Capturing the Climatic Effects of El Nino and La Nina on the Economy of Pakistan

Humayun Rashid, Usman Mustafa, Muhammad Touseef-Ur-Rehman

ABSTRACT

El Niño and La Niña cause changes in the sea surface temperatures in the Pacific Ocean. These temperature changes in turn cause weather anomalies globally, which once triggered, can last up to a year or more and leave significant economic implications on developing countries. El Niño Southern Oscillation (ENSO) has brought some of the greatest human disasters in the world in the form of droughts and floods (Selover, 2008). It has been estimated that ENSO accounts for about 10 to 20 percent variation in world GDP growth and consumer price indices (Brenner, 2002). While previous studies have not focused on Pakistan, the current study attempts to capture the climatic effects of ENSO Index (called SOI) on Consumer Price Index (CPI) and GDP Growth rate of Pakistan for 54 years between 1961 and 2015, using graphs, correlation and Granger Causality approach. The results establish a positive relationship between SOI and CPI which mean that La Niña (rainy) episode tends to cause a general rise in commodity prices in Pakistan, primarily because of cost-push inflation. The results further depict a weak negative relation between SOI and GDP growth rate, which means that the La Niña (rainy) episode causes negative effect on the GDP of Pakistan. The changes in CPI and GDP are caused due to contraction in aggregate supply due to La Niña (rainy) episode. The results call for inclusion of ENSO as a variable in planning phase leading to climatically compatible policies. Pakistan has not been able to take advantage of favorable rainy La Niña episodes because of incompatible agricultural policy and infrastructure. Based on the results, we can, to some extent, forecast and mitigate the economic effects of climatic fluctuations in Pakistan by including ENSO index as a variable in policy framework.

JEL Classification: A12, D04, Q54,
Key Words: Climate Change, El Nino, La Nina, Pakistan, ENSO, SOI

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1. INTRODUCTION

Pakistan possesses a unique and diverse climate. From the snowcapped mountains in the north to the deserts in south, having a 600-kilometer-long seashore along the Arabian Sea to coniferous forests, and above all, the mighty river Indus passing all the countryside. Due to this climatic diversity, Pakistan has all four distinctive seasons where extreme temperatures may reach up to
10 degrees Celsius below zero in the winter to 50 degrees above in the summer followed by drenching rains during the Monsoon. Pakistan has also got one of the world's biggest river water irrigation system, comprising of canals, culverts, barrages, and dams.

The El Nino has been defined as anomalous warming of the surface water in the equatorial Pacific Ocean, which alters the atmospheric pressure and consequently affects global weather parameters. The word El Nino is a Spanish term meaning Christ child, given due to the fact that such warm water currents come to the coast of Peru near Christmas time, when there is otherwise cooler water along the coast line (Ramage, 1986). Such years have been called "Years of Abundance" by the natives of Peru as the rains convert the desert to garden and slowly the whole country becomes a lush green pasture, with increased natural flock and better crops. Interestingly, the warm water currents sometimes bring yellow and black water snakes, and even bananas and coconuts from the farther coastal rain forests to the northern Peru coasts under the influence of El Nino. (Philander, 1989). However, El Nino usually brings drought-like conditions to South Asian countries, as in the case of 1998 El Nino that caused one of the most devastating droughts in the history of Pakistan.

The exact opposite condition is called La Nina (a Spanish term meaning 'the Little Girl'). During La Nina phase, central and eastern Pacific sea surface temperatures are unusually cooler. The area of warm surface waters contracts towards the western Pacific bearing lower than normal air pressure which contributes to increased rainfall in that region (Philander, 1989). La Nina tends to cause higher than normal Monsoon rainfall in South Asian countries, leading to better water supply, but also leaving a negative impact in case of floods. The El Nino of 2010 is marked with one of the worst floods in the history of Pakistan. The catastrophic flood of 2010 in the Indus River claimed around 2,000 lives and displaced about 20 million people. The Indus River flooded on 40,000 square kilometers of land (Syvitski & Brakenridge, 2013).

