EFECTS OF CLIMATIC CHANGE FACTORS IN AGRICULTURAL PRODUCTION – CASE OF REPUBLIC OF MACEDONIA

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Abstract: The main purpose of this paper is to determine the contribution of climatic change factors such as temperature and precipitation on the agrarian economy in Republic of Macedonia. In order to examine the impact of fluctuations of climate change in the economy of Republic of Macedonia, it is applied a Granger Causality Analysis in order to examine the causal relationship of temperature and precipitation on agrarian economy in the case of Republic of Macedonia for the time period from 1991-2015. So far, results from many papers have indicated climate change as a statistically proven factor to substantially influence the economy in European countries, particularly when this relationship is analyzed in long run period.
Although there exist many scholars that have been dealing with this issue in many regions worldwide, in Republic of Macedonia still there is a gap regarding the effects of temperature and precipitation in the agrarian economy in Republic of Macedonia as well as the causality of temperature and precipitation, therefore results from this paper will make a solid contribution to this issue in Republic of Macedonia as well as can contribute to existing theoretical and empirical findings so far for many regions worldwide. Developing countries like Republic of Macedonia have adopted strategies and policies that must be implemented, since of the noticeable impact of climate change as a potential damaging factor and therefore we emphasized the climate change as an integral element taking into consideration during the planning, designing and implementing development activities, where the results of this paper can be taken as further consideration from the government of Republic of Macedonia.
Keywords: agricultural production, temperature, precipitation, Granger causality Test, co-integration.

INTRODUCTION

It is proven that increased agricultural output and productivity tend to contribute substantially to the overall economic development of one country; thus is rational and appropriate to place greater emphasize on further development of the agricultural sector. The agriculture sector is the backbone of an economy which provides the basic ingredients to mankind and now raw material industrialization and plays a strategic role in the process of economic development of a country. It has already made a significant contribution to the economic prosperity of advanced countries and its role in the economic development of less developed countries is of vital importance. In other words, where per capita real income is low, emphasis is being laid on agriculture and other primary industries. Together with the industrialization and urbanization, increase in agricultural production and the rise in the per-capita income of the rural community lead to an increased demand in industrial production.

According to Cline (2008) climate change can affect agriculture in a variety of ways. Beyond a certain range of temperatures, warming tends to reduce yields because crops speed through their development, producing less grain in the process. And higher temperatures also interfere with the ability of plants to get and use moisture. Evaporation from the soil accelerates when temperatures rise and plants increase transpiration—that is, lose more moisture from their leaves. The combined effect is called "evapotranspiration." Because global warming is likely to increase rainfall, the net impact of higher temperatures on water availability is a race between higher evapotranspiration and higher precipitation. Typically, that race is won by higher evapotranspiration. But a key culprit in climate change—carbon emissions— can also help agriculture by enhancing photosynthesis in many important, so-called C3, crops such as wheat, rice, and soybeans. (William R. Cline, 2008)

Agriculture makes its contribution to economic development in several ways:
1) By providing food and raw material to non-agricultural sectors of the economy;
2) By creating demand for goods produced in non-agricultural sectors, by the rural people on the strength of the purchasing power, earned by them on selling the marketable surplus;
3) By providing investable surplus in the form of savings and taxes to be invested in non-agricultural sector;
4) By providing investable surplus in the form of savings and taxes to be invested in non-agricultural sector,
5) By earning valuable foreign exchange through the export of agricultural products;

6) Providing employment to a vast army of uneducated, backward and unskilled labor force. As a matter of fact, if the process of economic development is to be initiated and made self-sustaining, it must begin for agricultural sector.

As we observe the growth of plant as well as the yield is primarily determined by the climatic settings of the particular topography, the major constraints of the plant growth and yields are rainfall, sun light, and temperature. Since, agricultural sector, including value added processing of agricultural products accounted for 16% of the country's GDP and provide employment for 36% of the workforce. The last census registered 192,675 family farms (in a country with 2.1 million inhabitants). Accordingly, and having also in mind that 42% of the country's population lives in rural areas where employment opportunities outside the farms are quite limited (the unemployment rate of the active labour force in Macedonia is 32%), more realistic conclusion would be that the agricultural sector is essential to the welfare of about half the country's population. Agriculture and rural economies that exploit natural resources are particularly vulnerable to various anthropological stresses, including climate hazards, variability and long-term climate change. Although there has been a serious concern towards the mitigation and adaptation of climate change, the scientific study to capture the impact of climate variability and the vulnerability to the agricultural sector especially to the production is yet to be identified.

