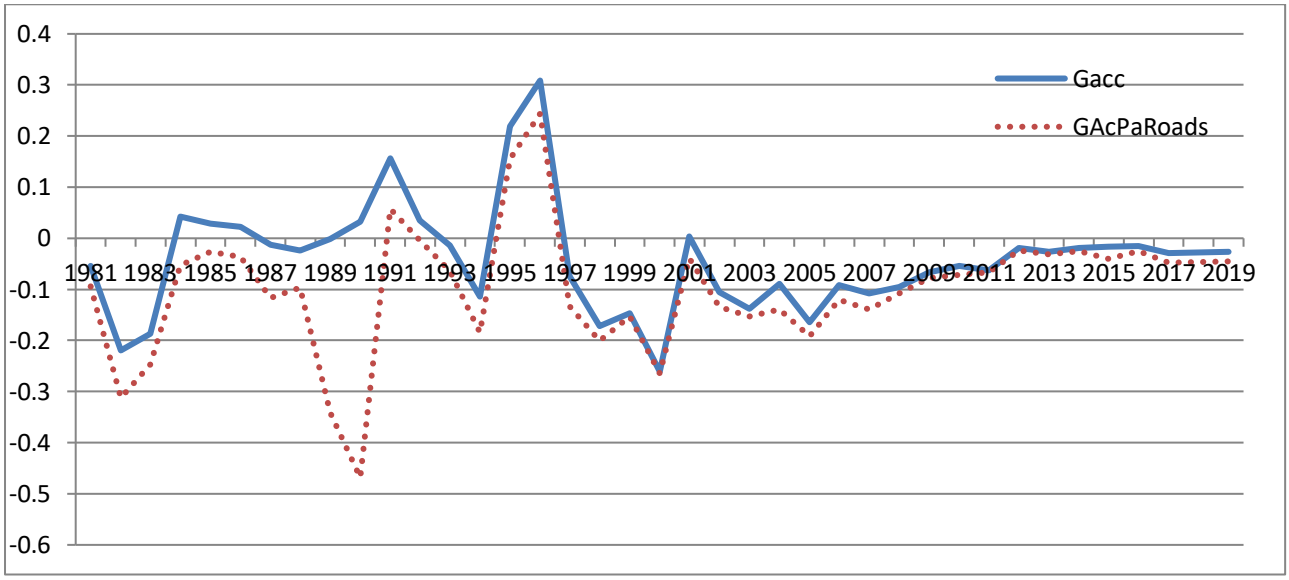
4.5.4 Paved Road and Growth Accounting of agriculture Sector of Pakistan

Growth accounting is basically a conceptual structure to analyze the economic growth (Bosworth et al., 2003). Previous chapter, study derives the equation of growth accounting in form of Solow residual. The short and long run results are estimated through Cobb-Douglas production function while for growth accounting study uses simple neoclassical production function. In our case growth accounting is simple measure the importance of road infrastructure in output growth of agriculture sector. According to Boianowsky & Hoover, (2009), the growth accounting is observed the output growth between the contribution of

changes in inputs and total factor productivity (TFP). TFP is measured the combination of changes in efficiency and changes in technology in the use of inputs.

Following Figure 03 contains the information of growth contributions of paved roads overtime for agriculture sector over the period of 1980 to 2020. Dotted line is TFP of agriculture sector overtime while the bold line is TFP after excluding the role of infrastructure from growth accounting.

Figure 6 Growth Accounting (total output)



The gap between the Gacc and the Gac PRoad is indicated the contributions of paved roads. In early times, one can see the difference or contributions of paved roads. Hereafter, the contributions of roads are gradually decreasing overtime.

At the last, study finds the insignificant impact of road infrastructure on agriculture sector in both short run as well as long run. In following sections, study investigates the impact of road infrastructure on output of three selected crops at disaggregate level.

4.6 Impact of Road Infrastructure on Selected Cash and Food Crops of Pakistan (Disaggregate Analysis)

This section contains the results of impact of roads on selected crops of Pakistan. For this purpose, study chooses three crops, two food crops and one cash crop. Study starts from foods crops and at the end reveals the impact of roads on the production and productivity of cotton crop.

4.6.1 Impact of Road Infrastructure on Wheat (Food Crop)

Theoretically, it is supposed that road infrastructure promotes the output of food crops that further enhance the economy wide growth. Moreover, labor force, GFCF, agriculture energy consumption, R&D, and farm technology effect the food crops indicate in long-run as well as in short-run. The following sub-section contains the impact of road infrastructure along with other control variables on wheat production in the short run along with in the long run. As study is using time series data and we have already find the unit root level of all variables of model. Based on the unit root tests, study opts ARDL technique to evaluation the short run and long run results.

4.6.2 Bound Testing

The following Table 4.9 is indicated that F-Statistic value is 8.44 which are higher than the both lower and upper critical value. So, the null hypothesis is unacceptable at the 1% significant level and thus cointegration exists.

Table 4.10 ARDL Bound Testing of Cointegration

Variables	**F-Statistic**	**Decision**
6	8.44	Cointegration Exist
Critical Value Bounds	**Lower Bound**	**Upper Bound**
(Significance)	**(I0)**	**(I1)**
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

In following Table 4.10, results of long run forms of model are presented. Results show that labor force, R&D, farm technology and paved road have positive and statistically significant effect on wheat production. In long run, coefficient value of paved roads is positive and statistically significant. The positive role of roads on agriculture output is discussed by (Llanto, 2012). According to this study, road is provided the connectivity from rural to urban areas and supply the goods & services to market. In this way, the rural producers and consumers face less inputs costs and transaction costs. The capital coefficient value is negative and statistically insignificant effect on output of wheat. But the energy consumption coefficient value is positive and statistically significant 10% level of significance. Consequently, the coefficient value of farm technology and R&D is positive, and t-value is statistically significant. The main motive of this significant impact of farm technology on agriculture output is discussed by (Javed et al., 2010). According to this study, developing country like Pakistan is distributed and restructured at a large scale of agriculture technology and knowledge. However, the use of pesticides, fertilizers, tractors and tube wells in agriculture creation is expended dramatically over the past two decades and the global economy has become well organized. Such factors have a positive effect on investment in agriculture research, and technology has affected the economy growth of Pakistan.