El Nino and La Nina are opposite phases of ENSO, wherein La Nina is referred as to cold phase and El Nino as warm phase. As ENSO affects global weather patterns, various studies have been conducted to capture their effects on economic activity across these regions. However, no such significant study has been conducted particularly for Pakistan. The current study attempts to establish a relationship between ENSO fluctuations and CPI and GDP growth rate in case of Pakistan.

2. LITERATURE REVIEW

Schoonmaker (1997) explained a relationship between El Nino and unemployment in the U.S. The study states that during the unusually mild winters of 1991-1992 and 1994-1995, natural gas demand dropped, gas prices decreased and hence profits of gas producing companies shrunk. Under these compelling parameters, many gas producers re-engineered and downsized their

workforce. It has been stated that mild winters of 1986-1987, 1991-1992, and 1994-1995, all occurred in El Nino years resulting in a decline in natural gas usage. El Nino has been taking the gas industry by surprise; however, it has been usually ignored instead of being accounted for in policy implications. When mid-winter weather is warmer due to El Nino, less gas is used for heating in North America than the anticipated level. Hence imbalance of supply and demand arises which puts downward pressure on gas prices. Moreover, El Nino reduces the number of tropical storms in the Gulf of Mexico, where the main source of natural gas for the U.S. is located, which promises uninterrupted supply. Gas inventories increase, and the supply-demand imbalance increases. Hence need is felt to make El Nino monitoring system coupled with natural gas industry performance monitors in order to avoid the shock.

Mjelde, Hill, & Griffiths (1998) reviewed the prevailing approaches for improved climate forecasts (ICF) and stated that need is felt to encourage and bring along the research potential of social scientists in the field of weather and climate forecasts. They stated that primary obstacle to interdisciplinary cooperation is a general understanding of each field's concepts, terminology and theory. They further state that ENSO is the best phenomenon for ICF. While ENSO is published as in index, it can be widely used by social scientists to calculate its economic impact on a number of fields. An example of Peru has been given where meteorologists work with agricultural community to help determine which crops are most appropriate in current climatic conditions. Cotton is advised for drier years, whereas rice is recommended for rainy spell. Likewise, dedicated climate research projects and programs also need to take social scientists and policy makers on board. Rather, climatic forecasts may be made public. Collaborations between climate scientists and other researchers is felt to be the need of the day.

Arndt & Bacou (2000) devised a CGE model to study the effects of climate forecast information using ENSO on Mozambique. The results show that drought phase causes decline in the GDP of Mozambique. Drought causes reduction in household consumption on the average. This lowering of home consumption in turn causes relatively low share of production in rural households. Consequently, rural households gain less from the increase in agricultural prices due to drought. Seasonal forecasts, that could enhance marketing sector efficiency could mitigate the aforementioned losses. The study recommends that while devising policies, Mozambique should include climatic effects of ENSO on region to region basis. A better solution is to extend such ENSO based forecast to marketing sector agents; they can communicate such forecast to farmers through anticipated price adjustments.

Chen & McCarl (2000) compared the effects of ENSO phase information with no ENSO phase information on U.S. agriculture. The model also accounted for rest of the world (ROW) ENSO sensitivity. The results show that El Nino phase causes 27.52 reduction in ROW soft wheat production, while La Nina phase causes 54.10 percent increase. These results highlight the value of ENSO information and its possible effect on the variables of interest. The results further show that estimate increases to twofold when considering the ENSO phase information impact on crop mix selection. The results depict that ENSO phase information significantly affects U.S. and ROW production and trade. About 6 to 15 percent shifts occur in U.S. production for almost all commodities. ROW volume of trade is also affected. ENSO phase information also affects U.S. storage, however, the percentage change in addition and withdrawals of storage varies with the ENSO phase and strength. Use of ENSO phase information decreases the world prices for all trade products, with a few exceptions such as hard red spring wheat and sorghum.

Brenner (2002) studied the effects of ENSO on CPI and GDP growth rate of G-7 countries using Granger Casualty tests. It has been observed that positive ENSO shocks lead to raised sea surface temperatures. The results show that ENSO has statistically significant effects on most of the sample economies. A one unit positive change in ENSO Granger causes approximately 3.5 percent rise in CPI. In addition, it has been observed that ENSO shocks tend to explain about 20 percent variation in CPI in a time series data. The results further show that about 10 to 20 percent variation in world CPI and world GDP growth rate is explained by ENSO. Such relationships are important in forecasting economic patterns with the onset of a positive or negative deviation in ENSO index.

