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Price Effect of Climate Change on Vegetable Crops: Evidence from Tigrai, Northern Most Ethiopia

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Abstract
Agriculture economic sector is vital for the main stay of enormous poor people and prime source of food in LDCs yet though negatively impacted by climate change often. That cause production to be low and increase prices thereby affect large staple food consumption to the have-nots more as compared to the rich. The research dealt on the price effect of climate change on vegetables using time series monthly collected data from 2009 to 20015 in Tigrai, Ethiopia. A univariate econometric analysis and finite distributed lag model was employed. As the average temperature increased by 1^{o}C (degree centigrade) in 2009, caused the price of tomato vegetable in Tigrai to increase almost more than threefold (310 percent) in 2015. Likewise, in the year 2010 (LD) as the temperature increased by 1^{o}C, the average price of tomato increased close to 155 percent, ceteris paribus. Even the price of tomato vegetables increased by around 118 percent in 2011(L2D) because of 1^{o}C increase in the average temperature holding other effects constant. Lastly, in L5D (2013) and L6D (2014) , a 1^{o}C raise in the average temperature in Tigrai caused close to 58 percent and 23 percent increase in the price of tomato, ceteris paribus. The price increase in tomato vegetable is higher than that of the price of potato and onion tuber crops.
So as to get healthy vegetables often at fair prices both by the poor and rich, applying outstanding climate adaptive strategies is decisive in tuning to the new agenda of 21st Century climate change in many countries of the Globe is recommendable.
Keywords: Climate change, Time Series, Vegetables price, Temperature, Consumption, Tigrai.

1. INTRODUCTION

Globally there are more than one point five billion people who are farming on less than two hectares of land (FAO *et al*., 2011). Around 80 percent of food consumed in some Less Developing Countries (LDCs), especially, in Asia and Sub-Saharan Africa (SSA) is derived from smallholder agriculture FAO added. This economic sector is important for the main stay of enormous poor people and prime source of food in LDCs. However, mostly the smallholders in LDCs immerse to price fluctuations repeatedly. In fact, the price ups and downs might be seasonal and expected sometimes. Large staple food consumption price soar impacts negatively on poor households more as compared to the rich ones since the have-nots spend just about three quarters of their income on food consumption (Ben and Mehroosh, 2013).

Food prices on the global market in the last 25 to 30years (starting from 1974 to 2005) has been reduced by 75 percent in real terms (Quentin and Hassan, 2008). However, this day the price down fall history of food consumption items of the planet has already been shifted and shows an increase path. Consumption staple foods such as wheat, rice, maize, milk powder, oilseeds, vegetables prices were doubled and more in nominal terms in 2007 production year (Quentin and Hassan, 2008; Ivanic and Martin, 2008; Mulat *et al.,* 2009; WFP, 2011; WB, 2011; Philip, 2012; Ben and Mehroosh, 2013). On the same fashion, WFP and FAO (2011) stated that approximately one point zero two billion people of the World were undernourished since 2009 alone. This figure alarmed to the globe that large numbers of hungry people were found compared to that of 1970 hunger in the world's economic history. In 2009 for example, the main causing factors agreed by most scholars for food insecurity on the globe's population were like high domestic food consumption inflation, poverty, and unemployment (Ibd). This global wise fastest food consumption price hikes result different social unrest and/or civil conflicts in over 40 countries (WB, 2011) in the past few years. Following some marginal price fall between 2008 and 2009, the world food price restarted upward and continued to increase up to 2010. Consequently, the World Bank food price index has increased by 15 percent which is lower than what actually was in 2008 by three percent (Phillip, 2012).

Though there are different debates on the causes of food price inflation by scholars, export bans by top wheat and rice producer countries, shifting food grains to bio fuels, higher energy prices, a depreciating dollar, and rise food crops demand were the mostly agreed reasons among other factors (Mitchell, 2008). Moreover, global crop price and oilseed supplies deficiency due to poor harvests, change in the eating habits of emerging economies because of income increase of the people were also the causes for consumption food price hikes (Tom and Joe, 2008). On the other hand, an amalgamation of both demand and supply sided factors plus government policy decisions are the main causes for the staple foods of the world up (Philip, 2012).The growing population and income in emerging economies and LDCs is forecasted to cause a higher demand for food consumption in the coming decades. Unlike to the current seven billion population size of the globe, in the coming 2050 the globe's population has projected to reach nine billion people. Thus, this rapid population growth projection is

predicted to bring among 70 percent to 100 percent rise on the demand of food consumption as compared to the 2007/08 world economic crisis (IFPRI *et al*., 2011).

Even in the coming 2019, some scientific projections of intellects have witnessed that there will be an increment in the prices of stable consumer items, vegetables, and livestock outputs (Mulat *et al*., 2009; FAO, 2011). Therefore, this breaking news told the World that boosting growth of food consumer items parallel to the present and coming demand of billion people for food is important; otherwise will outbreak food consumption hikes that lead at least to economic inequality and different social unrest in the globe continuously. Food consumption prices have increased at twice the rate of the Consumer Price Index in Australia since 2005 to 2007 because of the climate change. Unexpectedly, fresh fruit and vegetables which are sensitive in prices have been worst hit inflation, shows an increase of 43 percent and 33 percent sequentially (John, 2007). These price hikes show us that as there is a big challenge in consuming vegetables at an affordable and fair price. Consistent to the global, the economic forecast in the African continent witnessed that as there will 4.5 percent Gross Domestic Product (GDP) growth in 2015 and 5 percent in 2016 compared to 3.5 percent since 2013 (AfDB *et al*., 2015). Of which, East Africa's GDP is projected to increase by 5.6 percent in 2015 alone and restarted to grow by 6.7 percent by the year 2016 (Ibd). In a nutshell, these data's told that as the Eastern part of Africa will keep the swift growing macro economy continent wise in the coming years as well. However, there was a macroeconomic fluctuation in East Africa because of volatile development in South Sudan. As it can be remembered, South Sudan which is the new youngest country created by the year 2011where armed conflict cut oil production and GDP caused food consumption inflation since 2013. Many scholars in recent days have also witnessed that most rural poor African small farms agricultural food consumption productivity are forecasted to bring negative impact on food inflation due to the larger rise of temperature as compared to the recent low warming levels (as cited in Mikemina, 2013). Hence, the productivity of this main stay of most African rural residents is highly exposed to climate change.

Ethiopia in the last years (2004/5 to 2007) for example, has had registered around 18 percent price rise in food and 16 percent for non-food while the agricultural output have increased meaningfully than past years (Jeni *et al*., 2007). Besides, starting from and more recently parallel to the national price hikes in Ethiopia the global commodity inflation has also rising. The domestic supply is expected to run less than demand in a fast economic growth situation, particularly as production rise have been registered due to more area expansion, and trends in outputs remain mismatch, further increases in relative inflation is inevitable. International factors of inflation have not a direct negative impact on the Ethiopian inflation both in the short and medium run, especially because of Ethiopian prices are below import parity. The negative impact of higher international food prices on domestic inflation is estimated at the lower end of 9 percent in Tanzania and the upper limit of 13 percent for Ethiopia and Uganda (AfDB, 2011). Unlike to Kenya and Tanzania which accounts 20 and 26 percent inflation rise shown because of fuel price hikes, 40 percent of the main driver of short-run inflation in Ethiopia is a surge in money supply in addition to imported inflation, food production shocks, velocity of money, and exchange rate (Ibd).

Although both Ethiopia and Kenya have had experienced strong economic growth for over a decade, inflation which was thought to be under control has continuing as a major challenge to their macroeconomic growth (Dick and Bo, 2012). The Ethiopian economy has registered extraordinary macroeconomic performance with the GDP of 11 percent for the last one decade (2004 to 2014) in the country's history (UNDP, 2014). This remarkable macroeconomic achievement is two-fold of what is in SSA and even makes Ethiopia one of the fastest emerging economies in the globe (Ibd). Global market prices for major food commodities such as grains and vegetable oils have risen sharply to historic highs. That hike reaches even more than 60 percent above levels just two years ago (Ronald, 2008). Surprisingly, there is no consensus on why Ethiopia experienced such dramatic food price rises yet (Ibd). The Ethiopian inflation is primarily related with agriculture and food in the economy plus global food crisis. Unlike other food consumption items, vegetable crops due to their nature of perish-ability and seasonality forecasting their price soars is more sensitive (Edward, 2014).Temperature has a large effect on the development of vegetables.

Vegetables are important outputs in improving the livelihood of the people in giving a balanced diet thereby improving the health status of the people plus serves as cash crop in generating income to households. Though Ethiopia has a comparative advantage in horticulture agriculture in many ways, fruit processing industries are scarce. The 'Merti' processing factory is the only plant producing fruit juice for the local market. This investment gap revealed that there is an investment motive to investors on vegetables and fruits in the country (EIA, 2012). Today, large numbers of fruit juices are imported into the country because of high demand in fruit juice in homeland market (ibid). For example; 951, 920 Kg with a total cost of 9,022,271 Birr in 2009; 1,509,352 Kg at a cost of 20, 671, 644 Birr; and 1,558, 240Kg with a total cost of 22, 283, 409 Birr tomato fruit juice has been imported to Ethiopia from abroad for juice consumption in the last 2009 to 2011(as cited in EIA, 2012). Conversely, exports of vegetable products from Ethiopia to abroad have been increased from 253,000 quintals in 2002/03 to 631,400 quintal in 2009/10 which is below potential and earns 10 to 30 million USD profit.