Table 4.11 Results of Long run

	Labor Force	GFCF	Agri-Energy consumption	Research & Development	Farm Technology	Paved Road	C
Coefficient	467.0	-0.00	0.00	9850.4	3.15	0.05	4364.7
Std. Error	(83.92)	(0.00)	(0.00)	(2944.2)	(0.78)	(0.00)	(1316.9)
t-Statistics	[5.56]	[-0.81]	[1.67]	[3.34]	[4.01]	[12.58]	[3.31]
Prob.	0.00	0.42	0.10	0.00	0.00	0.00	0.00

Note. Standard error in ( ) & t-statistics in [ ]

In the short run, the value of ECM is -0.25 which is statistically insignificant at the 5% level. So, the value of ECM is negative and lies between zero and one. The short run value of coefficient is also indicating that the stable long run relationships between paved road and wheat production. The labor force is positive and statistically significant impact on agriculture wheat production in short run along with in long run. The capital coefficient value is positive and statistically significant, in short run. But in long run, capital shows the inverse

and insignificant relation with output of wheat. The finding of the study are contradicted with the study of (Awan & Alam, 2015) that finds the labor and capital has positive impact on the output of wheat. In short run, the coefficient value energy consumption is negative and statistically significant at 10% level of significance relation with wheat production. But in long run, energy consumption is positively related with wheat crop output. According to (Singh & Kaur, 2017) show the energy consumption inverse relation on the wheat production. The coefficient value of research and development is negative and insignificantly affect in short run. But in long run, R&D is positively affected the wheat crop output. In short run, farm technology is negatively and statistically significant impact on output of wheat. However, in long run, farm technology is positively linked with output of wheat. Hashmi et al., (2015) proved that R&D and farm technology are inversely linked with output of wheat in developing country like Pakistan. The coefficient value of paved road is positive but insignificant impact on wheat production in short run.

Table 4.12 Results of Short-Run

Variables	Coefficient	Std. Error	t-statistic	Prob.	Significance at 5% level
ECM(-1)	-0.25	0.12	-9.73	0.00	✓
D(L.F)	587.2	112.1	5.23	0.00	✓
D(F.T)	-3.02	0.79	-3.83	0.00	✓
D(GFCF)	0.01	0.00	2.43	0.02	✓
D(R&D)	-1054.0	2581.5	-0.40	1.68	○
D(R&D(-1))	-12384.6	3335.0	-3.71	0.00	✓
D(Agri.E.C)	-0.00	0.00	-1.68	0.10	○
D(road)	0.02	0.02	0.73	0.47	○

Note. Standard error in ( ) & t-statistics in [ ]

4.6.3 Model Diagnostics

Following Table 4.12 is shown that the probability value 0.2 of the models is lower than 0.05% on lag (2). While on the other side, if the probability value (0.00) of the model is greater than 0.05% on lag (2) and the null hypothesis is not rejected.

Table 4.13 Model Diagnostics

R-Squared	0.97	Sum sq. residual	18645334
Adj-R-Squared	0.96	S.E. equation	863.6
F-Statistic	91.89	Mean dependent	19098.0
Log-likelihood	-310.3	S.D. dependent	4892.5
Serial Correlation(LM-Stat)	Lags (2)	2.20	P-value(0.2)

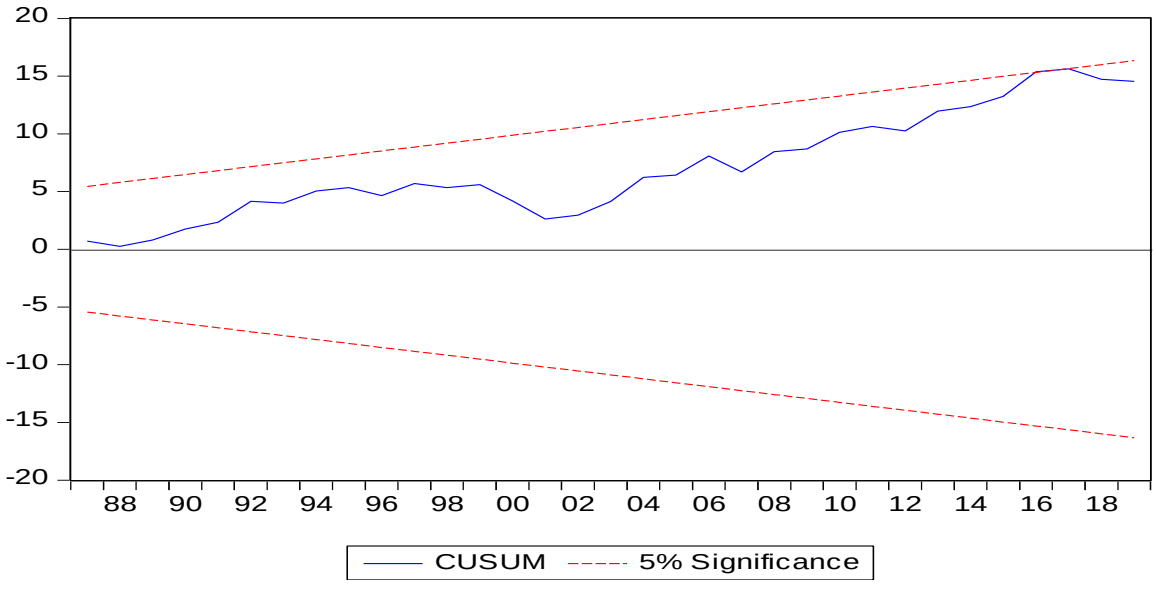
A higher value of R-Square is better for the model. The value of R-Square is 0.97 that showed the changes in endogenous variable are clarified by exogenous variables. The higher Adjusted R-Squared value is also confirming the goodness of fit. The high value of F-Statistic ensures the jointly significance of explanatory variables. The negative value of Log-Likelihood is -310.3 in the model specify the best fitting of model. The value of mean dependent is 19098.0 point out the average value of wheat production. So, the value of S.D. Dependent is 4892.5 point out the deviation from the average value of wheat production.

4.6.4 Stability Test

In the following figure 3 and figure 4, the CUSUM and CUSUMSQ lines are plot and lines do not break the borders which are implying that the coefficients are stable.