Nadlnyak, Vedenov, & Novak (2008) argue that ENSO phases affect crop yields. Hence it is felt important to find out whether such affects are significant enough to be incorporated in crop insurance models, or otherwise. Country level annual yield of corn, cotton and peanut crops have been used in the study for the U.S. The results show that crop yield distributions in different ENSO phases are statistically different from each for the majority of crop combinations. Expected losses by ENSO have been found to be highest for corn and cotton during El Nino phase and lowest for La Nina phase, whereas peanut losses are higher during neutral phase and lower during La Nina phase. Such different behavior has been justified on the grounds that peanut is freeze-sensitive which usually occur during neutral phase, whereas cotton is more sensitive to moisture which explains losses during El Nino. This important information merits incorporation in insurance programs. Eventually, producers would benefit from information in ENSO phases if the insurance rates are adjusted to reflect this information.

Selover (2008) examined the relationship between ENSO and CPI and GDP growth rate for a sample of 22 countries. The results show a weak relationship between El Nino events and GDP growth rate for majority of the sample countries. However, for Australia, South Africa, India and Malaysia, the results are different as these countries appear to be significantly hit by El Nino. The results further show a weak relationship in general, and a moderate relationship in particular between ENSO and CPI in case of South Africa, Australia, Philippines and UK. However, the relationship between ENSO and CPI is further different for diverse commodities, significantly affecting maize, rice, palm oil and coconut prices. Effect of El Nino are smaller on geographically large and diverse countries, and for those countries in which agriculture has a small share in GDP. Such countries are less vulnerable to El Nino events.

Dell, Jones, & Olken (2014) considered new approaches in climate-economy literature. In first place, the authors summarize the recent work, review their methodologies, data sets, and their findings. In second place, they check for its applicability in the real environment. They review the damage function within these models, which estimates the potential economic effects of climate change in future. The findings show that there is a wide range of economic effects delivered by the weather shocks. Temperature changes not only affect agricultural output and energy demand but in turn effect industrial output, labor productivity, health and even political stability. All these factors effect economic growth. Some of the estimates suggest a 1 to 2 percent loss per a 1-degree Celcius change in poor nations. In second place, a functional form insight shows that there are compounding effects of climatic changes over time with larger scope of damages, such as impeded economic growth. A need is felt to bridge the gap between short-term effects and long-term damages caused due to climate changes. Finally, it has been deduced that each part of the world faces a different weather, hence need is felt to conduct climate-economy studies on national level.

Cashin, Mohaddes, & Raissi (2015) examined the macroeconomic effects of El Nino on 21 countries using a dynamic multi-country model. The sample consisted of countries in Pacific and Asia which are likely to be directly affected by El Nino. However, other big economies, from the North and South American, European and Middle East region were also included to observe the effects (through changes in trade pattern, commodity prices, and financial channels). Using the Granger Casualty model, the results show a heterogenous pattern. The El Nino weather shock causes decline in the GDP of in India, New Zealand, Australia, South Africa, and Chile, whereas European countries, China and the United States receive positive effects from the El Nino shock. The results also show that El Nino shock tends to induce short run inflation in most of the economies, due to rise in global prices of energy and non-fuel commodities.

3. FRAMEWORK OF THE STUDY

While El Nino refers to warmer sea surface temperature at the Pacific, and La Nina refers to colder sea surface temperature, both of the conditions cause unusual weather events around the globe. Rainy areas may face drought while deserts may receive torrential rains. Such changes hit the economy hard where agriculture, fisheries, power consumption, fuel consumption, infrastructure, and other activities receive shocks. However, there is also some uncertainty linked with the impact of ENSO on rainfall statistics. This uncertainty is due to the fact that El Nino episodes not only vary in magnitude, but also have different impacts for different climatic zones across the world.