The annual inflation rate has risen by 11.9 percent since July 2014 and continuing this rate for the year 2015 as well. Similarly, the national inflation on foodstuffs has increased by 13.9 percent and non-food items increased by 9.7 percent in the year 2015 as compared to the inflation rate in July 2014 (Muluken, 2015). As it can be understood from the aforementioned references with regard to food consumption ups and falls, there is a continuous trend of food price hikes globally.

To the best of my knowledge there has not been a research which investigates tomato, onion, and potato vegetables inflation using time series data in terms of dynamic causal effect of price of potato and temperature in the Northern most part of Ethiopia. Studying the food price fluctuations of vegetables in Tigrai regional state using time series data has not been also researched yet. Analyzing the fluctuation trend on these vegetable prices in Tigrai is therefore relevant in filling the literature gap as well as forecasting its future price trends.

1.1. Objectives of the study

The general objective of the study is to estimate and forecast the effect of temperature on vegetable prices in Tigrai regional state of Ethiopia.

1.1.1. Specific Objectives

- To examine the causal relationship between temperature and price of vegetables
- To examine the effect of own price lag on its current value

2. RELATED LITERATURE REVIEW

2.1. Concepts of Inflation

Inflation by different scholars has been defined as a sustained increase for a long period in the general price level of goods and services in the economy. There are two main branches of inflation. Thus,

2.1.1. Demand pull inflation: Occurs when the economy grows quickly and starts to 'overheat': Aggregate demand (AD) will be increasing faster than that of aggregate supply (LRAS).

During the time aggregate demand exceeds aggregate supply, producers will respond by pushing up prices of goods and services.

2.1.2. Cost push inflation: Occurs when there is a rise in the price of raw materials, higher taxes, and the like. Amazingly, sometimes cost push inflation is synonymously interpreted as 'wrong type of inflation' since this inflation is associated with falling living standards. It is also hard for the Central Banks to deal with cost push inflation because they face both inflation and falling output. Furthermore, wage push inflation, imported inflation, temporary factors, and core inflation are compliment measures of inflation next to the aforementioned main divisions. There are a variety of methods used to measure inflation including consumer price index. Consumer Price Index (CPI): is an estimative indicator, which characterizes the general trends of the prices for purchased goods and the tariffs for services used by the population, in order to satisfy their needs over a certain period of time (current period) in comparison to a fixed period (base period). The widespread methods that are used to measure inflation are three: Namely, 1) Consumer Price Index (CPI): Take the change in the price of consumer goods and services; 2) Producer Price Index (PPI): Take the change in price of raw material or produce used by the producers; and 3) GDP-Deflator: It is the ratio of nominal and real gross domestic product.

The impact on capital accumulation, investment and exports, and can adversely impact a country's growth rate there by heighten the overall cost of living of citizens are the most mentioned macroeconomic negative consequences of real inflation soars (Admasu, 2014).

2.2. Empirical Literatures

2.2.1. Past Studies of inflation in Ethiopia

Ethiopia the second populous country in Africa, the seat of African Union (AU), the station of more than 80 embassies and many other international organizations, planned to reach middle-income country and zero balance of hunger by 2025, is the one among the fastest emerging economies of the globe. The structure of the economy has been shifted in 2015/2016 GTP2 from the previous agricultural development led-industrialization (ADLI) policy to Industry economy. Official government reports on growth, poverty reduction and inequality show that Ethiopia has registered a two-digit rate of growth for a decade (MoFED, 2014). Khan and Senhadji (2001) using a cross-country panel data have been produced the threshold level inflation for both DCs and LDCs. As a result, these researchers agreed and concluded that a threshold level ranging from 11 to 12 percent for LDCs is fine for stabilized macroeconomic objectives and sustainable growth. However, above the specified inflation threshold it can hurt the economic growth of LDCs. In the Ethiopian case a research done by Emerta (2010) using data 1971-2010 contended that a threshold of single digit inflation, especially 8 to 10 percent is convenient for having stabilized macro economy and economic growth (optimal inflation target policy).

On average around 11 percent GDP economic growth has been registered with in 2011 to 2015 years (GTP1) and for the past one decade. The double GDP economic growth proved that two-times of the SSA yearly macroeconomic growth and makes Ethiopia first (UNDP, 2014). The economic shares in GDP of different

economic sectors in Ethiopia are growing at various rates for the last years. For example, in the budget year 2012/13 agriculture sector covered (43 percent) GDP of the country grew by 7.1percent, industry sector (12 percent) in GDP grew by approximately 19 percent , and the service sector which accounts 45 percent in GDP have also grew on average at 9.9 percent. The national average food and non-food inflation rate has also been reduced from 55.3 percent what was in 2007/8 to 38.1 percent in 2010/11 and 7.4 percent in the year 2012/13 which is a single-digit inflation growth per annum (Ibd). Agriculture sector which represents 40.2 percent of GDP grew by 5.4 percent, industry also covers 14 percent of GDP and expanded by above 21.2 percent, and lastly the services economic sector that holds 46.2 percent of GDP rose by 11.9 percent in the last eleven successful years. Though many factors might be hindered not to keep the pace of this fastest economic growth in the coming years, the Ethiopian "awake of giant sleep lion" economy is forecasted to keep its growth (Admit *et al.,* 2015). This fact is also supported by various famous international organizations research outputs including the IMF.

The CPI inflation is expected to rise from what was 8.1 percent in 2014 to 9 percent for 2015 and 2016 budget years. On the other hand, the budget balance percent GDP will be declined from what were 1.9 deficits in 2013, 2.4 percent deficits in 2014, and 1.4 percent deficits in 2015 to 0.9 percent deficits in the coming budget year 2016 (Ibd). Similarly, there is also a revolution in the domestic savings. The average domestic saving in the year 2010/11(GTP1) was 12.8 percent of GDP and has been rise dramatically to above 18 percent of GDP in 2012/13 in Ethiopia. The newly established and under construction 'Hidassie Abay' great renaissance hydro electric dam (GRD) project with the capacity of production more than 6,000 mega watt (MW), bond sales and the opening of new branches by financial institutions in both urban and rural districts were the main causing factors for the domestic saving increment (UNDP, 2014). This momentum is expected to hold.

The Ethiopian government focus on agricultural growth and investments in basic services for all has ensured improvements in wellbeing for many poor households in the country. Of course, the proportion of the population living below the national poverty line fell from 44 percent in 2000 to 30 percent in 2011(WB, 2014). However, some government reports revealed that the proportion of the population living below the national poverty line has declined to 27 percent in 2014. Although accelerating poverty reduction will require looking beyond agriculture for sources of pro-poor growth, agricultural growth will remain important driver forces of poverty reduction in the near future. In order to fasten the poverty reduction in Ethiopia, ensuring women participation in rural activities is indispensable unlike the current biased situation. According to the study made by WB in 2014 revealed that more urbanization and growth in non-agricultural sectors would continue to exert upward pressure on food prices. This will need to be solved by increase agricultural productivity so as to keep labor costs competitive, but a high price reinforces the required agricultural investments. Even though it's beneficial for many poor rural households, high food prices carry costs for the urban poor. In order to alleviate the challenge, improving the fiscal position of poor urban households like doing through higher direct transfers or raising the minimum income threshold above which personal income tax is levied would support offset this effect.

2.3.1. Importance of vegetables and price hikes

Vegetables can be defined as any herbaceous (non-woody) plants whose fruit, seeds roots tubers, bulbs, stems, leaves or flower parts are used as food consumption. Furthermore, vegetables are those plants which are consumed in relatively small quantities as a side-dish or a relish with the staple food (as cited in Seid and Yeshi, 2013). Either in the Ethiopian context or world widely, vegetables are useful at least for the following reasons. Thus, it can serve as a source of vitamins, minerals, roughage, neutralizing the acid substances, medicinal value, generating income, and food and social security. Agriculture economic sector is usually prone to climate change and worked under high risk and unpredictability condition. Furthermore, crop pricing also affects negatively the production because the prices of agricultural producers are price takers that has been determined by the interplay of demand and supply (H.erdal *et al.,* 2009). Vegetables, especially potato is the high yielding crop and fourth food source in the world next to rice, wheat and corn. Potato is nutritious and easy to digest grown in many environments and consumed in various parts of the globe (Ibd).

Even if Ethiopia has a comparative advantage in a number of horticultural commodities because of favorable climate, proximity to Euro3pean and Middle Eastern markets and cheap labor: the production of horticultural crops is much less developed than the production of food grains in the country (EIA, 2012). The total area covered by fruits and vegetables is about 12,576 hectares in 2011. Of the total land area under cultivation in the country during the same year, the area under fruits and vegetables is less than one percent (which is 0.11percent), implies that very small as compared to food crops (CSA, 2011). However, fruit processing industries are scarce. The 'Merti' processing factory is the only plant producing fruit juice for the local market. This investment gap witnessed that there is an investment motive to investors in Ethiopia (EIA, 2012).Today, large numbers of fruit juices are imported into the country because of high demand in fruit juice in homeland market (Ibid). For example tomato; 951, 920 Kg with a total cost of 9,022,271 Birr in 2009; 1,509,352 Kg at a cost of 20, 671, 644 Birr; and 1,558, 240Kg with a total cost of 22,283,409 Birr tomato fruit juice has

been imported to Ethiopia from abroad for juice consumption in the last 2009 to 2011 (Ibd). Due to lack of sufficient supply of fruit juice raw materials like tomato, orange, grape, apple, mixtures, and others at home, the country is in loosing huge hard currency. The demand for these fruit juice import items specified above is on average at an increasing direction. That demand supply mismatch also cause price up.