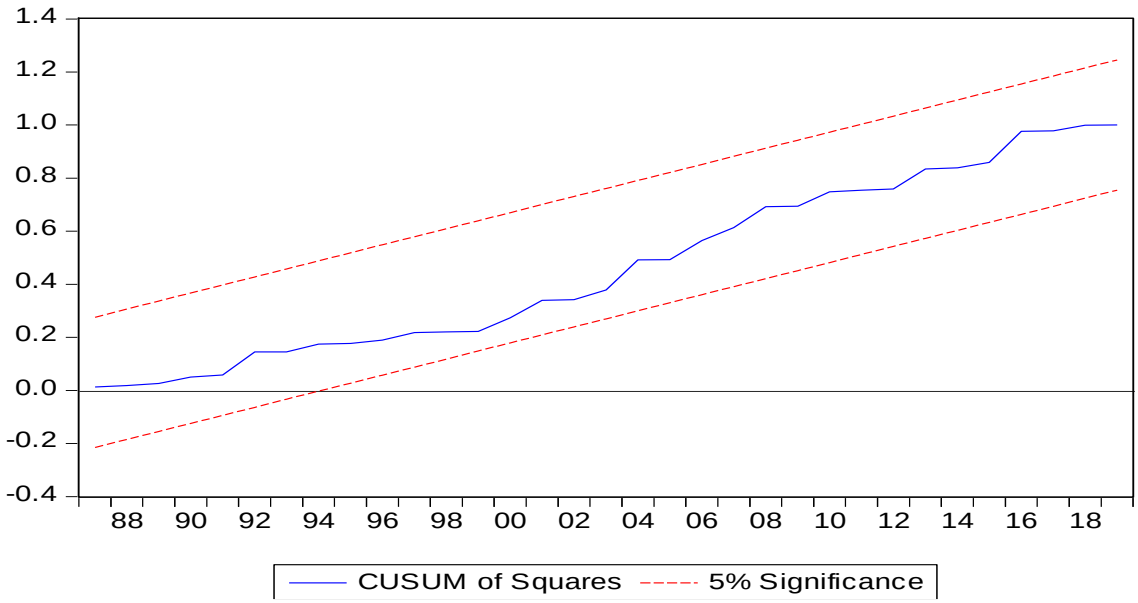
CUSUM Test

Figure 7: CUSUM Test



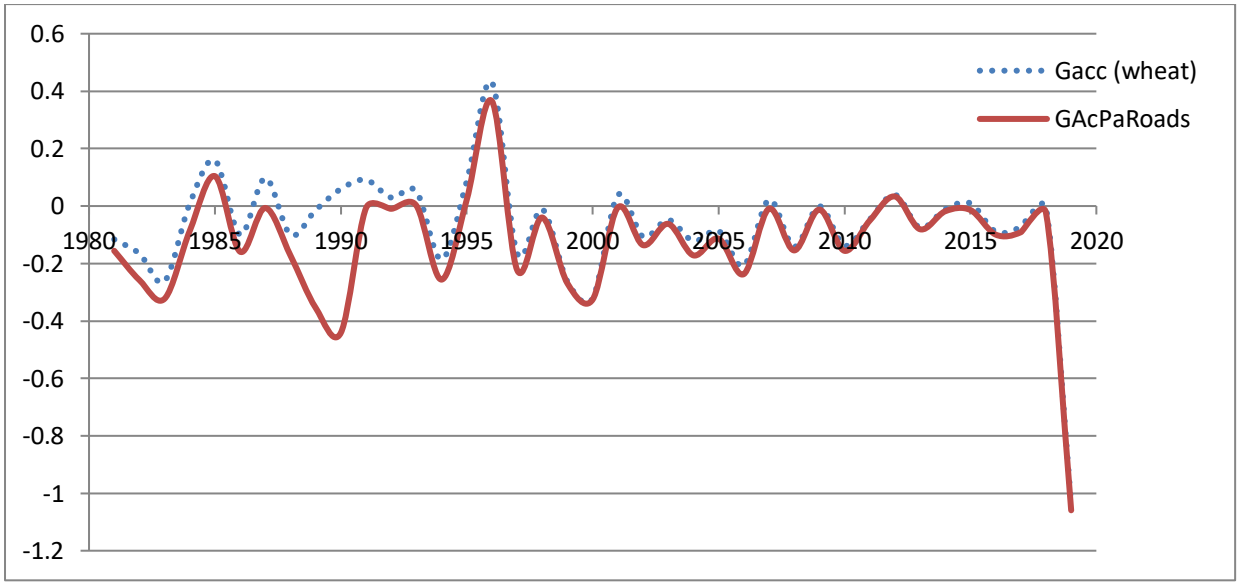
CUSUM of Squares Test

Figure 8: CUSUM of Squares



4.6.5 Growth Accounting in Food Crop (Wheat) & Paved Road

Figure 9: Growth Accounting (wheat)



The gap between the Gacc and the Gac PRoad is showed the participations of paved roads. In early times, one can see the difference or contributions of paved roads. After this, the contributions of roads are step by step decreasing overtime.

4.6.6 Impact of Road Infrastructure on Rice (Food Crop)

It is supposed that road infrastructure boosts the output of rice crop that further contributes in overall economy's economic growth. Furthermore, other variables like labor force, GFCF, agriculture energy consumption, R&D, and farm technology have also significant impact of on rice crop. So, in following pages of study contain the empirical results of impact of road infrastructure along with other variables on rice output. The same estimation methods are also going to use in this sub-section.

4.6.7 Bound Testing

In the following Table 4.13 is indicated that the value of F-Statistic is 3.640 which is higher, but the critical value lies in the upper bound. So, the null hypothesis is failed to accept at 1% significant level and thus cointegration exist.

Table 4.14 of ARDL Bound Testing of Cointegration

Variables	**F-Statistic**	**Decision**
6	3.640	Cointegration Exist
Critical Value Bounds	**Lower Bound**	**Upper Bound**
(Significance)	**(I0)**	**(I1)**
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

After bound testing, following Table 4.14 contains the estimated value of parameters of model of the long run. The long run results shows that labor force have positive and statistically significant impact on rice production. The significance level of labor parameter is 7%. While, capital and energy consumption has positive but statistically insignificant impact on the output of rice in agriculture sector. But the R&D and farm technology are negative relation with rice production and R&D is statistically insignificant although the farm technology is statistically significant. However, the quality roads have positive and statistically significant effect on rice production of agriculture sector. The rice production of

agriculture is positively linked with the independent variable like labor force, capital, paved roads, and energy consumption.

Consequently, the value of coefficient of energy consumption is positive but statistically insignificant. The main reason of this is not significantly effect of energy consumption on agricultural output is discussed by (Bielski et al., 2021). According to this study, the LDCs like Pakistan have a low rate of adoption to energy consumption in agricultural sector. While agriculture sector is used to generate energy in two ways: directly as fuel or electricity to drive machinery and equipment and indirectly as fertilizers and chemicals outside of fields.