DATA AND RESEARCH METHODOLOGY

The study area is Republic of Macedonia. This study uses time series data from 1991 to 2015. The data for precipitation (P) and temperature (T) were collected from the National Hydro Meteorological Service in Republic of Macedonia (http://www.meteo.gov.mk) that covers the collection of major 8 meteorological stations (*Skopje*, *Bitola*, *Shtip*, *Prilep*, *Berovo*, *Ohrid*, *Demir Kapija and Kriva Pallanka*) and the Agricultural Gross Domestic Production (AGDP) data are obtained from the Ministry of Finance of Republic of Macedonia (http://www.fin.gov.mk) and State Statistical office in Republic of Macedonia (http://www.stat.gov.mk). The data set of this analysis consists of average precipitation and average temperature data, covering the time period from January 1991 to December 2015. The spin of data set is covered with the reason of availability of unbroken series of temperature, rainfall and macroeconomic indicators data.

In order to analyze the data, descriptive statistics and Co-integration analysis were used. The co-integration analysis involve unit roots test performed on both level and first difference to determine whether the individual input series are stationary and exhibit similar statistical properties. It must be noted that regressing a non-stationary time series data over another non-stationary time series data gives a spurious or nonsense regression. In order to correct this, a unit root test is performed. A time series data is stationary if the joint distribution of any set of *n* observations $X_{(t1)}$, $X_{(t2)}$, …$X_{(tn)}$ is the same as joint distribution of any set of $X_{(t1+k)}$, $X_{(t2+k)}$, …$X_{(tn+k)}$ for all *n* and *k*.

$$Y_t = pY_{t-1} + U_t, \qquad 1 \leq p \qquad (1)$$

$1 \leq p$ where U is the white noise error.

If Y_t is regressed on its lagged value of Y_{t-1} and the estimated p is statistically equal to 1, then Y_t is non-stationary, thus it exhibit unit root [I(1)]. On the other hand, if the estimated value of *p* is does not equal to 1, the Y_t is stationary that is, has no Unit root [I(0)].

Augmented Dickey Fuller (ADF) Test was used to test for the stationarity of the data. The test consists of the following regression:

$$\Delta Y_t = \beta_1 + \beta_{2t} + \delta Y_{t-1} \alpha \sum_{t=1}^{n} \Delta Y_t + \varepsilon_t \qquad (2)$$

Where,

$$e_t = \Delta Y_{t-1} = (Y_{t-1} - Y_{t-2}), \qquad \Delta Y_{t-2} = (Y_{t-2} - Y_{t-3}) \qquad (3)$$

The Johansen procedure was used to test the number of co-integration vectors in the model. Johansen technique was used not only because it is vector auto-regressive based but because it performs better in multivariate model (Maddala (2001)). If X_t and Y_t are co-integrated, their short-run dynamics can be described by Error Correction Model (ECM). The theory states that if two variables Y and X are co-integrated, then the relationship between them can be expressed through ECM. The co-integration model is given as:

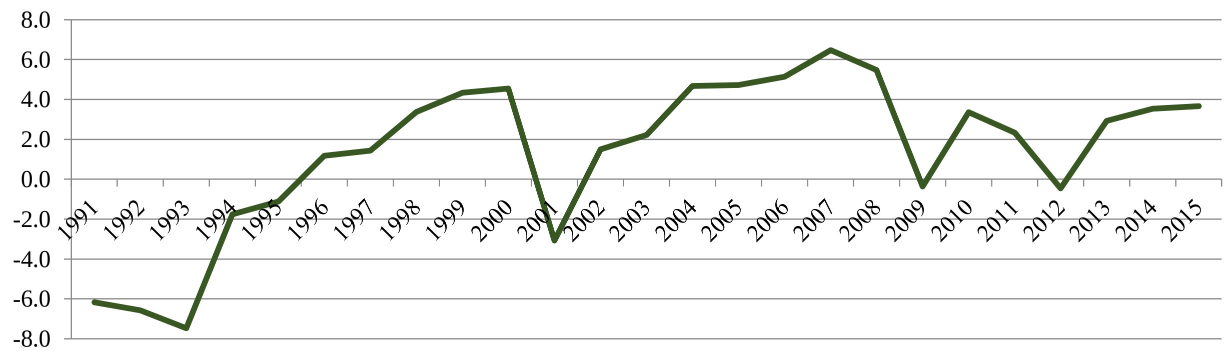
$$LY_t = \beta_0 + \beta_1 LX_{1t} + \beta_1 LX_{2t} + U_t \quad (4)$$

