C22 How has farming practices affected the cereal production in Morocco?

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ABSTRACT

The purpose of this paper is to present a new approach to modelling a cereal production function and propose an estimate of farming practices function in Morocco. Cereal production function would be determined by econometric model drawing in particular on the Solow approach (1957), based on five factors- land, water, employment and farming practices. To simplify the model, we aggregate the effects of the three first factors by using a principal components analysis (PCA). We use then the Space state models to provide an estimate for the non observable factor, namely agriculture practices. Such an estimate is a useful tool for examining the farming practices fluctuations and analyzing of its effects on cereal production, in particular, following the Government's adoption of the Green Moroccan Plan in 2008. The data comes from agriculture department and High commission for Planning, from 1991 to 2015. Results show that the improvement by 1% in the agricultural practices leads to a 0.3% increase in cereal production.

Keywords: agriculture, farming practices, cereal, PCA, Kalman filter JEL Classifications: Q1, Q12

PAPER

1. Introduction

The traditional factors determining the agricultural production are labor, capital, land and water. However, the standard approach of modeling the agricultural production generally holds two main factors- capital and labor. The improvements made by the introduction of the third factor land, highlighted by Martin and Mitra (1993), were rare. Most studies have retained the two first factors, assuming constant returns to scale. They have thus used the Solow approach (1957), which expresses the production from factor shares. In this approach, the operating surplus is frequently used to measure the return on capital. However, and taking into account the economic specificities of agriculture in many developing countries, the operating surplus cannot be considered as equivalent to return on capital, but would include also the return shares of land and employment. Furthermore, agricultural practices might also be considered as crucial factor that influences crops output and livestock strength. They play a decisive role in the development of agricultural production, since they achieve higher productivity and contribute to ensure the food security. Overall, the increase of agricultural production could result from the combination of two major sets of factors: the available quantities of traditional factors- land, water, labor and capital and the effectiveness of their contribution associated with the use of agricultural practices.

Agricultural practices consist of all techniques conducted by the farmers to improve crop and livestock productivity. They include irrigation, soil preparation, crop rotation, fertilizers, and pesticides. In Morocco, agricultural practices was continued to progress at a very moderate pace in the 80s and 90s. The fertilizer consumption was limited to 65 kg per hectare of arable land in 2002, instead of 72,8 in Turkey, 164,5 in Spain and 211,3 in France[1]. The number of tractors did not exceed 45 units per 100 square km of arable land. The largest proportion of the crops areas was under rain fed, while less than 15% of cultivated areas were irrigated. The production of rainfed crops, including cereals had not seen a dynamic growth, due to less intensive production system. Thus, the Moroccan government launched in 2008 a new strategy, namely Green Morocco Plan, in order to improve the sector's resilience to climate fluctuations and boost its production and exports through the reorganization of its productive chains, diffusion of good practices at both large and small farms and by adopting a proactive fundraising approach for financing agricultural projects.

This paper aims to present an innovative approach to econometric modelling of cereal production function and propose a new method for estimating agricultural practices indicator in Morocco. The study is carried out over the period from 1990 to 2015. The choice of sample period is related to the availability of data and the fact that the cereal production has been undergoing drastic changes, especially from 2000.

[1] Wolrd Bank Group, 2016

The approach starts with a production function that expresses cereal output as a function of the agricultural practices and the traditional factors. To simplify the model, we have grouped three factors (level and dispersion of rainfall per season, sown areas and employment) using a principal component analysis.

Unlike labor, capital, land and water factors, whose data were collected from the Department of Agriculture and the High Commission for Planning, the agricultural practices factor is a latent variable, which will be recovered by applying the Kalman filter (1960, 1963). An important feature of this filter is to provide an estimate of the unobservable variable "agricultural practices" for the sample period. The second advantage consists on its ability to generate forecasts for the latent variables that can be incorporated in econometric projections. In the next section, we examine the theoretical framework of our econometric model. Section 3 presents an extension of the Kalman filter leading to estimate the unknown model parameters and generate the latent variables. The empirical results will be presented in section 4. We find that agriculture practices and traditional factors are both important in representing changes in patterns of cereal production. Section 5 concludes.