As regards Pakistan, the Pakistan Meteorological Department (PMD) issues seasonal outlooks based on ENSO as per following:

Outlook for Summer Monsoon (J-A-S) 2016

"The El Niño phenomenon has weakened and La Niña is favored to develop during the summer 2016. Prevailing oceanic and atmospheric conditions are giving indications of good summer monsoon rainfall in the country". Based on statistical and dynamical downscaling of global circulation models, outlook for the season is prepared at 80% confidence level for planning purposes. The outlook for the season (July-September) 2016 is as under:

i) *Summer monsoon rainfall is likely to be 10-20% above normal over the country, averaged for three months.*

ii) *More than average rainfall is expected over Punjab, KP, Sindh, AJK and Northeast Baluchistan.*

iii) *Some extreme rainfall events are likely to occur in the catchment areas of major rivers and other parts of the country which may cause Floods.*

iv) *There is a high probability of heavy downpour which may generate Flash Flooding along Suleman Range.*

v) *Some heavy downpour events may produce urban flooding in big cities.*

vi) Some strong incursions of monsoon currents, coupled with high temperature, may trigger Glacial Lake Outburst Floods (GLOF), Landslides and Flash Floods in Upper KP and GB.

Preliminary Outlook: Monsoon 2014

"The emerging climatic features linked to El-Nino development have fairly large potential to suppress Pakistan Summer Monsoon 2014. According to the preliminary estimates of PMD, the amount of rainfall from July to September may be moderately below normal in Sindh, Baluchistan and Southern Punjab while nearly normal rainfall is expected in North Punjab, KP, GB and Kashmir".

Outlook: Winter 2011

"*La Niña phenomenon, causing abnormally low precipitation with low temperatures in Pakistan so far, is still prevailing and expected to continue well into the Northern Hemisphere during winter/spring 2011, as predicted by most of the global models."*

Source: Pakistan Meteorological Department. [3]

The above excerpts indicate a negative relationship between El Nino and Summer/ Monsoon rainfall in most areas of Pakistan, and a positive relationship between La Nina and rainfall. This stance has been further strengthened by Rashid (2004) wherein a negative relationship has been observed between El Nino and summer Monsoon rainfall in Pakistan.

In view of these studies, we can say that El Nino phases tend to cause drought-like conditions while La Nina phases tend to bring rainy weathers in Pakistan. For example, the worst drought-like condition in Pakistan occurred during the El Nino phase of 1997-1998, while one of the most devastating flood in Pakistan history occurred during La Nina phase in 2010. Hence need is felt to establish the economic impact of El Nino and La Nina on Pakistan, in order to mitigate the predicted weather effects by using SOI.

4. DATA AND METHODOLOGY

The Australian Bureau of Meteorology[1] publishes ENSO index (called SOI) on monthly basis. In current study, we have collected SOI index for 54 years from 1961 to 2015. Likewise, data on CPI and GDP Growth Rate of Pakistan for the corresponding years has been obtained from the website of World Bank. [2]

We have tested two different models to capture the effect of SOI on economic variables using Granger Causality approach which implies that if one variable *X* causes the other variable *Y*, then past values of *X* contain information that helps predict *Y* above and beyond the information contained in past values of *Y* alone (Granger, 1969).

In first model, we test the relationship between SOI and CPI through Regression Analysis using the following model:

$$\Delta CPI_t = \alpha + \beta CPI_{t-1} + \gamma SOI_{t-1} + \varepsilon_t \qquad 4.1$$

where CPI_t is consumer price index for the year *t*
CPI_{t-1} is consumer price index in previous year *t-1*
SOI_{t-1} is Southern Oscillation Index in previous year *t-1*
and ε_t is error term representing random shocks and the effect of excluded variables

In the second model we are interested to test the relationship between GDP Growth rate and SOI for the corresponding years, as per following:

$$\Delta GDPgrw_t = \alpha + \beta GDPgrw_{t-1} + \gamma SOI_{t-1} + \varepsilon_t \qquad 4.2$$

where $GDPgrw_t$ is GDP growth rate for the year *t*
$GDPgrw_{t-1}$ is GDP growth rate in previous year *t-1*
SOI_{t-1} is Southern Oscillation Index in previous year *t-1*
and ε_t is error term representing random shocks and the effect of excluded variables

5. RESULTS AND DISCUSSION

The first thing to be kept in mind while interpreting the results is that we are trying to establish the influence of weather on economic indicators ignoring other factors which otherwise directly and significantly affect economy. Therefore, theoretically, we are omitting the effect of some directly affecting variables and hence should not expect strong relationships. However, we are interested to see whether the currently studied weather indicator (SOI) significantly links to economic indicators of Pakistan, or not.