Where Y_t =Agricultural Gross Domestic Production (AGDP)
X_1 = Annual average temperature (°C),
X_2= Annual average precipitation (mm)

MAIN CARACTERISTICS OF REPUBLIC OF MACEDONIA

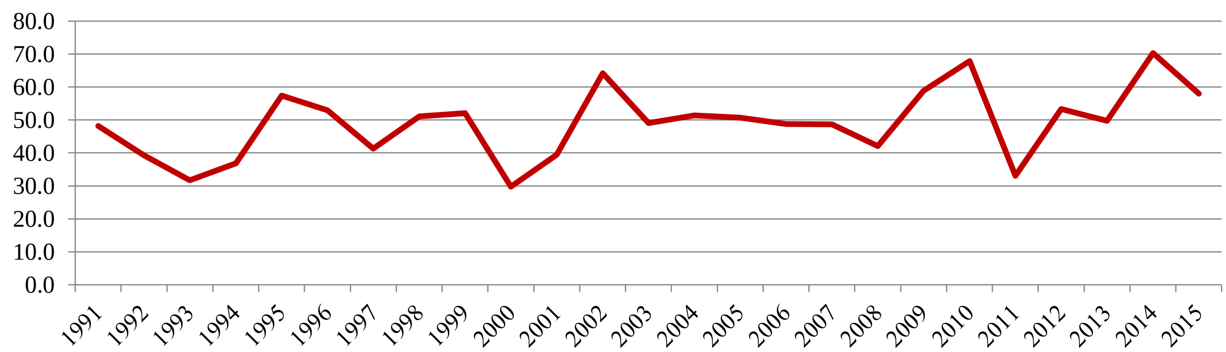
Republic of Macedonia is located in the central Balkan Peninsula in Southeast Europe. It is one of the successor states of the former Yugoslavia, from which it declared independence on the September 8, 1991. The country's capital is Skopje. According to the State Statistical Office in Republic of Macedonia, based on 25,713 sq. km, a bit more than 2 million inhabitants live. However, since lately Macedonia faces fairly large emigration rates and in an absence of official census since 2002, it is believed that the total population is below that figure.

Figure 1.1: GDP growth rate (%) from year 1991 to 2015 in Republic of Macedonia



Moreover, Republic of Macedonia was severely hit by the breakup of Yugoslavia. The fall in the GDP after the break up was more persistent than in other republics, despite the fact that it did not experienced a war. Further, the recession following the transformation, was very prolonged in Macedonia. The first year in which GDP has started growing was during 1996 (Figure 1.1).The economy sank even further in the nineties due to numerous factors: the disintegration of the common market, the wars in the former Yugoslavia, the Greek blockade, sanctions against Yugoslavia and many others. At the end of the nineties the economy started its slowly rising, but it was again interrupted by the war in Kosovo in 1999 and the war conflict in 2001. Finally, nowadays is present the increased recovery and development of the economy. Indeed, Unemployment presents the biggest problem, stating to be about 28%. Moreover, the level of domestic and foreign investment is also low. Macroeconomic indicators are good, and the state has high skilled but cheap labor. The infrastructure is in relatively good condition, but still more investment are needed in this area.

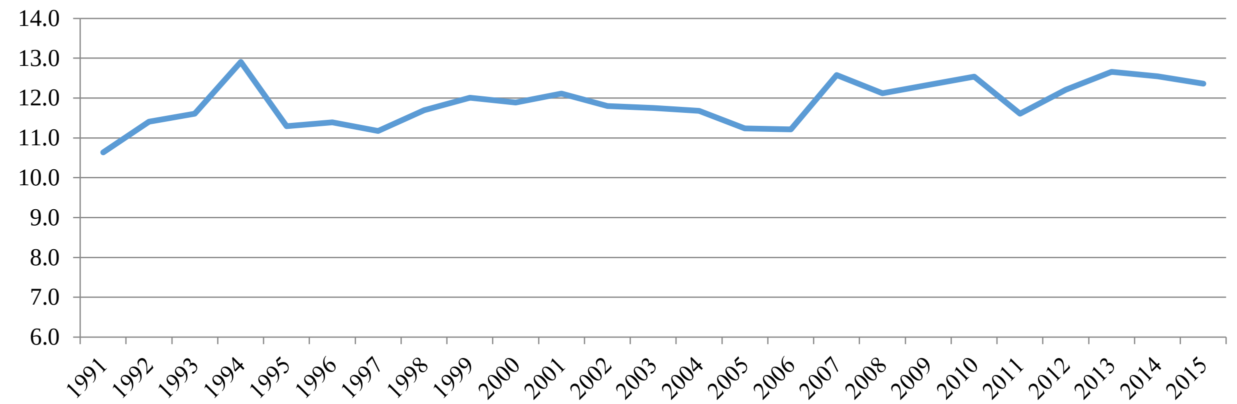
Figure 1.2: Average Precipitation from year 1991 to 2015 in Macedonia