Table 4.15 Results of Long run

	Labor Force	GFCF	Agri-Energy consumption	Research & Development	Farm Technology	Paved Road	C
Coefficient	242.5	0.00	0.00	-379.0	-1.86	0.01	-1066.8
Std. Error	(128.4)	(0.00)	(0.00)	(6140.1)	(0.80)	(0.00)	(1532.0)
t-Statistics	[1.88]	[0.17]	[0.49]	[-0.06]	[-2.32]	[1.86]	[-0.69]
Prob.	0.07	0.86	0.62	0.95	0.02	0.07	0.49

Note. Standard error in ( ) & t-statistics in [ ]

In the short run, the coefficient value of labor force is positive and statistically significant at 7% level of significance. Labor as an input has positive impact on rice production in the short term within the long run. Whereas coefficient value of capital is positive and statistically insignificant. As a similar finding, coefficient value of energy consumption is positive and statistically insignificant effect on rice crop in short run as well as in long run. The study like (Bui Khac et al., 2018) is proved that the labor force, capital and energy consumption is positively related with the output of rice. In short run, the R&D is positive and statistically insignificant impact on rice production. R&D shows the positive relation with output of cotton. But in long run, R&D is inverse relation with the rice production. Similar results by (Jayani & Ruffaida, 2020) confirmed that R&D is positive relation with the rice production. In the short term, coefficient value of farm technology is negatively and statistically not significant influence on rice production. The farm technology is inversely related with output of rice in short run as well as in long run. According to (Ambali et al., 2021) the study proved that farm technology is inversely related with rice production. In short run, the paved road is

negative and statistically insignificant influence on rice crop. But in long run, road is positively related with output of cotton. The value of ECM is -0.57 statistically significant at the 5% level. So, the value of ECM is negative and lies between zero and one. The short run value of coefficient is also indicating that the stable long run relationships between paved road and agriculture rice production.

Table 4.16 Results of Short-Run

Variables	Coefficient	Std. Error	t-statistic	Prob.	Significance at 5% level
ECM(-1)	-0.57	0.17	-3.21	0.00	✓
D(L.F)	181.5	97.66	1.85	0.07	○
D(F.T)	-1.06	0.56	-1.90	0.06	○
D(GFCF)	0.00	0.00	0.17	0.86	○
D(R&D)	1057.5	1668.6	0.63	0.53	○
D(Agri.E.C)	0.00	0.00	0.36	0.71	○
D(road)	-0.02	0.01	-1.29	0.20	○

Note. Standard error in ( ) & t-statistics in [ ]

4.6.8 Model Diagnostic

Following Table 4.19 is shown that the value of probability 0.06 of the models is greater than 0.05% on lag (2). Then the null hypothesis can't be denied. While on the further side, if the probability value (0.00) of the model is less than 0.05% on lag (2) and the null hypothesis is rejected.

Table 4.17 Model Diagnostic

R-Squared	0.92	Sum sq. residual	6477756.
Adj-R-Squared	0.88	S.E. equation	509.0
F-Statistic	22.83	Mean dependent	4829.1
Log-likelihood	-289.7	S.D. dependent	1481.2
Serial Correlation(LM-Stat)	Lags (2)	3.14	P-value(0.06)

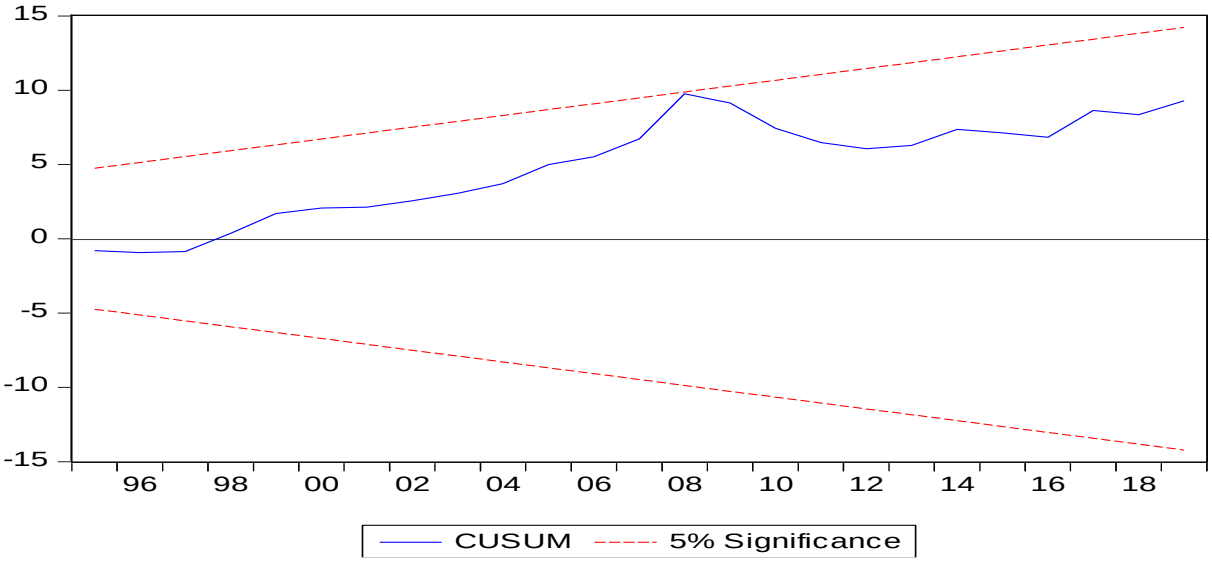
A higher value of R-Square is better for the model. The value of R-Square is 0.92 expressed the deviation of dependent variable is described by the independent variables. The higher Adjusted R-Squared value is also confirming the goodness of fit. The high value of F-Statistic ensures the jointly significance of explanatory variables. The negative value of Log-Likelihood is -289.7 in the model that specify the best fitting of model. The value of mean dependent is 4829.1 that show the average value of rice crop. So, the value of S.D. Dependent is 1481.2 that indicate the deviation from the average value of rice crop.

4.6.9 Stability Test

In the following figure 5 and figure 6, the CUSUM and CUSUMSQ lines are plot and lines do not break the limits which are implying that the coefficients are stable.