2. Econometric approach

The modeling approach of cereal production has derived from the Solow model (1957). Assuming three production factors (aggregated nature and employment factor, capital and agricultural practices), the cereal production function can be expressed as:

$$Y_t = NL_t^{\alpha} K_t^{\beta} P^{\delta}_t$$

Where Yt is the cereal production, Nl represents the aggregated nature and employment factor, K capital expenditure, and P is the farming or agricultural practices factor. α, β and δ represent respectively the shares of production that remunerate the three factors. These shares should be less than unity. By differentiating the production function with respect to time t, and dividing by Y, the growth rate can be estimated as :

$$\text{Log}(Y) = \alpha \log(NL) + \beta \log(K) + \delta \log(P)$$

$$\begin{aligned} d\text{Log } Y &= Y'dNL + Y'dK + Y'dP \\ &= \alpha\, NL_t^{\alpha-1} K_t^{\beta} P^{\delta}_t + \beta\, NL_t^{\alpha} K_t^{\beta-1} P^{\delta}_t + \delta\, NL_t^{\alpha} K_t^{\beta} P_t^{\delta-1} \end{aligned}$$

$$\frac{dlogY}{Y} = \frac{\alpha\, NL_t^{\alpha-1} K_t^{\beta} P^{\delta}_t}{NL_t^{\alpha} K_t^{\beta} P^{\delta}_t} dNL + \frac{\beta\, NL_t^{\alpha} K_t^{\beta-1} P^{\delta}_t}{NL_t^{\alpha} K_t^{\beta} P^{\delta}_t} dK + + \frac{\delta\, NL_t^{\alpha} K_t^{\beta} P_t^{\delta-1}}{NL_t^{\alpha} K_t^{\beta} P^{\delta}_t} dP$$

$$\frac{dlogY}{Y} = \alpha \frac{dNL}{NL} + \beta \frac{dK}{K} + \delta \frac{dP}{P}$$

The decomposition of the production growth shows the contributions of each factor to the growth and their remuneration.

3. Application of the Kalman Filter

The identification of the unobservable variable "agricultural practices" is based on the application of a State Space model. This type of model can distinguish between the specification of observed variables (the signal) and the unobserved variables (known as the state variables). It generally consists of one or more measurement equations describing how the observed variables are explained by the unobserved variables and one or more state equations indicating how these variables are generated from their dynamic of the past and from the residues.

In our study, the state space model highlights a linear decomposition of the dependant variable (cereal production) into three factors (aggregated indicator, capital, agricultural practices). The two first factors are observed and assumed uncorrelated, while the latter is not observable and assumed stochastic. The variable representing the agricultural practices follows a random walk model, taking into account the effects of two exogenous variables (fertilization and seeding use).

The State Space model is expressed as following:

$$\begin{cases} P_t = CP_{t-1} + \varepsilon_t \\ Y_t = A'X_t + B'P_t + \eta_t \end{cases} \quad \{t \geq 1\}$$

Where Y is the dependent variable determined by the vector of the independent variables X (NL, K) as well as the unobservable variable Pt. The irregular components εt and ηt are uncorrelated white noise. A, B and C are the parameter matrix. $P_0 \approx N(m, \sigma)$

We propose to include two major changes into the state equation. The first concerns the addition of explanatory variables in order to improve the quality of latent variable estimate. Pt equation would give a clear idea of the exogenous variables effects (fertilization and seeding use) taking into account the past effect of the variable changing itself according to random shocks.

The second is related to the dynamic change of Pt assumed following a random walk with drift. This latter change will allow Pt slope to change as a result of random shocks that could affect its level over time.