Relationship between CPI and SOI

In first model, we test the relationship between SOI and CPI of Pakistan for 54 years from 1961 to 2015. Ignoring all other factors, the graph between SOI and CPI should not be clearly linked, however, Figure 1 shows some common oscillations, particularly in positive (El Nino) ranges, like the La Nina of 1973-75, 1988-89, and then in 2007.

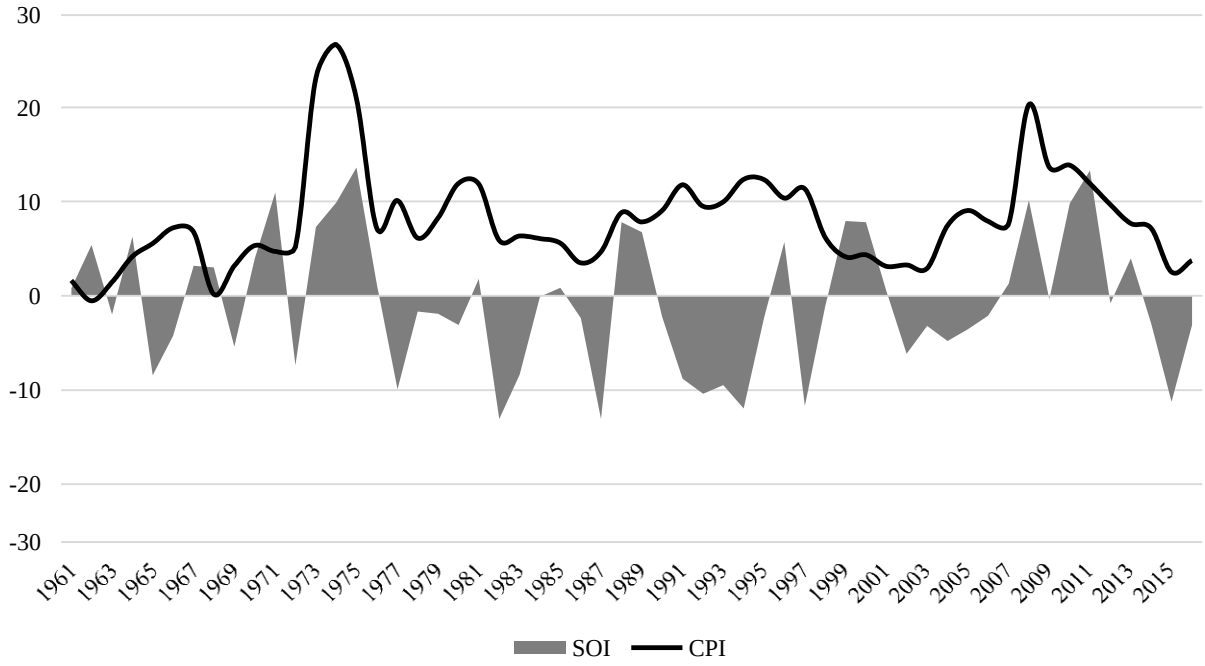
Table 1: Relationship between SOI and CPI of Pakistan for the years 1961-2016

Correlation between SOI and CPI	Granger Causality with 1 lag (t-stat)	F-Value [e]
0.297	21.414	0.001

Source: World Meteorological Organization

The Coefficient of Correlation between SOI and CPI is 0.297, which suggests that around 30 percent, the two variables vary commonly. The result of Granger Causality test, based on the model in Equation 4.1, is statistically significant. This shows that in our first model, SOI Granger Causes changes in CPI of Pakistan.