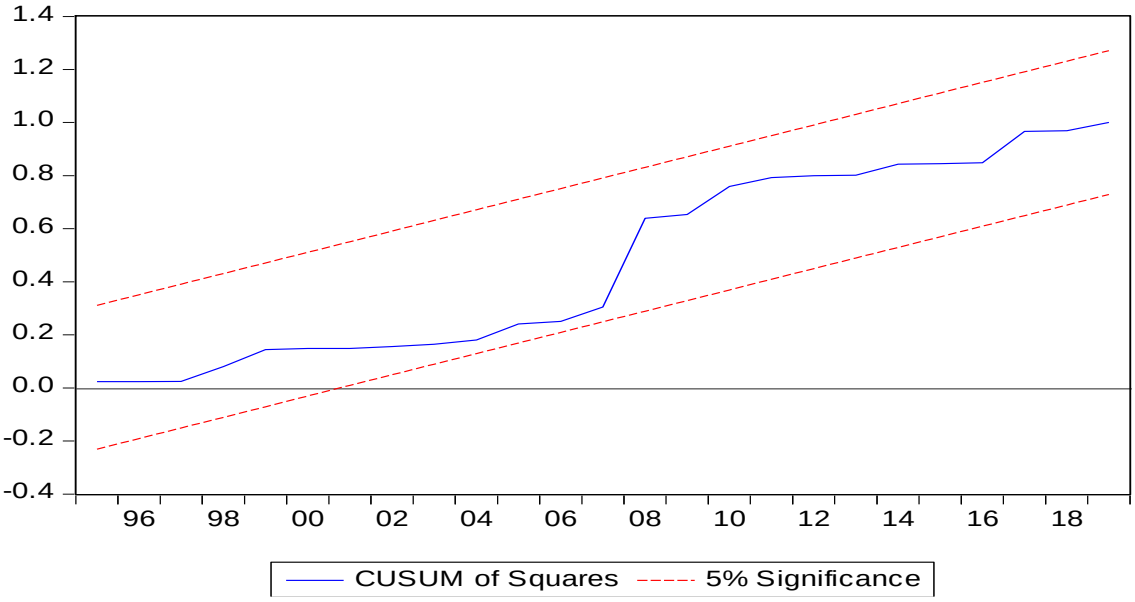
CUSUM Test

Figure 10: CUSUM Test



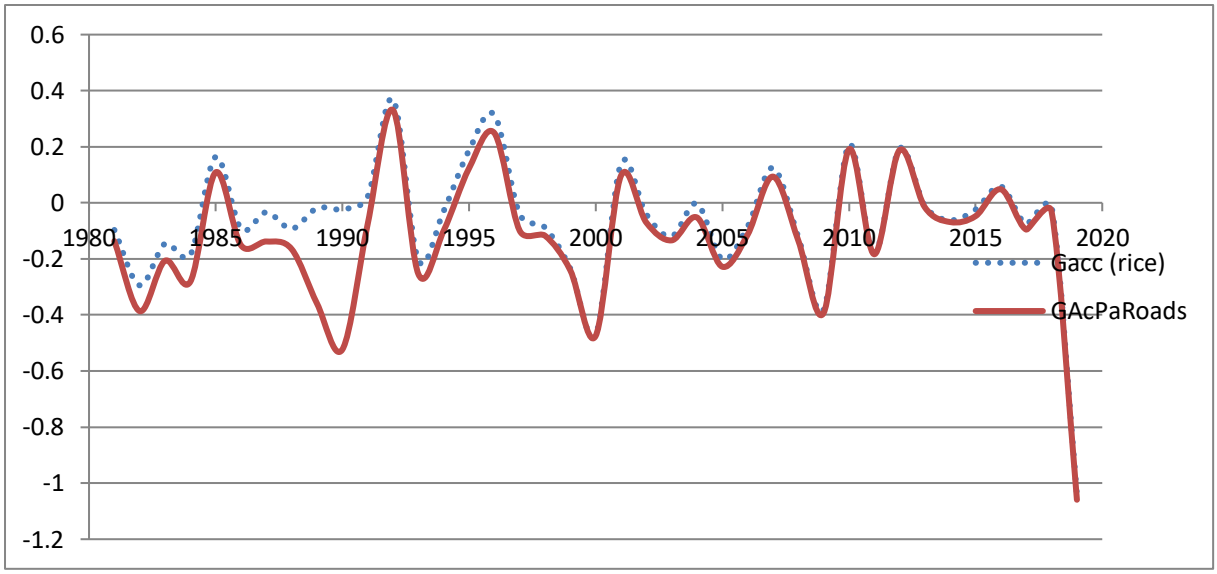
CUSUM of Squares Test

Figure 11: CUSUM of Squares



4.6.10 Growth Accounting in Food Crop (Rice) & Paved Road

Figure 12: Growth Accounting (rice)



The involvement of paved roads is specified by the gap between the Gacc and the Gac PRoad. Paved roads made an impact or made a support in the early days. Following that, the contributions of roads will progressively decay over time.

4.6.11 Impact of Road Infrastructure on Cotton (Cash Crop)

Theoretically, it is supposed that road infrastructure promotes the cotton production and increases the growth rate of economy as a whole. Additionally, labor force, GFCF, agriculture energy consumption, R&D, and farm technology effect the cash crop indicates in

long-run as well as in short-run. Because the study is established on time series data, we have previously determined the unit root level of all variables of models. The study uses the ARDL technique to estimate the short- and long-term impact of road infrastructure on cotton production.

4.6.12 Bound Testing

In the following Table 4.20 is indicated that the F-statistic value is 6.89 which is higher than both the lower and upper critical values. So, the null hypothesis is failed to accept at 1% significant level and there is a cointegration among the variables of present model.

Table 4.18 of ARDL Bound Testing of Cointegration

Variables	**F-Statistic**	**Decision**
6	6.89	Cointegration Exist
Critical Value Bounds	**Lower Bound**	**Upper Bound**
(Significance)	**(I0)**	**(I1)**
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

In the following Table 4.21, the results are presented in long run. Results of long run show that farm technology, R&D and paved road is positive and statistically significant impact on cotton production while the labor force, capital and energy consumption have a negative effect on production in agriculture sector but are not statistically significant. Whereas the quality of road is positive in addition to statistically significant influence on output of cotton in agricultural field.