In the production year of Meher 2012/13, productivity of tomato and onion vegetables per hectare of land by small farms revealed that under potential (CSA, 2012/13). Although there is an ample potential for the productivity of tomato and been proven that 159 to 463 quintal per hectare is the potential capacity of small farms, but in reality small farms are in producing it at around 90 quintal per hectare. Similarly, the small farms are actually producing onion vegetable at around 102 quintal per hectare but below what is 350 to 400 quintal per hectare the maximum productivity potential (CSA, 2012/13).There are kinds of incentives devised by the Ethiopian government under regulation No.84/2003 including customs duty exemption, income tax exemption, and loss carry forward to attract investors in establishing fruit juice vegetables and other new enterprises. Furthermore, there are favorable and diverse climate, irrigable land, and geographic location or export market opportunities are found; however, shortage of quality high yielding varieties, disease and insect pests, shortage of skilled personnel, poor post harvest handling, and weak production and market chain are the challenges to be solved soon so as to increase production and productivity of fruit juice vegetables (Endale, 2013). Price of vegetables such as tomato, potato, onion, and etcetera are among the most market sensitive commodities that can possibly create political instabilities on the world (Parmeshwar, 2014). Potato a kind of vegetable is the third most valuable agricultural food consumption product in the world next to wheat and rice stable items. Especially, potato fruit in India which is considered as vegetable and cultivated more in 2008 has contributed around 2.42 percent agricultural GDP (Ibd). Like many other vegetables, onion is also a valuable vegetable highly consumed worldwide. China is the first largest onion producer country in the globe. Next to China, India is the second largest onion vegetable producer with over 15million tones produce in 2010 to 2011 production year.

Parmeshwar (2014) made a research on vegetables like onion and tomato in India found that price volatility estimated as the predictable variance is found to have increased after 2007 production year. The agricultural output was also adversely affected by deficient rainfall in the first two months of the monsoon period of June to September. By and large, the high rate of overall inflation and particularly onion inflation caused by weather change witnessed during 2011 and 2013 production years. An increase in the price of fruits and vegetables relative to less healthy foods could reduce consumers' incentives to purchase fruits and vegetables and result in less healthy diets (Fred and Hayden, 2009).

Now a day thanks to many dieticians who are routinely encourage consumers to eat more fruits, vegetables, and whole-grain foods and less sugared desserts and salty snacks to have better life. Though eating these fresh vegetables are recommended everywhere in the world, individuals preference to taste, convenience, family structure and customs, age, health status, knowledge, lifestyle, and prices limited individuals not to consume more of it. Above all some scholars on health sectors forwarded their scientific findings messages were revealed that consumers are forced to prefer "unhealthy" foods to "healthy" items is mainly because of the relative prices, i.e. higher price soar was found in the fresh vegetables than staple foods (as cited in Fred and Hayden, 2009). A frequent and violent fluctuation of agricultural prices is not only affects the stable agriculture production, but also comes as a shock to consumers. Now a day, parts of China for example, have witnessed the problem of fresh agricultural products unsalable stock and roller coaster ride of agricultural product prices which have become a community concerns as well as a focus of government and scientific researches (Chuan *et al.,* 2014). The three major factors contributing for the unusual food prices in Ethiopia are: first, the growth in money supply far exceeded the overall economic growth; the second most important factor behind this puzzling price trend appears to an over-estimation of cereal production, and the final factor that caused domestic prices to rise was the balance of payment crisis in the country (Rashid, 2010).

2.4.1. Agricultural production and consequences of climate change

Various studies have been examined the relationship between weather and economic outcomes including wine prices and quality, prices for vineyard land, or winery revenue and profits for various wine growing regions and cultivars. Recently, the evidence of these intellects research output revealed that rising growing season temperatures can be beneficial to viticulture. Consequently, there will be winners and losers from climate change (Orley and Karl, 2014).

In Kenya the increase in the demand for vegetables is driven mainly by increasing wealth and the need of consumers for fiber, low cholesterol, low fat and high vitamins A and C (as cited in Edward, 2014). Of the world's production of fruit and vegetables, 42% is grown in China and India – more than one billion tonnes out of the total of 2.4 billion tonnes. China alone grows 38% of the vegetables and 19% of the fruit produced globally (tonnes measure). China produces 44% of the world's apple crop and 50% of the world's peaches and nectarines. India's largest volume fruit crop is bananas (27 million tonnes). This is 28% of global production in the year 2009. Confidently, Ethiopian vegetable production ranging from gardening smallholder farming to commercial state and private farms that are largely produced include pepper, kale (Ethiopian cabbage), onion,

tomato, pepper, chilies, carrot, garlic and cabbages as the major ones. However, the overall production yet is lower than what can possibly produce given its potential (Bezabih *et al.,* 2014). Unlike other food consumption items, vegetable crops due to their nature of perish-ability and seasonality forecasting price soars is more sensitive (Edward, 2014).Temperature has a large effect on the development of vegetable tomato.

Climate change is a key concern to Ethiopia in our time and need to be tackled in a state of emergency. It has brought an escalating burden to already existing environmental concerns of the country including deforestation, serious soil erosion and loss of top soil and land degradation which in turn have adversely impacted agricultural productivity (Ayana et al., 2011). By the year 2070-2099 for example; different scholars using different models have been forecasted that the average daily rainfall will be reduced to 1.97mm and rise temperature in Ethiopia (Ibd). And agriculture is the most climate change impacted sector. Similarly, as cited in Ayele et al., 2011 in the future fifty to eighty five years temperature will increase to 26.9 ^{0}C at the country. This is expected to reduce the agricultural sector production and productivity thereby heightens prices of consumption foods.

Over the coming decades, the global frequency and severity of drought is likely to increase as a result of climate change. Regional projections suggest that south-eastern Australia will be adversely affected by changes in rainfall patterns, as well as by rising temperatures, which increase the severity of drought. By 2070 there may be 40% more months of drought in eastern Australia, and conditions will be worse in a high-emissions scenario (John, 2007). Rain fed agriculture is the usual custom, a good rainy season means good crop production, certify food security, and a healthy macro economy in Ethiopia. However, failure of rains and occurrence of natural disasters such as floods and droughts could lead to crop failure, food insecurity, famine, loss of property and life, mass migration and negative national economic growth (WB, 2005).

"In the short term, unfavorable weather conditions, coupled with high world prices for commodities such as grains, will increase input costs for a wide range of fresh and processed foods. The largest price rises are likely for fruit and vegetables and we can also expect significant price increases for products that rely on grains as an input (either directly or indirectly as a feedstock) such as bread, cereals and snack foods, dairy, eggs and meat in the future. For example, the Australian Egg Corporation has warned that the price of eggs will rise by 50 to 60 cents a dozen (or at least 10%) (as cited in John, 2007)."

The commonly recognized causes related to many pushing factors of food inflation hikes in Australia are both the direct and indirect negative impacts of climate change. Although climate change have different negative impacts on agriculture thereby inflation, modest increases in CO_2 temperature concentrations 550 parts per million and 1 to 2^{o}C temperature changes have both harmful and useful impacts in the globe(Ibd). Tomato a kind of vegetable plant is a day neutral warm season crop which cannot tolerate cold. An optimum temperature that ranges from 21-28 °C during day and 15-20°C during night time is conducive for its higher yield. A temperature of 21-32^{0}c is also required for the better production of onion vegetable. Similarly, for developing and initial growth of plants, a temperature of 22-24°C is the best for potato vegetable (as cited in Seid and Yeshi, 2013). Contrary to what the world had been experienced in the 20th century with an average surface temperature increase of around 0.6 ^{o}C and 15 cm to 20 cm rise in sea level, in the 21st century some 85 years later the global average temperature will show another plus of 1.1 ^{o}C percent to 5.4 ^{o}C percent. However, this 85 later increase of global warming depends on how much human being will polluted the environment. But what can be possibly said is, in the 21st century there will be a fastest rate of climate change as compared to what the Earth had been experienced 10,000 years ago (Rachel *et al.,* 2009).

Climate change has various direct or indirect negative impacts on human being. Of which to mention some, negatively affect health and well-being of plants, pasture, rangeland, and livestock production. Globally, the horticultural crops (vegetables) such as tomatoes, onions, and fruits are more sensitive to the Earth's climate change unlike to other grains (Ibd). A research that has been done under the title "adaptation to climate change in the agriculture sector in the semi-arid region of Nigeria" an average mean temperature and rainfall data were collected from 1938 to 2007. The authors (Odjugo *et al.,* 2010) contended that in between 1938 to 1972 the temperature was 28.24^{o}C and the rainfall amounted to 937mm. However, in the year 1973 to 2007 temperature has been increased to 29.14^{o}C and rainfall reduced to 758mm in Nigeria. As a result, in the coming 85years Nigeria will become one member of 2.5 to 4.5^{o}C (medium to high temperature) because of the negative effects of climate change. This increase in temperature seeks climate adaptation to curve its negative impacts. At least it will affect directly the prices of agricultural products. Climate change in Ethiopia opposite to the recent regimes applying the green economic development policy, the average annual temperature has rose by 1.3 ^{o}C percent between 1960 and 2006 (McSweeney *et al*., 2008). Based on the National Meteorological Agency of Ethiopia reports, it has had experienced 10 wet years and 11 dry years over the last 55 years history as an example. This also cause soars in food consumption.