Figure 1: Trend of SOI with CPI of Pakistan for the years 1961-2016



The results show a weak but positive relationship between SOI and CPI, which means that as a result of positive fluctuation in SOI, (i.e. El Nino event), the general price level rises in Pakistan.

Relationship between SOI and GDP Growth

In an attempt to establish relationship between SOI and GDP Growth rate of Pakistan for a dataset of 54 years from 1961 to 2015, the graph can be seen in Figure 2. As discussed earlier, ignoring all other factors, the graph between SOI and GDP also seems to be weakly linked. Moreover, change in GDP Growth rate is a long-run phenomenon which is likely to appear after a certain lag to weather event.

Table 2: Relationship between SOI and GDP Growth rate of Pakistan for the years 1961-2016

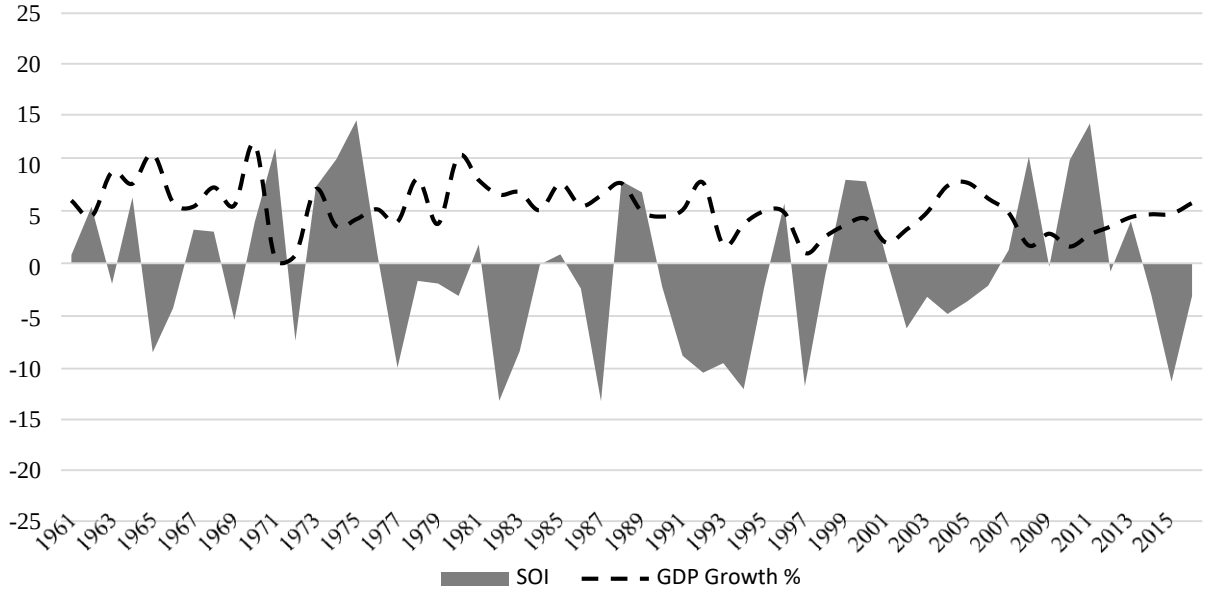
Correlation between SOI and CPI	Granger Causality with 1 lag (t-value)	P-Value
-0.139	4.162	0.021

Source: World Meteorological Organization

The Coefficient of Correlation between SOI and GDP Growth is -0.139, which suggests that the two variables vary commonly by approximately 14 percent, but in the opposite direction. The

result of Granger Causality test, based on the model in Equation 4.2, is statistically significant. This shows that in our model, SOI Granger Causes changes in GDP Growth rate.

Figure 2: Trend of SOI with GDP Growth rate of Pakistan for the years 1961-2016



The results show a weak negative relationship between SOI and GDP Growth rate, which implies that El Nino event gives negative shock to the GDP growth rate in the short run. However, due care needs to be taken while interpreting the above results because of the fact that change in GDP growth rate is a long term phenomenon and swift adjustments to shocks is not usually seen.