The new state space model is given by the system of the following equations:

$$\begin{cases} Y = A'X_{1,t} + B'P_t \\ P_t = C'X_{t,2} + P_{t-1} + W_{t-1} + \varepsilon_t \\ W_t = W_{t-1} + \mu_t \end{cases}$$

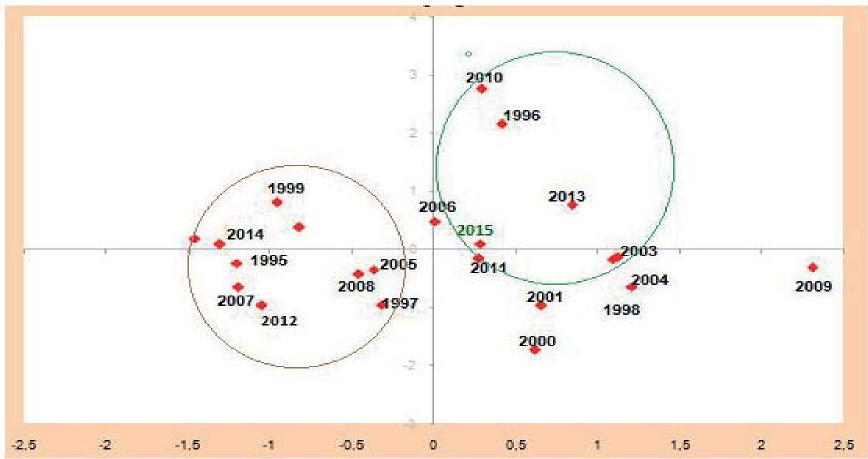
Where ´t and µt are independent vectors of mean zero Gaussian disturbances variance. ´t allows to the latent variable P to fluctuate by varying its slope. With the new State Space representation, extraction of the agricultural practices factor would be performed using the Kalman filter, which provides a recursive estimation of the latent variable at time t assuming the conditional distribution of the State vector.

4. Empirical results

In this section, we provide but are not limited to the results of our investigation. It seemed relevant firstly to present the results of principal components analysis conducted on rainfall, employment and areas sown data. The level of rainfall remains a determining factor of cereal production since the irrigated area did not exceeding 9% of the total area sown.

The 7 variables used in the principal components analysis were chosen because of their correlations and contributions to explain the cereal production. This include rainfall level divided into two periods (October to December and January to March) and differentiated in terms of distribution during the winter and autumn season, employment, sown area and the effect of early rains. The results reveal that the two axis resulting from the implementation of the PCA account for about 72% of the variation. The first axis is strongly associated with rainfall dispersion and area sown. Similar years in terms of climatic, land and employment conditions, easily emerge from their proximity from on the plane factor. Overall, and taking into account the first two axes selected by PCA, two homogeneous sets of agriculture campaigns are characterized (poor and good harvests).

Figure1 - similar crop year scatter



Once calculated the aggregated indicator based on rainfall, area sown and employment factors, we estimate the State Space model suggested in the previous section. However, we encountered severe convergence problems suggesting a specification problem. We decided to improve the model by inserting a constant in the equation state. The model is thus expressed as following:

$$\begin{cases} Y_t = \alpha Ag_t + \beta K_t + \delta P_t \\ P_t = a_0 + a_1 engr + a_2 sem + P_{t-1} + W_{t-1} + \varepsilon_t \\ W_t = W_{t-1} + \mu_t \end{cases}$$

The estimation of unknown parameters will be operated from the maximum likelihood method. The results are summarized in the following table:

Table 1 - parameter's estimate

Variable	Coefficient	1991-2015		2000-2015	
		Estimation	Z statistic	Estimation	Z statistic
Aggregated factor	α	0.31	3.37	0.10	2.20
Capital	β	0.28	1.87	0.43	3.42
Practices	δ	0.31	4.73	0.18	3.65
Constant Pt	a_0	-12.8	-0.00	0.18	0.129
Fertilizer	a_1	-6.42	-0.67	-46.36	1.46
Seed	a_2	3.74	1.71	24.57	1.86

The results show that the sign and the size of estimated parameters are consistent with economic theory. An increase of each quantity on the three factors (aggregated indicator, capital and agricultural practices) leading to improved cereal production. The homogeneity hypothesis of production function is also not rejected (the sum of the parameters associated with the three factors is near to unity). However, the results revealed a less prominent role of fertilizers; its z-statistic is not significant. To check the robustness of the parameter, we re-estimated the same model on a more recent period (2000-2015). The results show a fairly significant improvement in the contribution of seed and fertilizer use, especially from the adoption of the Green Morocco Plan in 2008.