A research conducted with a title 'the development and evaluation of onion and cabbage vegetables whole sale price forecasting model' using 2004 to 2014 data witnessed that onion price shows a constant price rise in 2012 and 2013 (Sohyun *et al.,* 2015). Thus, a total of 21.3 percent supply of onion output reduction was

registered in these two years that has been caused by weather inconvenience to the product. As a result, causes price of onion to increase sharply up plus motivates producers to produce more lately. Among the many factors which contribute for the consumption food inflation of the globe to increase are: Climate and weather change, increases in oil and energy prices, bio fuels, and increase in global food demand (Comm net, 2014). Supported by the diverse soil and climatic situations, India stood first in the world in cauliflower and brinjal, second in onion, third in cabbage, and sixth in potato. However, in the combined production of fruits and vegetables India receives its leadership in the international market (Vasant and N.V., n.d). In India the direct contact between commission agents and farmers is very low. Thus, for vegetables this is 50 percent and for fruits only 31 percent contacts directly between these two. Secret biddings are high unlike to open auction which is very essential but relatively rare (Ibd). A study conducted to examine 'the trends in wholesale prices of onion and potato in the major markets of Pakistan using time series data about annual average wholesale prices of onion and potato that were collected from 1981- 82 to 2011-2012,' found a result that wholesale prices of onion and potato were increased with time (Anum *et al.,* 2015). This was because of increasing demand and population growth. Consequently, the increase of prices of onion and tomato the most kitchen goods become unaffordable by most consumers that seek government regulation as a remedy. *Vegetable crops are very important due to their higher yield potential, higher return and high nutritional value and suitability for small land holding farmers. Vegetables provide proteins, minerals and vitamins required for human nutrition* (Anum *et al.,* 2015).

2.5.1. The dynamic causal effect of temperature and price of fruits

Koyk model of "distributed lag models were used to study the causal effect among the prices and production of potatoes in Turkey," concluded that high relationship between two variables and time period of 12.33 years is required for changes in the prices of potato which effects the output of potato crop and producers are very keen for growing this vegetable (Erdal *et al.,* 2009). Moreover, a research that have been worked by the author Richard Roll since 1984 on the relationship of orange juice and weather using secondary data, found a result that weather change brought major negative impacts on the price of orange juice. Lastly, when the weather got coldest the supply of orange fruit declines and price of orange juice rise up. Likewise, Stock and Watson (2000) have been introduced the distribution lag model in the context of estimating the dynamic causal effects on orange juice prices and Florida weather using monthly collected time series data of 1950 to 2000, concluded that as the weather gets cold the price of juice get higher over time. For example, an additional freezing degree day is estimated to increase prices of orange juice on that month by around 0.47 percent.

However, at the peak of the world food crisis, in July 2008, annual food price inflation exceeded 90 percent (Dick *et al.,* 2013). Thus, such price hike was a historically first-time increase that started since 2006. Food consumption prices have increased at twice the rate of the Consumer Price Index in Australia since 2005 to 2007 alone. Unexpectedly, fresh fruit and vegetables have been worst hit inflation, which it increases 43 percent and 33percent sequentially (John, 2007). This price hike shows that a big challenge in consuming vegetables at an affordable and reasonable price.

Lastly, the reviewed literatures indicate that distributed lag model can be used in the dynamic causal effect of time series data. These literatures have helped for this research to select the appropriate econometric estimator of the causal effects of climate change (temperature increase) and price of vegetables over time.

3. MATERIALS AND METHODS

3.1. Description of the study area

Tigrai is the Northern most of Ethiopia's federal states located at 12012' and 14032' North latitude and between 36030' and 40030' East longitude. Mekelle city the northern star is the capital of the region. The state of Tigrai shares common borders with Eritrea in the north, the regional state of Afar in the east, the regional state of Amhara in the south, and the republic of Sudan in the west.

Although the region has a number of legends about its history, the well known and documented history of Tigrai begins in the eighth century B.C. (Yeha), and with the founding of the Aksumite Kingdom around 300 B.C. Tigrai is the region where ancient Ethiopian civilization emerged, and it is believed that Aksum was one of the four great super powers of the globe in its time. During its high-day the Aksumite Empire is believed to have a highly civilized knowledge on pottery, and other crafts. In addition to that, the region is well known for its primacy in accepting Orthodox Christianity in the 4th century A.D. and for its accommodation of Islam in the 7th century AD which in turn has contributed to the peaceful co-existence of its people with different cultures and religious believes. It is the very root and proprietor of the greatest wealth of different kinds of heritages. Indeed, the region is the homeland to various spiritual and material cultures. Due to its diversified collection of heritages Aksum and its environs was inscribed on UNESCO's world heritage list in 1980. In nutshell, Tigrai is truly the Alpha and Omega of Ethiopia's ancient and remarkable history.

3.1.1. Population

Tigrai regional state has been recorded a population numbers of 4,316,988, of whom 2,126,465 were men and 2,190,523 women. The urban inhabitants were increase to 844,040 or 19.55% of the total population. This shows

high urbanization as compared to the country rate. It has an estimated area of 41,409.95 square kilometers; besides, the region has an estimated density of 100 people per square kilometer. For the entire region 992,635 households were counted, which results in an average for the region of 4.4 persons to a household, with urban households having on average 3.4 and rural households 4.6 people (CSA, 2007).

3.1.2. Ethnicity

In Tigrai regional state, more than 96.55 percent of the local population is predominantly inhabited by the Tigringna speaking Tigrai people. The Tigringna language is classified as belonging to the Semitic branch of the Afro-Asiatic family of languages. Most other residents hail from other Afro-Asiatic speaking communities, including the Amhara (1.63 percent), Irob(0.71 percent), Afar(0.29 percent), Agaw (0.19 percent) and Oromo(0.17 percent). There are also a minority of Nilo-Saharan-speaking Kunama Nilotes which they account 0.07 percent o Tigrai population (Census CSA, 2007).

3.1.3. Economic activity

As it has been estimated in (CSA, 2005), the estimated result revealed that farmers in Tigrai had a total of 2,713,750 cattle (representing 7 percent of Ethiopia's total cattle),72,640 sheep (0.42 percent), 208,970 goats (1.61 percent), 1,200 horses (less than 0.1percent), 9,190 mule (6.24 percent), 386,600 asses (15.43 percent), 32,650 camels (7.15 percent), 3,180,240 poultry of all species (10.3),percent and 20,480 beehives (0.47 percent). By and large, the residents of Tigrai like the people in other parts of Ethiopia, households base their economy on a mixed farming system.

3.2. Data type and source of data

The data of this research is taken from secondary sources. It was collected from two famous sources: first, from the National Meteorology Agency of Ethiopia Mekelle directorate branch; second, from Tigrai Agricultural Marketing Promotion Agency (TAMPA). The National Meteorology Agency of Ethiopia Mekelle directorate branch collected data's daily, weekly, and monthly concerning to temperature, rainfall, wind speed, and etcetera in different stations of Tigrai regional state of Ethiopia. Similarly, TAMPA has also been collected an average prices (recorded both weekly and monthly) on various type of cereals, fruits, vegetables, and live stocks. In order to address the objectives of this paper therefore the researcher used a time series (TS) data collected every month about temperature and prices of vegetables like tomato, potato, and onion from these two institutions in Tigrai (5 zonal woreda's) starting from 2009 to 2015.

3.3. Model Specification and Estimation

Time series data is nothing but it's a data collected for a single entity at multiple points in time. By and large, time series regression models are relevant mainly for at least two well mentioned functions. Thus, to estimate the dynamic causal effects and forecasting future situation based on the lag values we have estimated (Stock and Watson, 2000). In the economics literature, the distributed lag models are highly useful for the consumer, producer, and government behaviors economic units that had been implemented by different researchers (Richard Roll, 1984; Isyar, 1999; Stock and Watson, 2000; Hamilton, 2001; Hamilton, 2005; and Wooldridge, 2009). Especially, distributed lag models are essential not only in estimating the previous year (lag value) but also useful in estimating current year value of defining variable.

Time series data is divided in to two major parts called univariate and multivariate time series. A univariate time series analysis is nothing but it uses only the past history of the time series being forecast plus current and past random error terms. Besides, autoregressive integrated moving average (ARIMA) modeling is a specific subset of univariate modeling, in which a time series is expressed in terms of past values of itself (the autoregressive component) plus current and lagged values of a 'white noise' error term (the moving average component). Conversely, multivariate time series analysis involves more than one time series data sets. Multivariate time series analysis is used when one wants to model and explain the interactions and co movements among a group of time series variables. Therefore, the paper emphasizes with modeling univariate time series data (one variable temperature).

