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The Impact of Temperature Variability on Food Security of Cereals in Morocco: An Econometric Approach by VECM

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Abstract

The objective of this study is to determine the influence of temperature variability and some variables on the food security model of cereals in Morocco. Many variables can play a role in this model. The variables selected for analysis were temperature variation, grain land area, grain imports, fertilizer consumption, and energy consumption. These five independent variables were tested to determine their effect on the food security pattern of cereals in Morocco. This study uses time series data by treating the period from 1981 to 2014. An econometric analysis of food security was conducted for this purpose through the vector error correction model VECM (Vector Error Correction Model) approach. The results of our model estimation show that there is significant long-run causality between food security and the explanatory variables. It was also found that there is a short-term relationship between grain food security and the following variables: Temperature variation, cereal import, and cereal area.

Keywords: Food security, cereals, Morocco, Agriculture, temperature variability, VECM

1.0 INTRODUCTION

Food security in Morocco is a very important issue for the daily life of Moroccans, especially the poor and middle class citizens.

Cereal production is a dominant activity in Moroccan agriculture, both in terms of the area it occupies and the population that depends on it (Ministry of Agriculture and Agrarian Reform, Kingdom of Morocco, 1992).

It represents a multiple role in the agricultural Gross Domestic Product, and in the creation of employment in the rural environment. Cereals are represented essentially by the crops of soft wheat, barley, durum wheat and corn. In Morocco, sorghum and rice are also grown, but with less importance. Morocco focuses mainly on wheat, as it is the most demanded by its population. Agricultural production, and in particular cereal yields, show very high inter-annual variability in Morocco due to uncertain rainfall and periods of drought.

Lately, national cereal production has not been able to cover the country's needs due to low productivity, even in years with sufficient rainfall. This has motivate this research to find the determinants of food security of cereals in Morocco. The challenges facing this country are numerous: poor soils, uncertain rainfall, increasing population pressures, drought, and weaknesses in research and technology delivery systems. In addition, the long-standing neglect of agriculture by political leaders is among the causes of the current food crisis. As a result, agricultural and rural development is given low priority.

So, can the explanatory variables for grain production play an important role in ensuring future food security in Morocco? Is there significant long-term causality between the dependent variable and the explanatory variables? And is there a short-term causal relationship between food security and temperature variability? Furthermore, do these variables have a positive or negative effect on food security in Morocco?

To answer these questions, we will use an estimation by the VECM model. This model is the most appropriate because it allows us studying the short term and long term relationship between the food security of cereals and the explanatory variables. Then, in the second part of our paper we will present the literature review. Then in the third part we will present the methodology and the data that we have used for for modeling. The fourth part will be dedicated to the presentation of the results of the estimation of the VECM model, and to the analysis and discussion of the results. At the end we will present a conclusion with recommendations.

2.0 LITERATURE REVIEW

There are several research studies dealing with the topic of food security and grain production. The question we wish to examine is whether energy, cereal land area, cereal imports, fertilizer consumption and the climate variable contribute positively or negatively to the resolution of cereal food security constraints in Morocco. We want to better understand how these explanatory variables are likely to impact the model.

Food security

"Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996).

According to the FAO report in 2019, food insecurity has affected 750 million people worldwide, or nearly one in ten people worldwide.

In an article by Onyutha, C. (2018), an analyzis of trends and variability of grain production, yield and harvested area from 1961 to 2014 and the ratio of production to population (RPP) was carried out. Finding results that by 2050, poverty will increase in Africa, which will lead to high food insecurity in many African countries. Therefore, to ensure food security, it is recommended that the reduction of yield gaps be complemented by improved market access for smallholder farmers and the promotion of off-farm income-generating activities.

Temperature

Climate change is a factor that negatively impacts food security worldwide. It impacts both the environment and the well-being of the population. Drought has become a real threat that directly impacts agricultural production, especially cereals which are highly dependent on rainfall. The article by Pickson RB & Boateng, E (2021) dealt with the impact of climate change on food security in 15 African countries in the period from 1970 to 2016, showing in their results that rainfall plays a decisive role in Africa's food security. However, the level of the effect of rainfall is not the same, it changes from one country to another. In the long term, they found that the impact of climate change does not significantly affect food security. However, in the short term, extreme temperatures impact food security.

