

Influence of Global Climate Change on Production: Correlation between the Production Index and Temperature Changes in Istanbul

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Extensive Summary

Agricultural production has always been shaped by climate conditions that directly affect all the activities relating to needs for sheltering, nourishment and energy. Therefore, one of the mostly concerned issues is global climate change and there exists some debate on whether that change will occur as warming or cooling. But it is a common opinion that global climate change will manifest itself with some extraordinary weather events and natural disasters. Recently, scientists and other interested parties have started searching for the effect of these changes especially on production.

As a result of rapid growth in population, diversification and expansion in the types and number of goods and services produced and consequent upward trend in production level due to this diversification, companies have increased their capacity utilization rate thereby contributing more to greenhouse gas effect. There are an enormous number of studies focusing on climate change, but not much on its consideration within the context of accounting and finance, so we are encouraged to concentrate our attention and effort on this subject. At this juncture, it is needless to say that among the important issues to question are which industries shall be influenced positively and negatively by climate change and the magnitude of these influences. Recent research has indicated that especially such industries as transportation, tourism, food and energy could be unfavorably affected while the effect on the industries such as chemistry, construction, machinery and electricity engineering, and renewable energy is supposed to be relatively favorable. Moreover, the extent to which finance, agriculture, forestry and textile industries shall be affected by any undesirable changes in climate is assumed to be dependent on the dimension of regulatory market economy.

Looking into the history of research relating to global climate changes, we observe that majority of them are concerned mainly with analyses associated with greenhouse gas and emission beat indicators, but few concrete studies emphasizing the

effect of climate change on production have existed thus far. In a study carried out by Hübler et al. (2008), the impact of climate change on both human health and production activities was investigated and it was concluded that expected temperature changes could probably decrease work performance, leading to a sextuple rise in healthcare expenditures during the period of time spanning the years between 2071 and 2100. Another study done by Olesen et al. (2010) to search for possible influences of climate change on the production systems in Europe covers 26 European countries and points out considerable variations especially in agricultural production within the recent decade. Furthermore, Kemfert (2007) provided a significant warning, as a consequence of his study, that the average temperature in Germany may tend to rise by approximately 4,5 degrees up to the year 2100 unless some precautionary measures are taken beforehand, which may lead up to huge economic losses amounting to 800 billion EUROS in the country.

It is also possible to mention many other studies in the literature pertaining to such related topics as carbon bourse, accounting for carbon beat, and so on. Being inspired of this intense and hectic interest in climate change and its effects on many aspects of life and economy, this paper is intended to explore a probable relationship between fluctuations in production index and changes in temperature in order to test our hypothesis that upward changes in temperature cause directly proportional movements in production index. To achieve the test, the data of both production index values calculated on a monthly basis and the daily temperatures measured in Istanbul for the time period between January 1986 and December 2008 were collected to apply econometric analyses on them. Since the production index data are monthly, the temperature measurements were converted to monthly averages by computing simple mean for each month. In the end, we have come up with 276 monthly observations with paired numbers.

The empirical part of our study starts with our descriptive findings to argue the validity of model assumptions regarding normality of variable distributions. Then, a Johansen Cointegration Analysis has been done to diagnose the assumed long-term relationship between the variables, followed by EGARCH (Exponential Generalized Autoregressive Conditional Heteroskedasticity) modeling that was conducted to unveil volatility effects between them. Additionally, we have undertaken Cross Correlation and Granger Causality tests to portray a lead-lag (cause-effect) profile between temperature and production index and also conducted a Variance Decomposition Analysis to mark the extent to which the production index is affected by changes in temperature. We have also used the ARCH-LM test in our determination on the presence of autocorrelation among error terms. Finally, the study ends with some parametric and nonparametric correlation analyses on the new data set containing 12-month moving averages of production index and temperature.

According to the results of normality test, both of the variables seem to not distribute normally, but slightly skewed to the right and are platykurtic. Our cross correlation analysis results suggest that the production index variable behaves as a lagged (effect) variable for up to a three-month lag and is affected by temperature changes in direct proportion. On the other hand, the group unit root tests that we have conducted before the implementation of cointegration analysis suggest that the variables are not stationary, which has compelled us to take the first differences of each series so as to make them stationary. A further unit root test carried out on the differenced data

sets has indicated that the variables are stationary and suitable for cointegration analysis while new cross-correlation results still continue to prove our previous conclusion that the production variable is an effect variable up to three months. In addition, the VAR residual normality tests on the data sets of first differences show that the distributions are almost normal or very approximate to a normal distribution.

Prior to cointegration analysis, we have determined the best lag order (or length) for both of the variables to be 13 months according to five separate criteria; LR, FPE, AIC, SC, and HQ. Subsequently, a Johansen cointegration analysis has been performed as based on this selected lag order. The analysis provides important findings supporting the idea that there is at least one cointegration relation between the variables at 5 % significance level. Respecting the proposed cointegration equation, it can be concluded that a change of one degree in temperature is expected to create a direct proportional change of 16,24 units in production index. Meanwhile, as the Granger statistics suggest, there exists a statistically significant leading effect even at 1 % from temperature to production index for all the lag orders up to 5-month lag whereas the leading effect from production index to temperature is substantial and significant only for the 4th and 5th orders at 1 %, but less important when compared to the effect from temperature to production.

Separately, our variance decomposition findings reveal that at most 4,38 % of changes in production index is being caused by temperature variation, Even though this rate of explained variation is relatively small, we consider this finding to be noteworthy in investigating an interconnection between the variables of interest.

For the presence of autocorrelation in dependent variable is an important condition that should be satisfied to be able to execute an accurate modeling study on volatility, we have tested autocorrelation phenomenon for the production index series (first differences) using the ARCH-LM test for the lag order of 13. The test statistics support the presence of autocorrelation at the 2 % significance level. Afterwards, a EGARCH (1,1) model with one-month lagged ARCH and GARCH parameters and an additional parameter representing asymmetric effect has been developed in that temperature changes are included as another independent variable. The model results demonstrate statistical significance both of the ARCH and GARCH parameters (at 2 % and 5 % respectively) and of the effect of temperature changes on the index volatility (at 1 %) while no sufficient proofs can be revealed that suggest the importance of asymmetric effect parameter at 5 %. Furthermore, the ARCH-LM statistics for 5 and 15 periods of lag lead us to produce a adequate conclusion about the absence of autocorrelation among the model error terms, which enables us to deem our model to be accurate in prediction. Similarly, the ADF unit root statistics for the model's estimation errors suggest that the error terms are stationary at all levels.

The parametric and nonparametric correlation statistics obtained for the paired data set that includes 12-month moving averages of both variables as a matter of the need to deseasonalize affirm our expectation and previous findings about the existent relationship between production and temperature. All the correlation statistics (Pearson's correlation Coefficient, Spearman's Rho, and Kendall's tau-b) are found to be significant at 1 %, showing a moderately strong connection between the variables.

It is satisfactory for us to end up with important findings and conclusions strengthening our belief that production is not independent of climate conditions,

especially changes in temperature. Our hypothesis suggesting the positive connection of production level with temperature is not rejected in light of the statistical findings of this study. We recommend for further research on the topic to capture probable effects of other extraneous variables as well as temperature that are supposed to influence production performance, in order to achieve a higher degree of prediction accuracy.