Definitely, dynamic effects usually happened over time so that the econometric model used to estimate the dynamic causal effects require including lags. There are two fundamental concepts in time series data to define variables. They are the "infinite lag model" and "finite distributed lag model ones." In regressing the time series data when we failed to know how far back will be gone in defining variable is not clearly specified is named as the "infinite lag model." This paper is therefore categorized under the "finite distributed lag model" hence the number of years to go back is defined in years i.e., 2009 to 2015. In a nutshell, the dynamic causal effect of the paper is modeled as here below:

$$P_{iwt} = \beta_0 + \beta_1 P_{iwt-1} + \beta_2 P_{iwt-2} + \beta_3 P_{iwt-3} + \beta_4 P_{iwt-4} + \beta_5 P_{iwt-5} + \beta_6 P_{iwt-6} + \alpha_1 T_{iwt-1} + \alpha_2 T_{iwt-2} + \alpha_3 T_{iwt-3} + \alpha_4 T_{iwt-4} + \alpha_5 T_{iwt-5} + \alpha_6 T_{iwt-6} + \varepsilon_t \quad \ldots\ldots \quad (1)$$

Where,

P_t = the current prices of tomato, onion, and potato in the specified woreda[1]

i= number of vegetable items (tomato, onion, and potato) used in the estimation

w = number of woreda β_0 = constant t = time measured in years

β_1= the immediate effect of a unit change in P_{iwt} on P_t holding constant past P_t (one period lag dynamic multiplier effect) short β_2= two year dynamic multiplier, ceteris paribus Pt, Pt-1, Pt-2, Pt-3 …

β_3= three year dynamic multiplier effect of change in Pt-2 on P_{iwt}, ceteris paribus Pt, Pt-1, Pt-3, β_4 = four year dynamic multiplier effect of change in Pt-3 on P_{iwt}, ceteris paribus

β_6= six year dynamic multiplier effect of change in Pt-5 on P_{iwt}, ceteris paribus

T = the average monthly temperature of every woreda α_1= one year lag dynamic multiplier effect of temperature on $\mathbf{P_{iwt}}$, ceteris paribus α_2= two year lag dynamic multiplier effect of temperature on $\mathbf{P_{iwt}}$, ceteris paribus α_6= six year lag dynamic multiplier effect of temperature on $\mathbf{P_{iwt}}$, ceteris paribus

ε_t= includes both measurement error and the effect of omitted determinants of P_{iwt}, or stochastic term or/ and error term. A priori expectation is stated as follows: first, represent the coefficients to estimate the short term effects of variation in temperature on the dependent variable (price of vegetables) that is $\beta1 > 0$, $\beta2 > 0$, $\beta3 > 0$, $\beta4 > 0$, $\beta5 > 0$, and $\beta6 > 0$. And the long run expectation is also stated as follows: $\alpha1 > 0$, $\alpha2 > 0$, $\alpha3 > 0$, $\alpha4 > 0$, $\alpha5 > 0$, and $\alpha6 > 0$.

According to the authors like Alt, 1942; Tinbergen, 1949; and Gujarati, 2001contended those parameters α, α0, α1, α2… α6 in distributed lag models can possibly be estimated using classical least square method. However, Gujarati, 2001 criticizes certain points concerning to estimates in distributed lag models. These are: first there is a difficulty to know a pre-information in the model regarding to how long the lag period will be; second, when a data set that can estimate the lag period is not set up, degree of freedom is continuously decreased, and the last important challenge is that variables decided as defining variables are in a multiple linear relationships.

Consequently, in resolving the aforementioned failures Koyck has been developed an econometric model since 1954 and Dikmen in 2005. Lags in an explanatory variable affect the explained variable to some extent and the weight of these lags decrease, the model is reduced and thus made to estimate the regression equation. Koyck (1954) assumed that in an infinitely distributed lag model for example, all 'β's had the same signs and geometrically reduced so as to obtain the reduced model. Similarly, in determining the order of an auto regression (AR) balancing the marginal benefit of including more lags against the marginal cost of additional estimation uncertainty is essential. If the order of an estimated AR is too low, show and as we were omitted valuable information contained in the more distant lagged values. Conversely, if the order of an estimated AR is too high, revealed that as it was estimated more coefficients than necessary, which in turn creates additional estimation error into our forecast trends (Stock and Watson, 2000). When using information criterion to estimate the lag lengths two important things has to be considered. Thus: first, as is the case for the AR, all the candidate models must be estimated over the same sample that is the number of observations used to estimate the model. Time (T) must be equal for all models. Second, when there are multiple predictors, this approach is computationally demanding because it requires computing many combinations of the lag parameters (many different models).

3.3.1. How should we choose the lag length P?

There are two essential information criteria in selecting lag length selection time random model (RM). These are the Bayes information criterion (BIC) or Schwarz information criterion (SIC) and Akaike information criterion (AIC).

The BIC: is a way estimating the number of lags P by minimizing an information criterion. The BIC helps decide precisely how large the increase in R^2 must be to justify including the additional lag. It is formulated as:

$$BIC(P) = \ln\left(\frac{SSR(P)}{T}\right) + (p+1)\ln\frac{T}{T} \quad ; \ldots \ldots\ldots \qquad (2)$$

Where,

SSR (P) = the sum of squared residuals of the estimated AR (P)

[1] Woreda in this context is an administrative structure of governance next to that of zone level.

P = the value that minimizes BIC (p) among the possible choices p= 0, 1, 2, 3, ... P_{max}

P_{max} = the largest value of p considered T = the number of time periods

The AIC: a smaller decrease in the SSR is needed to justify including other lag. It is widely practiced as compared to BIC. There are some imperfections in it, however.

Simply, AIC is formulated as specified below:

AIC (p) = $\ln\left(\frac{SSR(P)}{T}\right) + (p+1)\ln\frac{2}{T}$; ... (3)

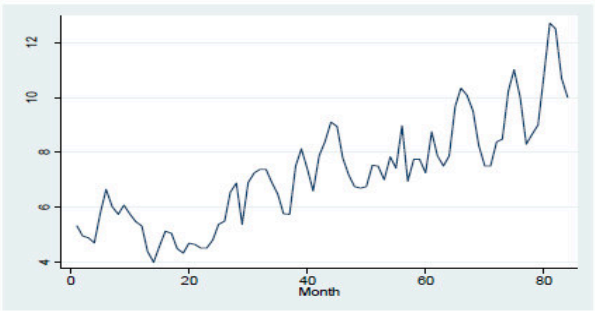
The " $\ln T$ " in the BIC simply is substituted by two in equation three above. As a result, the second term in the AIC is smaller, therefore is the basic dissimilarities of the two information criterion.

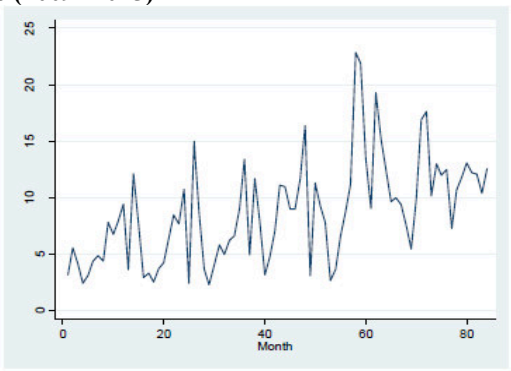
3.3.2. A trend

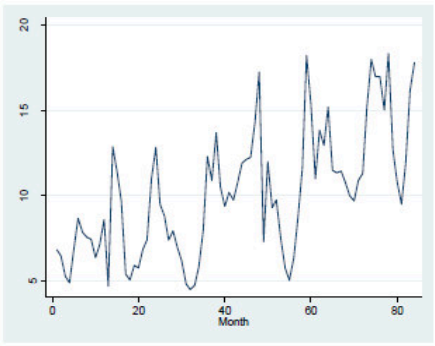
A trend is conceptualized as a continual long-term movement of a variable over years. Surely, a time series variable fluctuates around its trend. Furthermore, deterministic and stochastic are the two types of trends that are seen in the time series data. A deterministic trend is a non random function of time. However, a stochastic trend is random and varies over time. Trends can possibly also be detected using both informal and formal methods. The informal method inspects the time series plot as first test. Second, the informal Dickey-Fuller (1979) test also helped to test for a stochastic test trend. Lastly, the paper made different econometric tests such as Stationarity /random walk/ unit root, Break, Serial Correlation/ Autocorrelation, and Co-integration so as to assure the robustness of the results.