Climate change can enhance higher incidence of flooding that as a results might change the condition of precipitation. Further, these future changes in weather condition will also affect different regions in different ways

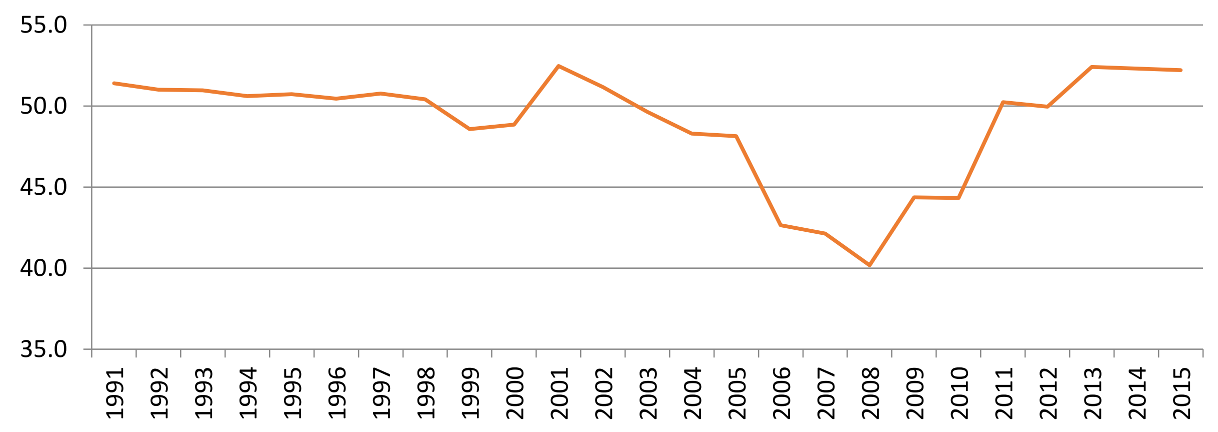
(*Intergovernmental Panel on Climate Change*, 2001). On the other side, precipitation might decrease in high latitude regions when experiencing high temperatures. As a result, such situation can cause water crisis among agriculture. This impending water crisis could be solve if there is another water treatment plant that is built to process raw water and support state heavy usage. Furthermore, inconsistent precipitation in developing countries might be risky, thus also indicating negative indirect effects towards GDP growth rate.

Figure 1.3: Average Temperature (°C) from 1991 until 2015 in Republic of Macedonia.



The above figure shows the trend of annual temperature which is measured in degree Celsius from 1991 until 2015 in Republic of Macedonia. Macedonians temperature is increasing throughout the entire period. Although there is present a certain decrease during some years, yet it remains high and unstable. Moreover, we can notice the peak value during 1994, and the lowest during 1991.

Figure 1.4: Agricultural land (% of land area) from year 1991 to 2015 in Macedonia



Recent studies suggest that tropical forest can acts as lung of our planet, where it helps regarding the filtering of carbon dioxide and provides the oxygen during photosynthesis.

As a result by decreasing the tropical forest will lead to higher temperature as well as carbon dioxide emissions. Thus, it will cause an indirect reducing effect at GDP growth rate. Recent evidence claims that people have graduated from the consumption of highly scary food to the consumption of more proteins, fruits and vegetables. Moreover, changes of consumer taste effects the size of agricultural land for the mean of production regarding different agricultural crops such as fruits and vegetables. These subsequent taste changes are mainly due to increased per capita income, resulted to the change in agricultural land use in favor of highly rewarding and better-demanded crops like fruits and vegetables, thus causing dynamic agricultural land use.