In the same context, Morocco is facing two challenges, one to ensure food security and two to address drought. According to the Moroccan Ministry of Agriculture, drought is expected to gradually intensify in Morocco until 2050 due to the decrease in rainfall (-11%) and the increase in temperature (+1.3°C).

Cereal acreage

Most research has focused on increasing the yield per hectare of cereals through improved cultivars (Reynolds, M.P et.al), nitrogen management (Davis, K.F et.al), irrigation patterns (Wang, Z. et.al). However, few studies have attempted to clarify variations in cereals (rice, wheat and maize) production and cropped area, and to detect relationships between cropped area and production in Morocco.

Fertilizer consumption

Morocco has long been considered a phosphate giant, with more than 70% of the world's phosphate reserves. Hosphates are in ever-increasing global demand.

According to the FAO report (2006), fertilizer consumption by cereal crops in Morocco varies from year to year. Since the country is very dependent on rainfall, when it has a good year, farmers consume a little more fertilizer. But this level is still low. This situation is explained by the increase in the cost of fertilizer, which is not compensated.

Energy efficiency in Moroccan agriculture

The agricultural sector faces a real challenge to maximize energy efficiency, such as limited fossil fuel reserves and the problem of greenhouse gases. According to the FAO report, the food sector accounts for about 30% of the world's energy consumption, and it produces more than 20% of global greenhouse gas emissions. Noting that butane gas is subsidized by the state. Butane gas has become in the last decade one of the main sources of energy used for pumping groundwater in farms. Imane Raïs (2016).

Importation

Morocco is one of the countries in the North Africa region that are net importers of food products. They import, for example, more than 30% of their cereal consumption. Racha Ramadan 2011.

Morocco remains dependent on cereal imports. Nearly 61 million quintals of cereal imports with an average annual cost of 8 billion MAD were estimated between 2008 and 2018 (DEPF, 2019; ONICL, 2018). An empirical study e R. HARBOUZE et al, 2020 carried out based on surveys with the managers of 78% of cereal importing companies. The purpose of this study was to analyze the role played by futures markets in current cereal imports in Morocco. The results show that access to price risk hedging instruments for cereal importers is limited and occupies 26% of importing firms and concerns mainly traders and some grain merchants.

In the following section, we will present the data we used and the working methodology we followed to make the VECM model.

3. Data and Methodology

3.1. Data

The following linear regression model is used:

$$Y_t = \alpha_0 \, SCC_t^{\alpha_1} \, E_t^{\alpha_2} \, ENG_t^{\alpha_3} \, IMP_t^{\alpha_4} \, TEMP_t^{\alpha_5} \, \varepsilon_t \qquad (1)$$

Variables and Proxies:

The food security variables used in this study over the period 1981-2014 are:

-Dependent Variable :

Y : Gross Grain Production Index per Person CPI (Reference 2014-2016) which is a proxy for grain food security. (Source : FAO)

- Independent variables :

SCC = Cereal cultivated area (Land devoted to cereal production in hectares) (Source: The World Bank).

IMP = Total imports of the four major grains in 1000 Qx (June/May) (% of merchandise imports) (Source:https://www.onicl.org.ma/portail/situation-du-march%C3%A9/statistiques)

TEMP = Temperature variation in Morocco measured in C° (Source: FAO)

ENG: Fertilizer consumption (Source: World Bank)

E: Energy use (World Bank)

Taking the logarithm of (1) we have the following:

$$\ln(Y_t) = \alpha_0 + \alpha_1 \ln(SCC_t) + \alpha_2 \ln(E_t) + \alpha_3 \ln(ENG_t) + \alpha_4 \ln(IMP_t) + \alpha_5 \ln(TEMP_t) + \varepsilon_t$$

With:

$\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4$, et α_5 are the coefficients of the explanatory variables.

ε = error term; and t represent the period of time series.

3.0 METHODOLOGY

To estimate the model, we use the VECM (vector error correction model), which is applied when the series are not stationary but cointegrated. It allows us to study the long-term stable relationships while at the same time analyzing the dynamics of the short-term variables. We will use Eviews software (reference please).