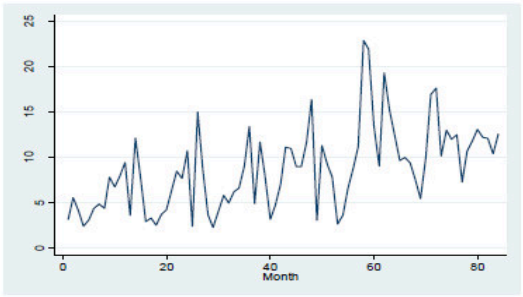
4. Empirical results and Data Analysis

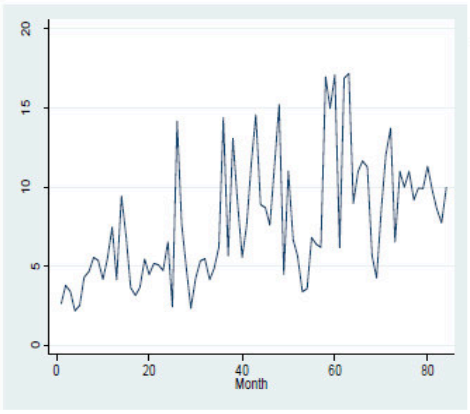
4.1. Some trends of price of vegetables and temperature (2009- 2015)

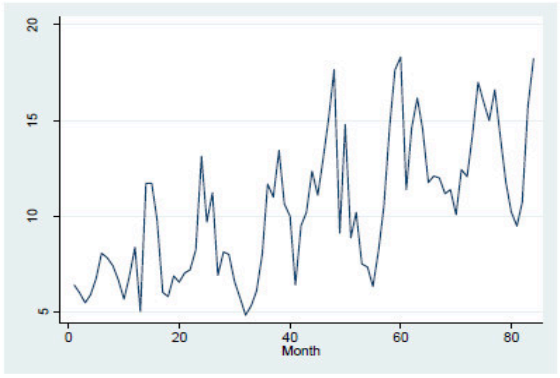


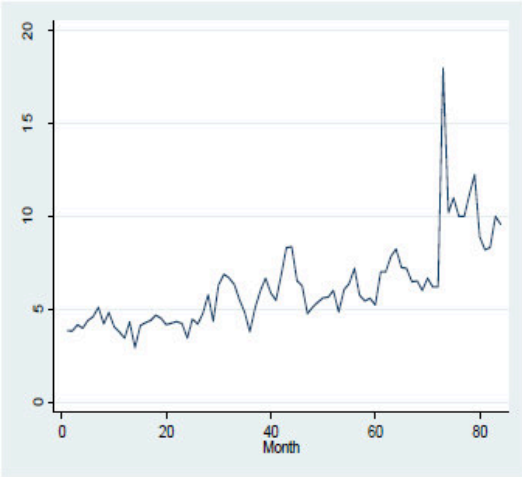


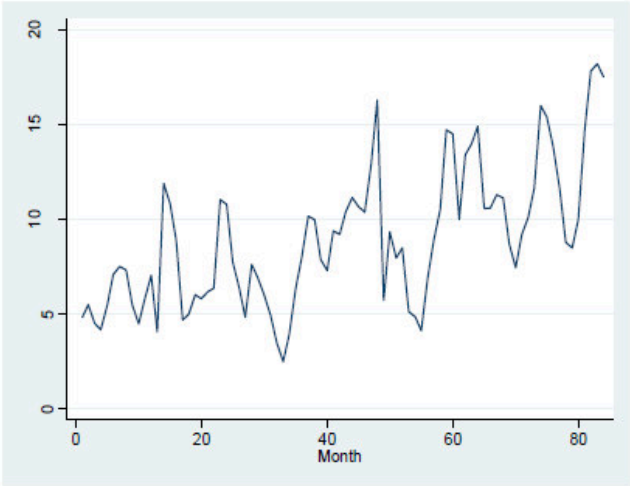


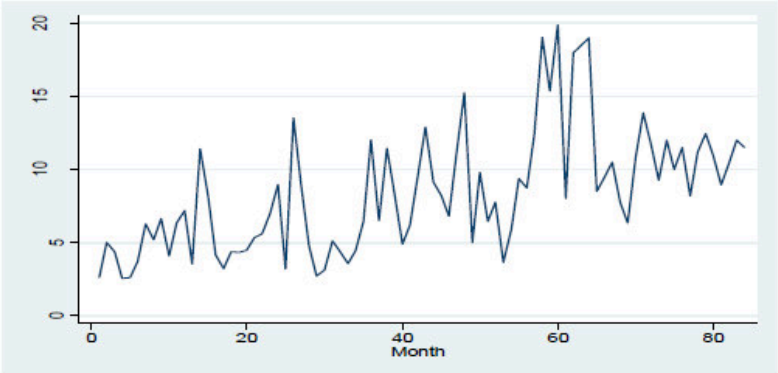






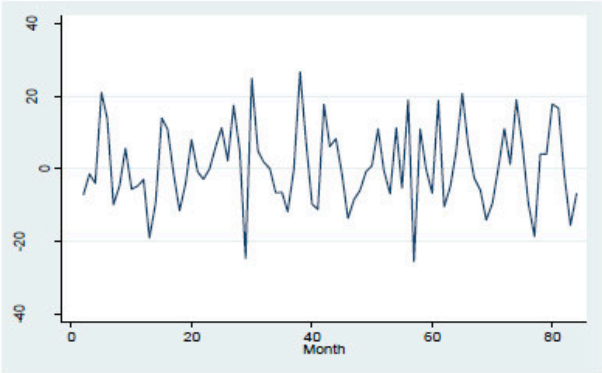


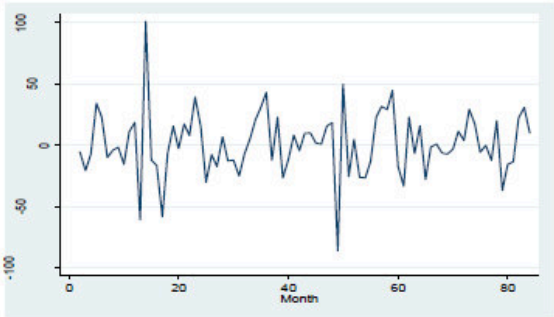


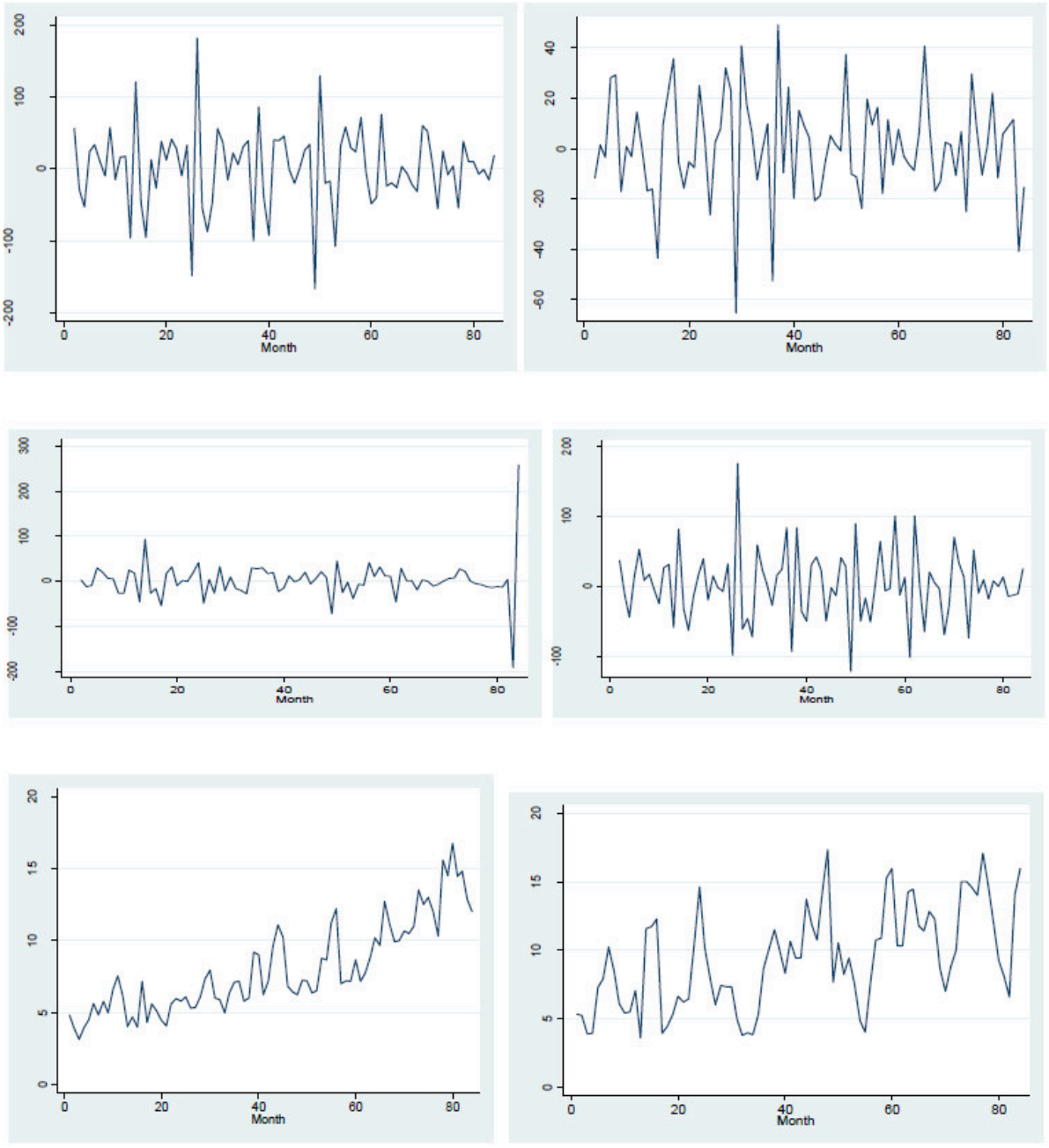


As it can be seen from the aforementioned graphs, there were vegetable price ups and downs every month parallel with the average temperature in Tigrai. Thus, this trend is a kind of supporting and consistent to our theoretical hypothesis.