It is widely known that the production of one economy is crucially affected by the factors of production, such as land, labor, capital and technology. However, there exist and other factors that play dominant role in the agricultural sector, such as rainfall, chemical fertilizers, availability of seeds as well as irrigation facility. Rainfall and

temperature effects at output in this sector can be important especially at developing and least developed economies that deal with the unavailability of irrigation, having problems for improving the seeds and getting fertilizers.
Moreover, the *t* indicates the years, ***AGDPt*** represents total real value addition of the agricultural sector in a given year, ***Prec*** denotes the annual average rainfall in milliliters while **Temp** indicates the annual average temperature calculated from the average of minimum and maximum temperature across the country. The main hypothesis of this paper sets rainfall and temperature as two most significant variables for agricultural production in Republic of Macedonia.
Before estimating the effects of temperature and precipitation, we test the stationarity of time series for each variable statistically and graphically. Moreover, we utilize Augmented Dickey Fuller (ADF) test for unit root for testing the statistical identification of stationarity. This method is used since it gives the optimal lag number to be included in an analysis. By applying one of the crucial lag-length criteria, such as Schwarz Info Criterion (SIC), we can identify the lag length in this model. When the variables are found to be stationary in level, they are included at level while variables that are stationary at first difference are included accordingly to this result.

TEST RESULTS AND ANALYSIS
The main objective of this study is to investigate the effects of climatic factors such as temperature and precipitation on agricultural GDP. Moreover, the below Table 1 represent descriptive statistics regarding the three included variables. Indeed, the data distribution was examined by using graphs and standard descriptive statistics namely mean, standard deviation, maximum, minimum, skewness and kurtosis. De facto, skewness and kurtosis represent the nature of normality departure, where in normally distributed series, skewness is 0 and kurtosis is 3. Moreover, if there are present positive or negative skewness, it indicates asymmetry in these time series while a value less or greater than 3 of the kurtosis coefficient, implies flatness and peakedness.
Table 1: Descriptive Statistics of Variables

	AGDP	**Temperature (Temp)**	**Precipitation (Prec)**
Mean	30562.5	11.92083	49.07917
Minimum	1264	11.2	29.8
Maximum	55623	12.9	70.3
Std. Dev.	14568.57	.5124359	10.85053
Skewness	-.0204426	.1898869	.0345687
Kurtosis	2.260459	1.933882	2.423026
Observations	24	24	24

Source: authors calculations
The properties of these time series regarding these three variables are investigated through utilizing Augmented Dickey Fuller Test for testing the unit root regarding the stationarity of the data. Table 2 gives the results of ADF test, accepting the null hypothesis that there is unit root at 1%, 5% and 10% significance level when compared with the respective critical values. From Table 2, we can notice that the variables under study (AGDP, Temp and Prec) are of all behavior.
Moreover, stationarity of the variables is obtained on their first difference, showing the same order as required, except for the variable AGDP. Thus, they are stationary at first difference. Since all the remaining series are found to be stationary at first difference, it is concluded that each series are intergraded of order one, I(1) and RGDP is integrated of I(2).

Table 2: ADF Test

Variables	Intercept				Intercept & Trend			
	Level		First difference		Level		First difference	
	t – stat	p - value	t - stat	p - value	t - stat	p - value	t - stat	p - value
AGDP	-4.445	0.0019	-4.187	0.0047	-0.881	0.7943	-4.388	0.0003
Temp	-3.492	0.0403	-6.486	0.0000	-2.762	0.0639	-6.652	0.0000
Prec	-5.018	0.0002	-4.792	0.0000	-4.223	0.0006	-4.971	0.0000
lnAGDP	-6.397	0.0000	-6.347	0.0000	-1.358	0.6021	-7.488	0.0000
lnT	-3.481	0.0415	-6.442	0.0000	-2.747	0.0662	-6.607	0.0000
lnP	-4.142	0.0008	-4.441	0.0019	-4.838	0.0004	-4.617	0.0001

Source: author's calculations.
JOHANSEN-JUSELIUS TEST FOR CO-INTEGRATION

For detecting the co-integration relationship between variables, Johansen-Juselius procedure was implemented. Moreover, Table 3 indicates trace statistics and maximum eigenvalue values, thus showing one co-integrating relationship, indicating as well the presence of long-run equilibrium relationship between these variables. If the variables are found to have unit roots (are non stationary), and have same order of integration, this indicates the tendency of variables to move together in the long run. (Engle-Granger (1987)). Further, the Johansen-Juselius procedure (Johansen-Juselius 1992, 1999) had overcame the associated problem of spurious correlation and misleading inferences, thus it is also applied in our paper. If results indicate that variables are co-integrated, this relationship represents its long run relationship.