In long term, the coefficient value of labor force has negative and statistically insignificant effect on output of cotton. The main reason of this inverse and insignificant or small impact of labor force on agriculture output is discussed by (Shuli et al., 2018). According to this study, at globally growth in cotton production is driven by the major factors like biotechnology innovation and increased farm mechanization. As a similar study (M. Ali, 1971) that is discussed about the cotton production in which is used the improve seeds and

fertilizers play a key role in Pakistan. So, the labor force role in cotton production paly a very minor as compared to technology and fertilizers.

However, the coefficients value of farm technology and paved road are positively affect the output of cotton. The positive role of farm technology on agricultural output is discussed by (Iqbal & Ahmad, 2005). In other similar study (Usman et al., 2021) argued about the role of farm technology on cotton production. The R&D coefficient value show the positive relation with cotton production and statistically significant at 13% level of significance. As this study, cotton production is raised due to improve in irrigation system, high varieties (HYVs), capital and pesticides.

Table 4.19 of Results of Long run

	Labor Force	GFCF	Agri-Energy consumption	Research & Development	Farm Technology	Paved Road	C
Coefficient	-65.38	-0.00	-0.02	13316.4	1.39	0.04	18076.7
Std. Error	(260.0)	(0.01)	(0.00)	(8659.7)	(1.47)	(0.01)	(5421.4)
t-Statistics	[-0.25]	[-1.05]	[-3.03]	[1.53]	[0.94]	[3.00]	[3.33]
Prob.	0.80	0.30	0.00	0.13	0.35	0.00	0.00

Note. Standard error in ( ) & t-statistics in [ ]

In the short run, the value of ECM is -0.73 indicated that at 5% level of statistically significant. So, the value of ECM is negative and lies between zero and one. The short run value of coefficient is also indicating that the stable long run relationships between paved road and agriculture cotton production. In short run, labor force has positive and statistically significant at the 7% level of significance. Other studies such as (Arshad et al., 2022) back up these finding. According to this study, the labor force shows the positive relationship with output of cotton in short term. The coefficient of labor force is negative and statistically insignificant in long run. Other studies like (Shabbir & Yaqoob, 2019) support these finding. The coefficient of capital is negative and statistically insignificant effect on output of cotton in short run plus in long run. The negative relation between capital and output of cotton is discussed such as (Ali.S, 2011) same finding. The energy consumption is coefficient value negative and statistically 7% level of significance in short run as well as in long run impact on cotton production. Similar results is discussed by (Imran et al., 2020) which show inverse link among energy consumption and cotton production. The coefficient value of R&D is

positive and statistically 8% level of significant impact on output of cotton in short run as well as in long run. The R&D show the positive relation with the cotton production as a similar results like (Shabbir & Yaqoob, 2019). In short run, the coefficient values of farm technology and paved road has positive and statistically insignificant impact on cotton production. But in long run both variables farm technology and paved road has positive and statistically significant effect on output of cotton.

Table 4.20 Results of Short-Run

Variables	Coefficient	Std. Error	t-statistic	Prob.	Significance at 5% level
ECM(-1)	-0.73	0.17	-4.15	0.00	✓
D(L.F)	554.7	294.9	1.88	0.07	○
D(F.T)	1.03	1.04	0.99	0.33	○
D(GFCF)	-0.00	0.00	-0.97	0.33	○
D(R&D)	9829.4	5463.6	1.79	0.08	○
D(Agri.E.C)	-0.00	0.00	-1.86	0.07	○
D(Road)	0.02	0.05	0.51	0.61	○

Note. Standard error in ( ) & t-statistics in [ ]

4.6.13 Model Diagnostics

Following Table 4.23 is shown that the probability value 0.19 of the models is greater than 0.05% on lag (2). Then the null hypothesis is not refused. While on the further side, if the probability value (0.00) of the model is less than 0.05% on lag (2) and the null hypothesis is rejected.

Table 4.21 Model Diagnostics

R-Squared	0.74	Sum sq. residual	60038482
Adj-R-Squared	0.61	S.E. equation	1549.6
F-Statistic	5.71	Mean dependent	10069.3
Log-likelihood	-333.1	S.D. dependent	2504.7
Serial Correlation (LM-Stat)	Lags (2)	1.73	P-value(0.19)

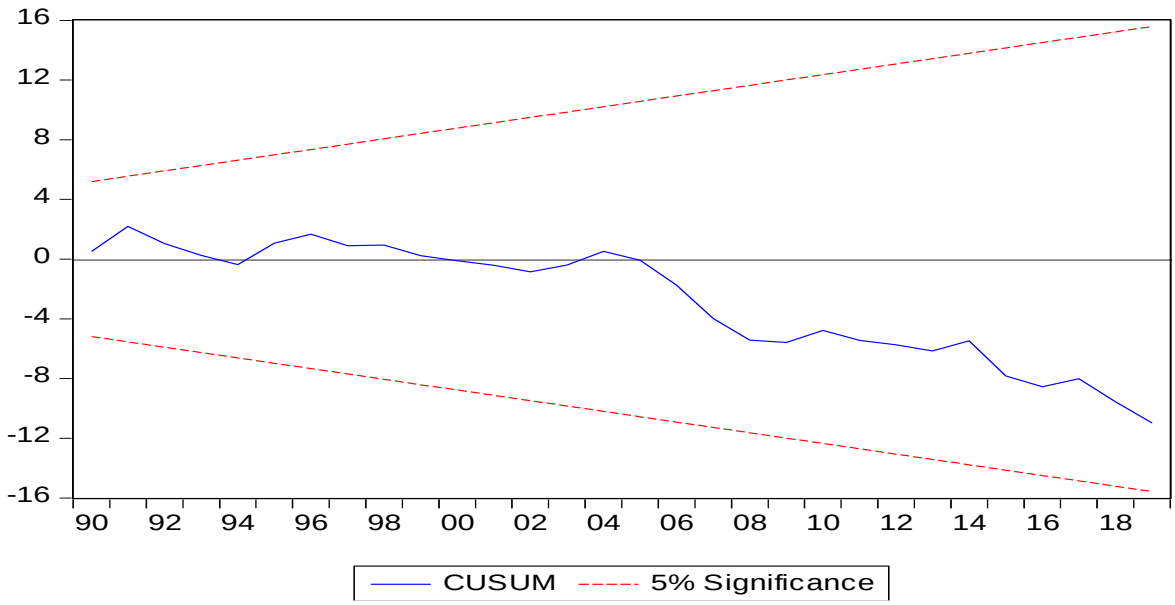
A higher value of R-Square is better for the model. The value of R-Square is 0.74 specifies that the deviation in regress and is explained by regressor. The higher value of Adjusted R-Squared is also confirms the goodness of fit. The high value of F-Statistic ensures the jointly significance of explanatory variables. The negative value of log-likelihood is -333.1 in the model which indicate the best fitting of model. The value of mean dependent is 10069.3 which indicate the average value of cash crop. So, the value of S.D. Dependent is 2504.7 that point out the deviation from the average value of cash crop.