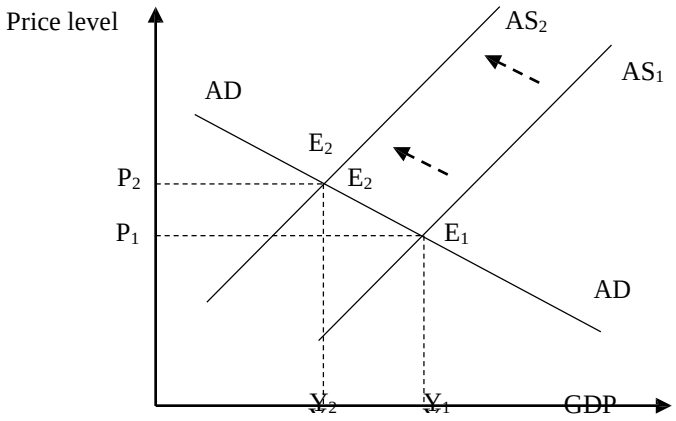
The relationships established in preceding paras can be explained with the help of Figure 3 which shows the shifts in aggregate supply in the economy.

In Pakistan, positive SOI values (La Nina events) are known to cause rainy weather, often leading to above average rainfall, and/ or floods. Apparently, La Nina events cause increase in general price level due to cost push inflation. Crops, sensitive to rain and moisture, are damaged and hence their supply is discontinued. Manufacturing industries, on the brink of water channels or in flood prone areas, are also affected, and hence production is also halted. Poor road infrastructure further causes discontinued supply of goods, even essentialities, such as food and fuel could not reach far northern areas. International trade gets effected due to discontinued supply of goods from southern part of country. All of these situations cause a contraction in aggregate supply leading to increased prices and contracted GDP.

Backshift in aggregate supply induces cost push inflation. When the aggregate supply curve of the economy shifts from AS_1 to AS_2 level, the economy moves from equilibrium point E_1 to E_2 which creates a 2-tier effect. On one side it causes the GDP to shrink from Y_1 to Y_2 level. On the other

side, it causes the general price level to rise from P_1 to P_2 level. This is graphical representation of the effect we have calculated empirically in the relationships between SOI, CPI and GDP.

Figure 3: Shift in Aggregate Supply and its impact on CPI and GDP Growth



6. CONCLUSIONS

In the light of preceding discussion, we are inclined to believe that rain bearing La Nina episodes is unfavorable to our economy. However, if we carefully watch the background reasons, we will be able to mitigate its adverse effects on our economy, so that it may become favorable to Pakistan's economy. In first step, forecasting and broadcasting ENSO information to a bigger span of farmers and agriculture departments could lead to a better crop selection and hence better yield to take full advantage of weather. This would not only prevent crop destruction, but may produce surplus. Likewise, ENSO forecasting on all sides of economy may help to not only prevent untoward events but would lead to take full advantage of the forthcoming weather.

Secondly, construction of big water reservoirs is a crucial matter for survival of Pakistan. We lose huge quantity of precious Monsoon rainfall water, which, otherwise could benefit us in the times of need. We can prevent agricultural and infrastructure damage due to floods by constructing big dams. Due to rapidly declining surface and underground water resources, we are not in a position to afford drought like conditions due to El Nino, and wastage of monsoon water. However, presently due to poor planning and management, we are facing adverse effects of La Nina, which otherwise could have been very beneficial for our economy.

This study empirically establishes relationship between ENSO and CPI and between ENSO and GDP growth rate. Hence need is felt to include ENSO as a variable while modelling economic policies for the country. Literature review reveals that majority of the countries include ENSO in their short term and long term planning. Further, this study is based on Granger Causality between SOI and CPI and GDP which omits other important variables affecting CPI and GDP growth rates. Therefore, the above methodology may be extended by adding other important variables to establish a more solid relationship between SOI and economic variables.

DATA APPENDIX

[1] SOI Data: The Australian Bureau of Meteorology
website: www.bom.gov.au/climate/current/soihtm1.stml

[2] CPI and GDP Growth Rate Data: The World Bank
website: https://data.worldbank.org/indicator

[3] Seasonal Outlooks for Pakistan: Pakistan Meteorological Department
website: http://nwfc.pmd.gov.pk/MON&TC/Monsoon/Seasonal-Outlook.html

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