Table 3: Unrestricted Co integration Rank Test (Trace)

Hypothesized Number of Co integrating Equations	Eigen value	Trace Statistic	5% Critical Value	1% Critical Value
None		39.7933	29.68	35.65
At most 1	0.71910	11.8586*	15.41	20.04
At most 2	0.38701	1.0916	3.76	6.65
At most 3	0.4841			

Hypothesized Number of Co integrating Equations	Eigen value	Max Statistic	5% Critical Value	1% Critical Value
None		27.9347	20.97	25.52
At most 1	0.71910	10.7677*	14.07	18.63
At most 2	0.38701	1.0916	3.67	6.65
At most 3	0.4841			

Source: author's calculations.

The above table indicates the results of co-integration test applied through trace statistics and max statistics. By using the determined lags 2, trace statistics value of 11.8586 is smaller than 5% critical value of 15.41. So we can reject the null hypothesis. Analyzing the maximum Trace statistic value of 10.7677, we can see that it is smaller than 5% critical value of 14.07. Therefore we can reject null hypothesis, suggesting existence of co-integration and long run association.

GRANGER CAUSALITY TEST

In the empirical literature there is evident of many models that assume different hypotheses regarding the variables relationship, however they did not ensure exact variables cause and effect relationship. In this regard, Granger (1969) for the first time defined the lag relations based on the role of predictability; by using twin factors of VAR in order to find variables causality among them. The following table indicates the results of Pair wise granger Causality Test.

Table 4: Pair wise Granger Causality Tests

Null Hypothesis	Observation	lag	F-test	P-value	Decision
Temp does not Granger Cause AGDP AGDP does not Granger Cause Temp	24	**2** 2	**3.8127** 2.6727	**0.0458** 0.1017	**Reject Ho** Do not reject Ho
Prec does not Granger Cause AGDP AGDP does not Granger Cause Prec	24	2 2	.4701 2.7105	0.6338 0.0989	Do not reject Ho Do not reject Ho
Temp does not Granger Cause Prec Prec does not Granger Cause Temp	24	2 2	3.8127 1.8172	0.6585 0.1965	Do not reject Ho Do not reject Ho

Source: author's calculations.

The results in Table 4 indicate that by adopting Pair wise Granger Causality test in order to examine the causal relationship among the three variables. In this method, Ho is accepted at 5 percent level, where Granger causality test is applied to test the relationship between the variables. Moreover, F-statistics significance of explanatory variables was tested for each function. Indeed, we can emphasize that through Granger causality test we can see that the null hypothesis is only rejected for the causality between Temperature and AGDP, at 5% level of significance, indicating a unidirectional causality among these variables running from Temp to AGDP. For Prec and AGDP, Ho is not rejected at 5 percent level of significance. This means that Prec has not contributed significantly to the actualization of AGDP in the country. Also for Temp and Prec, Ho is not rejected at 5 % at level of significance. This means Temp and Prec does not have causality relationship among them in Republic of Macedonia, during the analyzed period.

SUMMARY AND CONCLUSIONS

Since we know that agriculture sector represents the backbone of one economy by providing the basic ingredients to mankind by already making a significant contribution to the economic prosperity of advanced countries as well as its role in the economic development of less developed countries is of vital importance, we saw it appropriate to investigate the causality relationship among AGDP, temperature and precipitation in Republic of Macedonia.

The first step of the empirical analysis included the selection of lag order and the implementation of Augmented Dickey Fuller test in order to check the stationarity of the data. Results indicated that variables are non-stationary (have unit root) at their level, while showing to become stationary at their first difference. Thus, by implying the Johnsen-Jusilius test for co-integration we find that the integration order is one. Moreover, the results of Granger causality test indicate the causal relationship among these variables in Republic of Macedonia for the analyzed period. Further, these results indicate the existence of **unidirectional causality among AGDP and Temperature**, indicating the causality to run from **Temperature to AGDP** and found no causal relationship among AGDP and precipitation and among Temperature and Precipitation.

Such results indicate that **in Republic of Macedonia, temperature is the most important variable of climate change that affects its agricultural activity**.

Finally, in Republic of Macedonia there is a gap regarding the effects of temperature and precipitation in the agrarian economy in Republic of Macedonia, thus the causality of temperature and precipitation, therefore results from this paper make a solid contribution to this issue in Republic of Macedonia as well as can contribute to existing theoretical and empirical findings so far for many regions worldwide.

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