4.2. Percentage change of price of vegetables and temperature (2009- 2015)

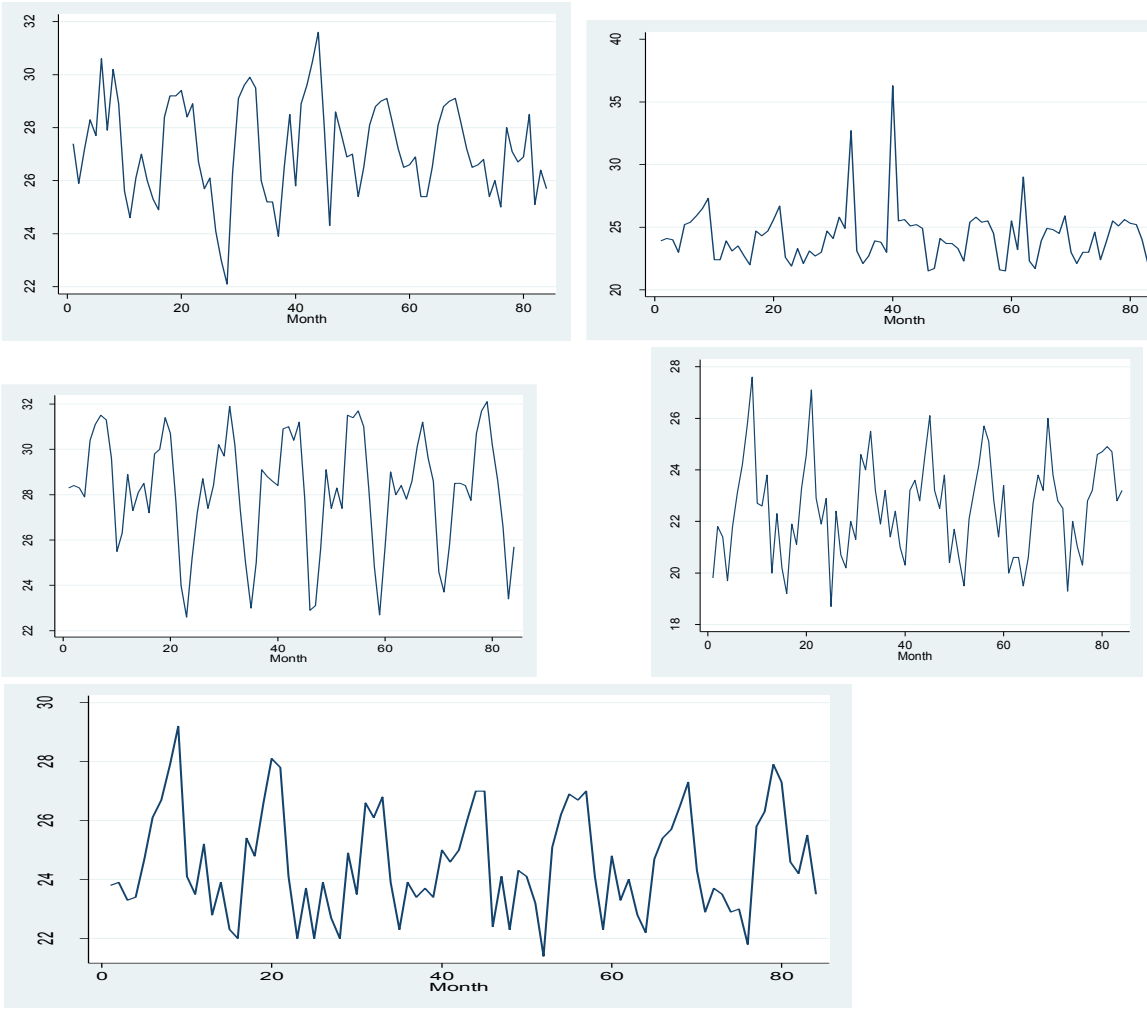






The percentage change and two-way change which is better measurement as compared to that of the direct trends reveals that there were price ups and downs in vegetables, but somehow smooth. However, in the 25th month (January 2011) and 45th month (June 2012) the vegetables price (more of potato) was inflated in line with temperature. Similarly, in the 15th month (November 2010); 25th month (January 2011); 60th month (September 2013); and 78th month (March 2015) show price hike in the price of vegetables, especially on onions. The prices of potato show in the last seven years almost an increasing trend every month with a slight change. Opposite to what is said above, in the 24th month (September 2010); 35th month (August 2011); 55th month (April 2013); 75th month (November 2015); above 80th month (June 2015) the price of vegetables fallen down dramatically. In nutshell, the trends we regress validated our research.

4.3. Some trends of temperature and price of vegetables (2009-2015)



In fact, we have discussed in the theoretical part earlier that as temperature increased by 1°C, the price of vegetables increased. The trends we have evaluated above are consistent to that fact.

4.4. Lag length selection process

After using Final prediction error (FPE), Akaike information criterion (AIC), Schwarz's Bayesian information criterion (SBIC) and Hannan-Quinni information criterion (HQIC) to select the appropriate lag length in our study; we select the best lag length at which the values of information criterions are minimal. The result is therefore reported on the tables 4.1 to 4.6 below.

Table4.1.The price of potato in Tigrai (Mekelle city only)

lag	LL	LR	Df	P	FPE	AIC	HQIC	SBIC
0	-319.525				13.046	8.24424	8.26843	8.30467
1	-237.881	163.29	4	0.000	1.78188	6.25335	6.32592*	6.43463*
2	-234.285	7.1919	4	0.126	1.80093	6.26371	6.38466	6.56585
3	-232.522	3.5259	4	0.474	1.90843	6.32107	6.4904	6.74407
4	-225.144	14.755	4	0.005	1.75203	6.23446	6.45218	6.77832
5	-218.618	13.052	4	0.011	1.64498	6.1697	6.4358	6.83441
6	-213.614	10.009*	4	0.040	1.60715*	6.14394*	6.45842	6.92951

We select the favorable lag length from the provided table 4.1 above to our current analysis is assumed to be 6; the AIC is minimal and the data is monthly collected.

Table4.2.The price of potato in Tigrai (Aksum, Adigrat, and Shire)

lag	LL	LR	Df	P	FPE	AIC	HQIC	SBIC
0	-346.84				26.2813	8.94461	8.9688	9.00504
1	-303.612	86.456	4	0.000	9.61273	7.93877	8.01134*	8.12005*
2	-302.94	1.3441	4	0.854	10.4719	8.0241	8.14505	8.32624
3	-301.365	3.1494	4	0.533	11.1507	8.08629	8.25562	8.50929
4	-290.809	21.112*	4	0.000	9.43567*	7.91819*	8.1359	8.46204
5	-288.631	4.3572	4	0.360	9.90382	7.96489	8.23099	8.6296
6	-285.921	5.4188	4	0.247	10.2626	7.99798	8.31246	8.78355

We select the favorable lag length from the provided table 4.2 above to our current analysis is also assumed to be four.

Table4.3.The price of onion in Tigrai

lag	LL	LR	Df	P	FPE	AIC	HQIC	SBIC
0	-388.9				77.2713	10.0231	10.0473	10.0835
1	-333.534	110.73	4	0.000	20.7038	8.706	8.77857	8.88728
2	-321.162	24.744	4	0.000	16.7087	8.49133	8.61228*	8.79347*
3	-316.397	9.5292	4	0.049	16.3944	8.47172	8.64106	8.89472
4	-314.975	2.8447	4	0.0584	17.5338	8.53782	8.75553	9.08167
5	-308.813	12.324	4	0.015	16.6167	8.48238	8.74847	9.14709
6	-303.319	10.988*	4	0.027	16.032*	8.44406*	8.75854	9.22963

We select the favorable lag length from the provided table 4.3 above to our current analysis is also assumed to be six.

Table4.4.The price of tomato in Tigrai

lag	LL	LR	Df	p	FPE	AIC	HQIC	SBIC
0	-403.62				112.703	10.4005	10.4247	10.4609
1	-370.18	66.88	4	0.000	52.9821	9.64563	9.7182	9.82692
2	-356.998	26.363	4	0.000	41.8797	9.4102	9.53116*	9.71235*
3	-354.803	- 4.3902	4	0.356	43.8905	9.45648	9.62582	9.87948
4	352.283	5.0389	4	0.283	45.6388	9.49445	9.71216	10.0383
5	-341.482	21.603*	4	0.000	38.401*	9.32005*	9.58615	9.98476
6	-337.923	7.1179	4	0.130	38.9346	9.33136	9.64584	10.1169

We select the favorable lag length from the provided table 4.3 above to our current analysis is five.

4.5. The Augmented Dickey-Fuller test for unit root

In order to find the robust regression result, econometricians advised to test stationarity as a prior pre-requisition in time series data. The researcher applied the test using ADF model with constant and trends. Having a unit root in a time series mean that there is more than one trend in the series. However, our statistics test discovered that there is one trend in the series. That is to mean that there is no unit root problem in the study.