4.6.14 Stability Test

In the following figure 7 and figure 8, the CUSUM and CUSUMSQ lines are plot and lines do not break the boundaries which are implying that the coefficients are stable.

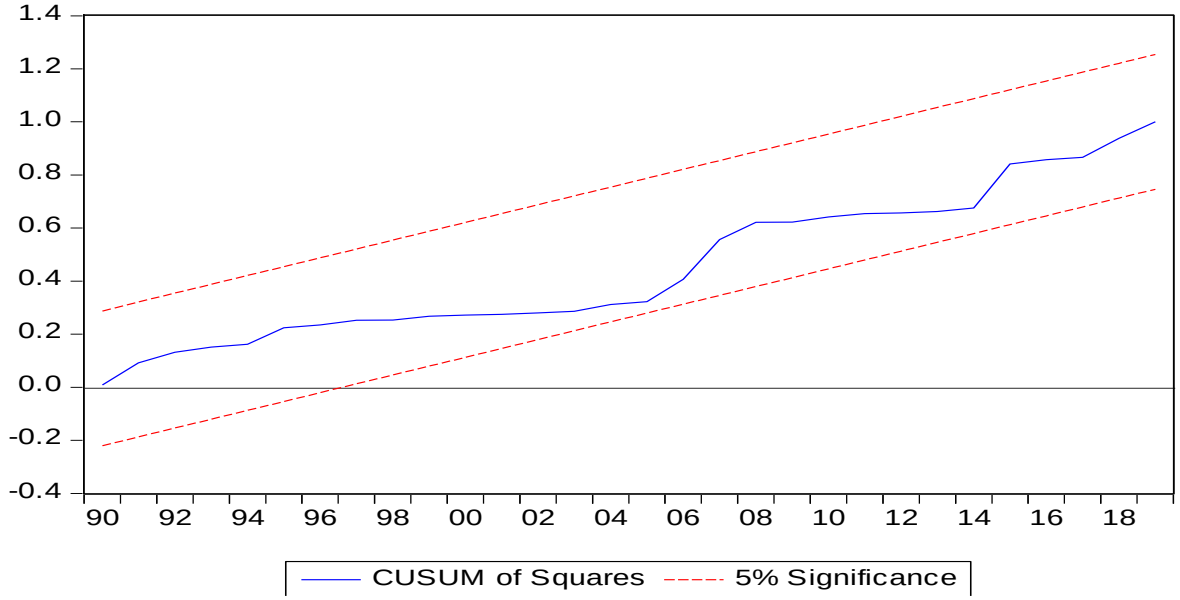
CUSUM Test

Figure 13: CUSUM Test



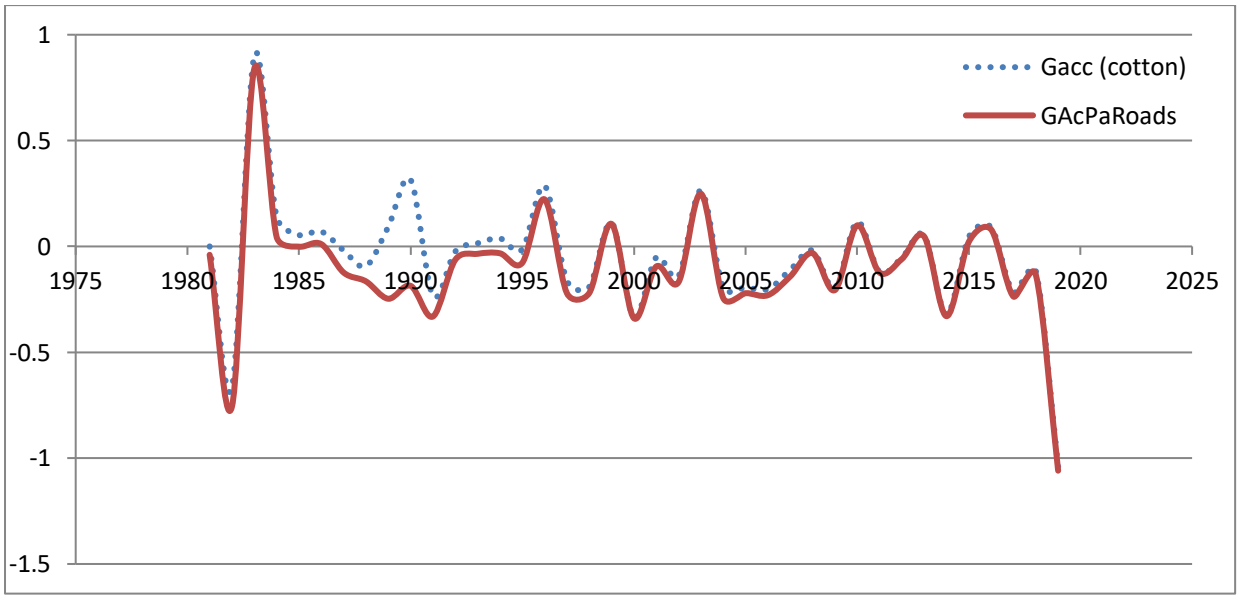
CUSUM of Squares Test

Figure 14: CUSUM of Squares



4.6.15 Growth Accounting in Cash Crop (Cotton) & Paved Road

Figure 15: Growth Accounting (paved road)



The contribution of paved roads is indicated by the gap between the Gacc and the Gac PRoad. Paved roads made an impact or made a contribution in the early days. Following that, the contributions of roads will gradually decline over time.