To estimate our parameters in the model we must first test the stationarity our series, then determine the optimal number of lags, then do a cointegration test, finally estimate the VECM model and validate the model

3.2.1. Stationarity of variables

All variables used in this model are tested for stationarity using the unit root test. The time series stationarity test ensures that the variables used in the analysis do not give spurious results. The standard Augmented Dickey-Fuller (ADF) test is used. A stationary series is one that has constant mean and variance over time and constant autocovariances for each given lag (Barreto & Howland, 2006).

3.2.2. Determining the number of lags:

To determine the order of a VAR model, the Akaike criterion is used. The procedure for selecting the optimal number of lags consists of estimating all VAR models for an order up to the maximum lag allowed by economic theory or by the available data. (reference please).

3.2.3. Cointegration test

The cointegration test is used to test the existence of the long-run relationship between two non-stationary variables.

3.2.4 Study of the VECM model

It is important to verify the existence of a causal relationship between the variables of our model. Because this will allow us to have a better understanding. (To do this, we will try to verify empirically whether the exogenous variables selected influence our endogenous variable, we will use a VECM (Vector Error-Correction Model).

4.0 RESULTS AND DISCUSSION

Table 1: ADF test

Source: Eviews software output (prepared by the author)

Variables	**Level**	**First Difference**	**Inference**
LNY	ADF 1% 5% 10% -4.36098 -4.256987 -3.536789 -3.236985	ADF 1% 5% 10% -5.048430 -2.647120 -1.952910 -1.610011	I (1)
LNSCC	ADF 1% 5% 10% -6.475150 -4.262735 -3.552973 -3.209642	ADF 1% 5% 10% -6.753409 -2.641672 -1.952066 -1.610400	I (1)
LNTEMP	ADF 1% 5% 10% - 4.907440 -4.262735 -3.552973 -3.209642	ADF 1% 5% 10% - 10.01970 -2.639210 -1.951687 -1.610579	I (1)
LNIMP	ADF 1% 5% 10% -5.308285 -4.262735 -3.552973 -3.209642	ADF 1% 5% 10% -11.11093 -2.644302 -1.952473 -1.610211	I (1)
LNE	ADF 1% 5% 10% -3.155075 - 4.262735 -3.552973 -3.209642	ADF 1% 5% 10% -8.097147 -2.644302 -1.952473 -1.610211	I (1)
LNENG	ADF 1% 5% 10% -3.904849 -4.323979 -3.580622 -3.225334	ADF 1% 5% 10% -5.762633 -2.650145 -1.953381 -1.609798	I (1)

All variables are stationary and differentiated of first order I(1) with a DS Process. It is important to test for the presence of cointegration between the variables. If the cointegration relation is verified, we will use a VECM model, otherwise we will opt for a VAR model. But before that we must determine the number of optimal lags.

Test to determine the optimal lags:

This step is used to determine the optimal number of lags for the estimation of the model, this number influences the quality of the estimation, as well as the relative number of cointegrations. The results of the optimal lag determination test applied on the model data are provided by the Eviews 12 software as follows:

Table 2: VAR Lag Order Selection Criteria
Source: Eviews 12 software output (prepared by the author)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	147.9631	NA	4.24e-12	-9.158913	-8.881367	-9.068440
1	267.9822	185.8359*	1.97e-14*	-14.57950	-12.63667*	-13.94618*
2	293.9012	30.09955	5.01e-14	-13.92911	-10.32102	-12.75296
3	356.0063	48.08135	2.23e-14	-15.61331*	-10.33994	-13.89432

The results of the test for determining the optimal lag inform about the lag 3 as optimal, as it was defined by the AIC criterion. To estimate our model we will proceed to the cointegration test.

Test of cointegration between variables

The evaluation of the cointegration of the variables in the study, as well as the degree of their cointegrations, is carried out using the Johansen test under the following assumptions: Null hypothesis: The statistical series of the study variables are not cointegrated; Alternative hypothesis: The statistical series of the study variables are cointegrated.