The estimate of the Space State model reveals a gradual progress of agricultural practices function, especially during the dry seasons with a significant rainfall deficit. This is particularly true for 2000 and 2007 which were characterized by an important improvement of agricultural practices, in line with the increase of the use of irrigation and certified seeds. Conversely, the campaigns which are marked by good temporal dispersion of rainfall, especially during the winter, were down on the use of agricultural practices, due, in particular, to the large proportion of rainfed areas that do not require irrigation during the wet years.

Figure 2 - agricultural practices indicator

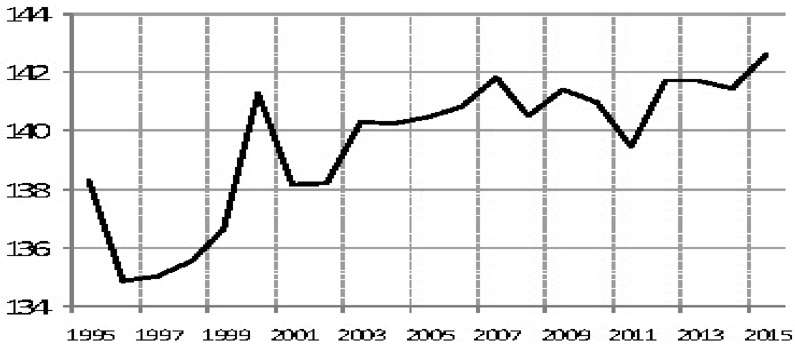
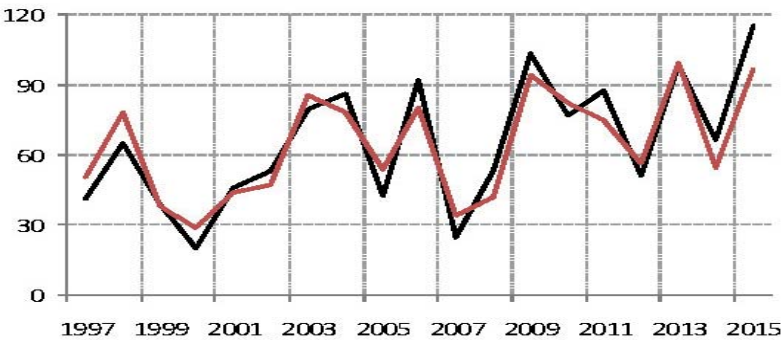


Figure 3 shows the performance of Space Stat models. It reveals a perfect synchronization movement of the original and fitted series on the whole sample period. It shows also the ability of the model to reproduce output fluctuations throughout the sample period. Specifically, the graph shows that the cereal production function cannot be performed from the two only traditional factors- labor and capital, but should also take into account the effect of natural factors, employment and agricultural practices, particularly in countries that are highly exposed to climate disruption.

Figure 3 - cereal production(original and fit series)



5. Conclusion

The principal innovation of this paper is to generate empirical measure of the agricultural practices factor as latent or unobservable variable, while providing cereal production function. The results reveal the crucial role of agricultural practices in improved cereal production in Morocco. Agricultural practices focused on the use of inputs have generally achieved a higher crop yield in recent years, but found liable for accelerated pollution of fresh water, soil and a decline in food safety. The increase of restrictive practices and more geared towards the use of natural inputs and a local knowledge of farmers should answer, in part, to the growing demand for sustainable organic agriculture. However, it marks a major shift in agricultural production function that should give a prominent role to the labor factor (knowledge and technical competence) rather than practiceintensive factors. It should be emphasized that this transformation, highly recommended as part of Sustainable Development Goals (SDGs) could be long and difficult in the short term, as it would be difficult to ensure the nutrition of the entire Moroccan population or meet changes in market access at affordable rates. Moroccan Farmers would continue to use intensive agricultural practices and the cereal production function would be thus continued to be influenced by the effect of inputs (fertilizer, pesticides) in the short term.

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