Table 4.22 Impact of selected Variables on Agri-Sector

	Labor Force	GFCF	Agri-Energy consumption	Research & Development	Farm Technology	Paved Road
Sector	✓	✓	✓	✓	✓	×
Wheat	✓	×	✓	✓	✓	✓
Rice	✓	×	×	×	✓	×
Cotton	×	×	×	✓	✓	✓

Note. Standard error in ( ) & t-statistics in [ ]

In the above Table 4.22 explaines the selected sub sectors of agriculture. The paved road during 1980 to 2020 shows that its negative impact on total output of agriculture in the long run. Because, agriculture productivity increases due to the variables which has positively influence. Next in the first crop like wheat, in long run due to the better uses of labor force, agriculture energy consumption, research & development, farm technology and paved road instead of capital. Then in the second crop like rice, its productivity in agriculture sector last forty years are not significant but depends on some variables like labor force and farm technology which support the rice production. Consequently, capital, paved road, agri energy consumption and research & development are not well supporting. Lastly in the form of cash crop like cotton, its growth rate increses due to few variables like research & development, farm technology and paved road in the last forty years. According to the present study finding, the labor fore, capital and agri energy consumption is not well perfom. As finding shows that the GNP and wheat production has major contribution in the Pakistan's economic growth. The main part of economic growth and development owing to well performance in agriculture sector for the duration of the last forty years.

4.7 Concluding Remarks

This chapter examines the impact of road infrastructure on agriculture output and agriculture productivity in case of Pakistan for the long run plus for the short run. The main objective of this chapter is to test the hypothesis that there is not significant impact of road infrastructure on agricultural production at aggregate level as well as disaggregate level (wheat, rice and cotton). The best models that fit the observed data are used for discussion and interpretation. From the long run results it is found that road infrastructure has insignificant impact on total output and rice production but it has significant impact on wheat and cotton production.

However, in short run road infrastructures have shown the insignificant impact at aggregate and disaggregate models.

CHAPTER 5

Conclusion and Policy Recommendations

Economic growth of Pakistan is depending on agricultural growth while agricultural growth is the function of various factors like road quality, farm technology, etc. This research is being conducted to look into the effect of road infrastructure on total output of agriculture sector as well as productivity of this sector of Pakistan. Moreover, study also investigates the impact the quality road infrastructure at disaggregate level and try to investigate the impact of road infrastructure on output as well as productivity of three main crops of Pakistan's agriculture sector. For these purposes, study utilizes the time series data from 1980 to 2020. First of all, order of integration is checked through unit root tests of each series of all models of study. The Augmented Dickey Fuller and Phillips Perron tests reveal that the variables are stationary stationary at level and 1st difference. So, few series are not stationary at level but some series are stationary at first difference. These outcomes indicate that there may be cointegration among the variables of model. So, ARDL method that also known as bound testing approach is considered most suitable technique to get short run and long run results.

At aggregate sector, the relationship between road infrastructure and total agricultural output has positive but statistically insignificant in long term along with in short term..At disaggregate level of agriculture sector, the effect of road infrastructure is useful and significant in the long term, in case of wheat crop. While in short run, the relationship between road infrastructure and wheat production is statistically insignificantThird model estimates the impact of road infrastructure on rice (crop) output and find positive but insignificant impact in long run. The same relationship between road infrastructure and rice production is found in the short run as well.. In the long term, the road infrastructures have shown the positively significant effect on production of cotton crop. Although in the short run, the effect of road infrastructure on cotton crop is insignificant as in case of other two crops. . Present study finds so the effect of road infrastructure on agricultural production is not significant at aggregate level (total output) as well as disaggregate level but with exceptions at disaggregate level. Moreover, study also calculates the Solow residual or total factor productivity for three crops and sector. There are some significant contributions from the road infrastructure in early 90s and some patches can be seen in later years.

So, the above study summarizes that in the long run relationship, the better quality of road (road infrastructure) positively influences the production of wheat and cotton crops. But it

negatively effects in the form of total agricultural output and rice production in Pakistan economy. In agriculture sector, road infrastructure is no meaningful changed in growth rate. Roads infrastructure increased with the passage of time and used it for public lexury. But the road infrastructure from agriculture productivity side showed no significant impact on agri-output.In developing countries like Pakistan, at aggregate and disaggregate level, the relationship between road infrastructure with wheat and cotton production is significant in long run. As well as, the link between the road infrastructure with total agriculture output and rice is insignificant in long term. But in short run results are insignificant due to the growth of agriculture in Pakistan is facing a lot of problems like techno-economic and natural. Firstly, techno-economic problems like limited cultivated area due to inefficiency of farm technology, slow growth of allied produts due to lack of research & development in agriculture, inadequate rural infrastructure rather than raods and energy shortfalls, old methods of production due to lack of capital, inadequate agriculture research due to scarcity of skilled labore and information. Secondly, the natural problems like various plant diseases in major crops like wheat, rice and cotton due to attack of pests and insects, natural climates owing too much rain and flood, scarcity of High Yielding Variety (HYV) seeds due to lack of govt. subsidy, under utilization of land owing to farmer unable to used the advanced and modern agriculture system adopt.

5.1Recommendations

Here are some selected recommendations that are based on the results of the study. The study has the following recommendations.

- Authorities should differentiate the research & development in rural infrastructure from road infrastructure and now focus point should be improvements in rural infrastructure instead of only focus on road infrastructure. The R&D in rural infrastructure should be proper storage, effective fertilizer and pesticides, information, and modern links between the markets.

- The farm technology (numbers of tractors and tube-wells) is the main source of increase in the agricultural growth. If authorities facilitate the private sector to adopt new agricultural technologiesthat may promot national income.

- The technically sound labor force is source to increase the output of major crops (food crops (wheat, rice) and cash crop (cotton)). If the labor is more skilled in the country

and uses better farm technology, it will greatly impact the Pakistan's agricultural sector. Government should initiate the different cooperative-schemes to enhance the capacity of labor in agriculture sector. For example, the cleanliness of cotton of Pakistan is far behind other nations. If government launch new schemes and incentives to labor class, then outcomes will be beneficial for both agriculture sector and economy of Pakistan.

- In agriculture sector, more capital stock and energy availability at affordable prices may also affect the agriculture sector in addition to the economic growth of Pakistan. So, private sector along with public sector should focus on advanced farm machinery and renewable energy sources to improve agricultural sector of the country.

5.2 Indications for Further Research

This study motivates the other researchers to look into other factors (variables) that influence agriculture output and productivity that are not covered in this study. The academic and other research studies in Pakistan have compensated minor heed to the onward and backward linkage among the roads infrastructure and agricultural sector. More emphasis is placed on the interrelationships between agricultural productivity and roads infrastructure in Pakistan. The relevance of these connections among the two sectors is most important due to only then the Pakistan's agricultural sector will contribute to real GNP (Gross National Product) and be fully appreciated.

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