Table4.1.Augmented Dicky-Fuller test for unit root on price of Potato

Augmented Dickey-Fuller test for unit root Number of obs = 77

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
		---------- Interpolated Dickey-Fuller ---------		
Z(t)	-5.006	-3.542	-2.908	-2.589

MacKinnon approximate p-value for Z (t) = 0.0000

D.dprpotato	Coef.	Std. Err.	T	P>|t|	[95% Conf. Interval]	
D.prpotato L1.	2.00479	.4004804	-5.01	0.000 ***	-2.803522 -1.206057	
LD.	.9171122	.3485658	2.63	0.010 **	.2219196 1.612305	
L2D.	.6635122	.2919518	2.27	0.026 **	.0812326 1.245792	
L3D.	.4127278	.2365494	1.74	0.085 *	-.0590551 .8845106	
L4D.	.1534358	.1782097	0.86	0.392	-.2019922 .5088638	
L5D.	.0778125	.1192705	0.65	0.516	-.160065 .31569	
_cons	1.662603	1.279016	1.30	0.198	-.8883144 4.21352	

Note: *, ** and* are statistically significant at 1%, 5% and 10% respectively**

According to the ADF result, the Test Statistic value (5.006) is higher than that of these three critical values ranges from 2.58 to 3.42. As a result, the lags were non-stationary at level (normal regression), but become stationary after first difference (with change (d)) equals to what is in Table 4.1 above. Hence, one way to test the stochastic trends (unit root) is by taking the first difference of the variable.

In the last seven years before (2009) as an example; a one degree centigrade (°C) temperature increase caused price of potato to increase almost double. Similarly, in the year 2010 (LD) as the temperature increased by 1°C in Tigrai, the average price of potato vegetable increased close to 92 percent, *ceteris paribus*. Moreover, the price of potato increased by around 66 percent in 2011(L2D) because of 1°C increase in the average temperature in Tigrai. In the L3D (2012) a 1°C raise in the average temperature in Tigrai caused 41 percent increase in the price of potato. The research output is consistent and valid with that of the previous researches done by these researchers such as (Sohyun *et al.,* 2015; Anum *et al.,* 2015; Edward, 2014; Parmeshwar, 2014; Bezabih *et al.,* 2014; Dick *et al.,* 2013; John, 2007).

Table4.2.Augmented Dicky-Fuller test for unit root on price of onion

D.dponion	Coef.	Std. Err.	T	P>|t|	[95% Conf. Interval]
L1.	2.22257	.4314388	-5.15	0.000***	-3.083496 -1.36165
LD.	.991054	.3819008	2.60	0.012**	.2289833 1.753126
L2D.	.968551	.3331333	2.91	0.005***	.3037943 1.633308
L3D.	.733398	.2865262	2.56	0.013**	.1616442 1.305153
L4D.	.519147	.2363885	2.20	0.031**	.0474421 .9908538
L5D.	.395032	.1872427	2.11	0.039**	.0213952 .7686692
L6D.	.167367	.120601	1.39	0.170	-.0732893 .4080241
_cons	2.31114	3.00760	0.77	0.445	-3.690435 8.312723

Note: *, ** and* are statistically significant at 1%, 5% and 10% respectively**

Similar to the price of potato above, in (2009) as an example (L1); a one degree centigrade (°C) temperature increase caused price of onion to increase almost more than double (220 percent) in the northernmost part of Ethiopia. Moreover, in the year 2010 (LD) as the temperature increased by 1°C in Tigrai, the average price of onion vegetables were increased close to 100 percent, *ceteris paribus*. And the price of onion tuber vegetables increased by around 96 percent in 2011(L2D) because of 1°C increase in the average temperature in Tigrai holding other effects constant. In the L5D (2013) a 1°C raise in the average temperature in Tigrai caused 39 percent increase in the price of onion, *ceteris paribus*.

Table4.3.Augmented Dicky-Fuller test for unit root on price of tomato

Augmented Dickey-Fuller test for unit root Number of obs = 76

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
		---------- Interpolated Dickey-Fuller ---------		
Z(t)	-5.152	-3.544	-2.909	-2.590

MacKinnon approximate p-value for Z(t) = 0.0000

D.dponion	Coef.	Std. Err.	T	P>|t|	[95% Conf. Interval]
L1.	3.113679	.5655991	-5.51	0.000 ***	-4.242314 -1.985043
LD.	1.557604	.5136121	3.03	003 ***	.532707 2.582501
L2D.	1.186641	.4541789	2.61	0.011 **	.2803417 2.092941
L3D.	.9234498	.3830264	2.41	0.019 **	.1591325 1.687767
L4D.	.7707081	.2981146	2.59	0.012 **	.1758298 1.365587
L5D.	.586104	.2083753	2.81	0.006 ***	.1702975 1.00191
L6D.	.2345798	.116744	2.01	0.048 **	.0016207 .4675389
_cons	4.052695	5.882374	0.69	0.493	-7.685399 15.79079

Note: *, ** and* are statistically significant at 1%, 5% and 10% respectively**

Opposite of what we have found in tables 4.1.and 4.2.above, the price of tomato in (2009) that is (L1); a single degree centigrade (°C) temperature increase caused the price of tomato vegetable in Tigrai to increase almost more than threefold (310percent). Likewise, in the year 2010 (LD) as the temperature increased by 1°C in Tigrai, the average price of tomato vegetables were increased close to 155 percent, *ceteris paribus*. Even the price of tomato vegetables increased by approximately to 118 percent in 2011(L2D) because of 1°C increase in the average temperature in Tigrai holding other effects constant. Lastly, in the L5D (2013) and L6D (2014) only, a 1°C raise in the average temperature in Tigrai caused close to 58 percent and 23 percent increase in the price of tomato, *ceteris paribus*. As it can be inferred from the mentioned tables above, the price increase is higher in the tomato vegetables because of the average temperature increase by 1°C in Tigrai (2009 to 2015), unlike that of potato and onion.

4.6. Co-integration Test

This test refers to the fact that two or more series share a stochastic trend. After we made a statistic test therefore found the variables are co-integrated. That mean price of vegetables has direct relationship with the average temperature increase by 1°C increase in Tigrai in the last seven years. Hence, the test statistic in the table 4.4 below witnessed that with a larger value as compared to that of the 5 percent critical value.

Table4.4.The result of Co-integrated test

dfuller e, lags(5) Augmented Dickey-Fuller test for unit root		Number of obs = 78		
		----- Interpolated Dickey-Fuller -----		
Test	Statistic	1% CriticalValue	5% Critical Value	10% Critical Value
Z(t)	-3.135	-3.537	-2.905	-2.588
MacKinnon approximate p-value for Z(t) = 0.0240				

4.7. Serial Correlation Test

In fact, White noise defined that a variable does not have an autocorrelation. Using the statistics test the outcome witnessed that there is no problem of serial correlation in this study. Similarly, the break test revealed that there is no problem of Chow test (test for known break) and unknown break test.

Table4.5.The outcome of Serial Correlation test

```
wntestq  prtomato,lags(6)
Portmanteau test for white noise
---------------------------------------
Portmanteau (Q) statistic =    50.5364
Prob > chi2(6)          =     0.0000
```

```
Wntestq prpotato,lags(4)
Portmanteau test for white noise
---------------------------------------
 Portmanteau (Q) statistic =   182.4024
 Prob > chi2(4)          =     0.0000
```

```
wntestq  pronion,lags(5)
Portmanteau test for white noise
---------------------------------------
 Portmanteau (Q) statistic =    90.9565
 Prob > chi2(5)          =     0.0000
```

5. Conclusion and Policy implication

The research is motivated to find out a new way in the price effect of climate change on the average price inflation of vegetables using time series data collected every month from 2009 to 20015 in Tigrai, Ethiopia. A univariate econometric analysis and finite distributed lag model was implemented in defining the variables and the outcome. In fact, the negative impact of climate change has various direct or indirect consequences. Of which it inflated more the important vegetables prices in the last seven years recorded data in Tigrai. More to the point, the price of tomato in (2009) that is (L1); a single degree centigrade (1^oC) temperature increase caused the price of tomato vegetable in Tigrai to increase almost more than threefold (310 percent) in 2015. Likewise, in the year 2010 (LD) as the temperature increased by 1^oC in Tigrai, the average price of tomato vegetables were increased close to 155 percent, *ceteris paribus*. Even the price of tomato vegetables increased by around 118 percent in 2011(L2D) because of 1^oC increase in the average temperature in Tigrai holding other effects constant. Lastly, in the L5D (2013) and L6D (2014) only, a 1^oC raise in the average temperature in Tigrai caused close to 58 percent and 23 percent increase in the price of tomato, *ceteris paribus*. As it can be inferred, the price increase is higher in the tomato vegetables because of the average temperature increase by 1^oC in Tigrai (2009 to 2015) than that of onion and potato. Although the average prices of potato and onion increment is not equal to the increment in tomato, but shows near to the tomato vegetables price rise in the past seven years in Tigrai as well.

In a nut shell, applying different econometric tests confirm that there were high vegetable price ups and downs every month parallel to the average temperature increase in Tigrai (2009 to 2015) though the degree of increment is not constant overtime.

Therefore, the research recommend that in order to get many healthy advantages in feeding vegetables often at an affordable price by many of us, implementing due climate adaptive strategies is decisive in tuning to the new agenda of 21st Century which is “Green Economic Development Policy” underway though with varied commitments in many countries of the World.

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