Table 3: Results of the Johansen cointegration test
Source: Eviews software output (prepared by the author)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob
None *	0.884985	141.4983	95.75366	0.00
At most 1 *	0.757939	74.45479	69.81889	0.02
At most 2	0.409936	30.47927	47.85613	0.69
At most 3	0.213886	14.12604	29.79707	0.83
At most 4	0.117049	6.665788	15.49471	0.61
At most 5	0.086562	2.806739	3.841465	0.09

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.
None *	0.884985	67.04351	40.07757	0.000
At most 1 *	0.757939	43.97552	33.87687	0.002
At most 2	0.409936	16.35323	27.58434	0.635
At most 3	0.213886	7.460254	21.13162	0.933
At most 4	0.117049	3.859049	14.26460	0.873
At most 5	0.086562	2.806739	3.841465	0.093

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

We note from the results given by the Johansen test that its p-value is less than 5% for the first three orders, and that from the second order onwards the probability exceeds the 5% threshold. In other words, the variables in this study are cointegrated of order 2 at most.

Short run and Long-Run Causality Test on the VECM:

Table 4: Estimates for VECM Regression
Source: Author's estimate of results using EViews 12

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-9.90E-05	0.000227	-0.437076	0.6655
DLN_TEMP_	0.000712	0.000347	2.054428	0.0497
DLN_ENG_	0.000124	0.000992	0.125169	0.9013
DLN_IMP_	0.001607	0.000727	2.209909	0.0358
DLN_SCC_	-0.004686	0.002096	-2.235262	0.0339
ECT(-1)	-0.398015	0.171428	-2.321766	0.0280

The results in Table 4 show that the error correction term (ECT) is statistically significant and negative. This confirms the presence of a long-term causal relationship between the dependent variable and the independent variables over the study period. According to the results of this estimation, the coefficient at the 1% threshold of the error correction term reaches 0.3980 which means that there is a long-term equilibrium relationship correcting the imbalances between food security and its determinants in the short term of 39.80% over the long term. These results also show that there is a long-term relationship. We can then say that the coefficient of ECT contain information about whether the past values affect the current values of the variable under our study which is food security.

From the results of the estimation presented in Table 4, we can conclude that in the short term the variation of the temperature, the importation of cereals and the cultivated area of cereals influence the food security of cereals in Morocco because the probability of Student is significant (p-value lower than (0.05)). On the other hand the variable of consumption of fertilizers does not influence the food security of cereals. The positive sign attached to the variation of temperature and the importation show that these two variables are important for the stability of the food security of cereals in Morocco. These results are consistent with those of Barnett, Adger, 2007; Barrios et al, 2008. Finally, these results explain why the model is globally satisfactory.

Table 7: Autocorrelation test

Source: Eviews software output (prepared by the author)

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 3 lags

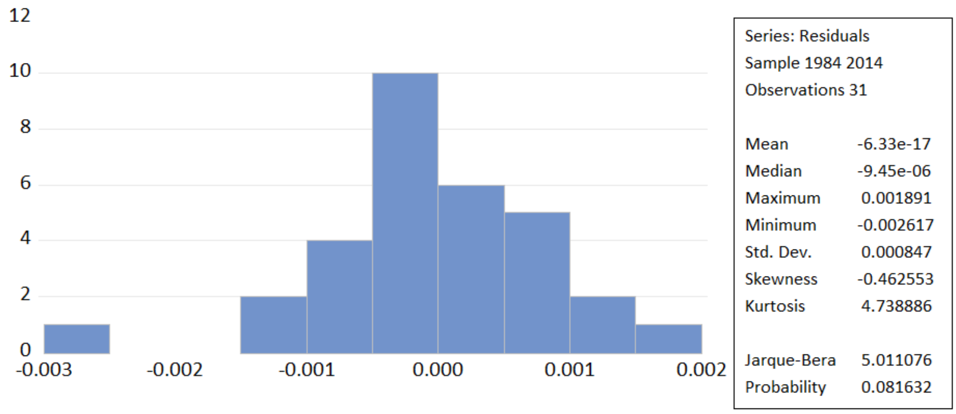
F-statistic	0.183547	Prob. F(3,14)	0.9058
Obs*R-squared	1.173132	Prob. Chi-Square(3)	0.7595

Source: Eviews software output (prepared by the author)

Table 8: Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	0.966706	Prob. F(3,24)	0.4246
Obs*R-squared	3.018698	Prob. Chi-Square(3)	0.3888



Graph 1: Normality test. Source: Eviews software output (prepared by the author)

The results of the validation tests show that our model is well estimated and robust. For, all the p-values associated with each test are significant (they are above the 5% threshold). This allows us to say that the errors of the model are homoscedastic, not autocorrelated, and normally distributed.

Test of CUSUM and CUSUMQ

It is important to test the stability of the parameters. To do this, we use the test of "Cumulative sum of recursive residuals" (CUSUM), we also add the test of CUSUM of Squares (CUSUMQ) of Pesaran.

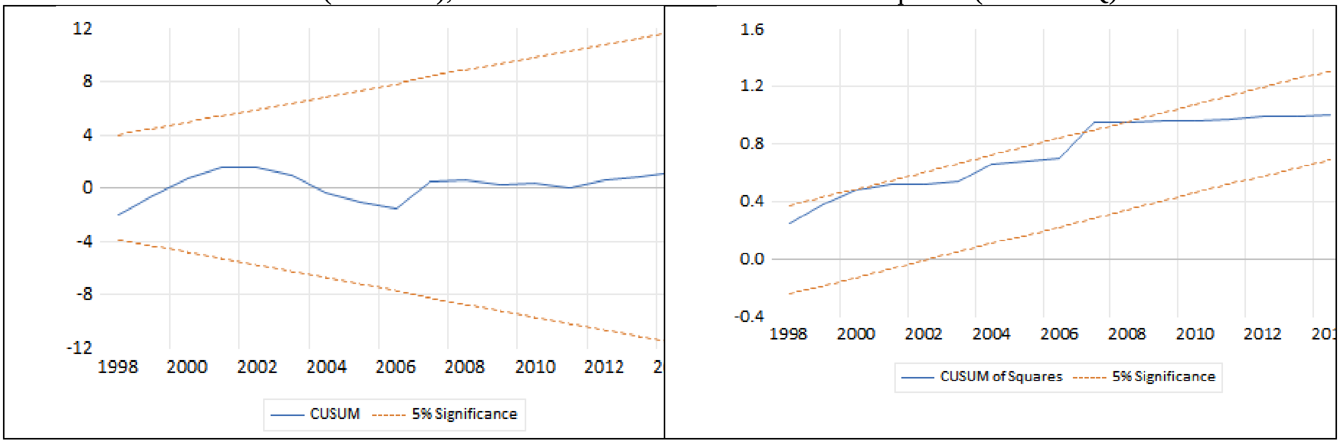


Figure 2: CUSUM and CUSUM squared test (Source: Eviews software output by the author)

In the figure to the left we see that the model is structurally and punctually stable, because the blue curve does not intersect the red dotted corridor.

On the other hand, in the figure to the right we see that there is instability during the period 1999-2001 and the period 2007-2009, since the estimators are outside the confidence interval associated with the "CUSUMQ" test. Indeed, in the first period it is a period of one of the major droughts that occurred in Morocco. The second period concerns the period before and after the crisis of 2008.

5.0 CONCLUSIONS AND POLICY RECOMMANDATIONS

The objective of this paper was to analyze the relationship between food security and variability in Morocco. According to the literature review, it is observed that the studies that have dealt with this topic in Morocco are very few, especially with the econometric approach, and it has been noticed that no paper has done the study with the explanatory variables that we have used for the period 1981-2014.

We conducted an empirical study using the VECM model. This model is considered the most appropriate for our analysis in the short term and long term, as it meets the conditions of application. In this context and to build our model, we used some variables cited in the economic literature and other variables that we chose, taking into account the availability of data and based on empirical tests.

The results of our model estimation show that there is a significant causality in the long run between food security and the explanatory variables. It was also found that there is a short-term relationship between grain food security and the following variables: Temperature variation, cereal import, and cereal area.

The recommendations that we can propose in the long term, is to encourage small farmers to have objectives to commercialize their production and not only to ensure individual satisfaction, to make them aware of the need to use modern fertilizers. As the cultivated area of cereals negatively impacts food security, it is necessary to develop strategies for long-term conservation of natural resources, such as cultivated land in Morocco, to improve their fertility. The country should invest in R&D and innovation to improve irrigation techniques (e.g. drip irrigation, and drones). It should then spend more on infrastructure that encourages value addition, to improve the food security situation in accordance with the FAO recommendations. Microfinance is also recommended, to allow the poorest to secure access to finance.

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