DOI: 10.17707/AgricultForest.61.3.11

Nikola LJILJANIĆ, Snežana JANKOVIĆ,
Zoran RAJIĆ, Nebojša RALEVIĆ, Sveto RAKIĆ [1]

WHEAT PRODUCTION ANALYSIS BY USING ECONOMETRIC MODELS

SUMMARY

The study analyzed time series data for the period 1994–2013 on areas sown with wheat, purchase price for wheat, subsidies and wheat used for seed in Serbia. The authors developed dynamic models, on which they forecast that 89000 tons of wheat would be used in 2014 for an area of 507000 ha. This ARIMA model confirms that in wheat production economic factors have a dominant impact on sown areas and quantities of wheat used for seed. Subsidies are a quite important factor in wheat production. The authors ascertained that wheat yields were increasing, less affected by economic than by agro–ecological factors. The accuracy of this model was tested with standard statistical methods.

The model provides some very useful information that could serve a starting point for agricultural policy decision-making and farmers who plan future production.

Keywords: wheat, dynamic econometric models, ARIMA, Serbia.

INTRODUCTION

Wheat has a high economic importance to Serbia. It is mostly sown in Vojvodina province (Serbia). It is more grown by family farms with crop production than by agribusiness enterprises (Marković et al., 2013). Over last 20 years, wheat has been grown in Serbia on about 600 000 hectares (RZS, 1994-2014), but a decline in this trend can be noticed.

On the contrary, wheat production in the world shows a growing trend. Given that the world's population is increasing, as well as the number of people who eat bread as a staple food, Braun et al. (2008) calculated that wheat production had to increase at a rate of 1.5% per year as in 2030, for example, the world's population would need 850 million tonnes of wheat.

Forecasting of production is mostly based on structural econometric models. In this study, the authors used dynamic models that can be widely applied to all economic levels and sectors. Saeed et al. (2000) forecast wheat production, whereas Prabakaran et al. (2013) forecast both sown areas and production. For these studies, the accuracy and success of the Autoregressive

[1] Nikola Ljiljanić (corresponding author: nljiljanic@ipn.bg.ac.rs), Snežana Janković, Institute for Science Application in Agriculture, 68b Blvd. despota Stefana, Belgrade, SERBIA. Zoran Rajić, Nebojša Ralević, Sveto Rakić, Faculty of Agriculture, University of Belgrade, 6 Nemanjina St, Belgrade-Zemun, SERBIA.
Note: The authors declare that they have no conflicts of interest. Authorship Form signed online.

Integrated Moving Average (ARIMA) models were confirmed after comparing with the obtained results. ARIMA models have been also widely used in other studies (Prindycke and Rubinfeld, 1981). Advantages of these models lie in their good forecasts. Sabir and Tahir (2012) used dynamic models to forecast production, sown areas and wheat population.

Sown areas, as well as yields and wheat used for seed are key factors that define wheat production. Hence, the goal of this study was to develop proper models in order to forecast the main elements of wheat production.

MATERIAL AND METHODS

Data for the period 1994–2013 on sown areas, average yields, average annual purchase price, subsidies and wheat used for seed were incorporated into dynamic models to forecast future values. The main goal of these models was to identify a stochastic process of time series data and forecast future values accurately. The time series data comprised information from the Serbian "Statistical Yearbook", the Serbian Grain Fund, the electronic database of the Statistical Office of the Republic of Serbia and internal documents of the Serbian Ministry of Agriculture and Environmental Protection.

In order to achieve satisfactory specifications of the models, and therefore accurate and reliable coefficients, the authors used the statistical methods of testing significance of multiple and serial correlation coefficients, together with the Durbin–Watson test. Statistical criteria, i.e. testing the significance of the coefficients of determination, were used to assess the obtained parameters. When choosing models, the authors considered the significance of the coefficients, as well as the logic, based on the economic theory. In terms of forecasting, which is the final step of econometric research, this model was assessed as valid.

Karim et al. (2005) used the regression modelling to forecast wheat production. Their results showed that different models can apply to different areas. In an intensive study (Amin et al., 2014) that took into account some previous research and was conducted to predict sown areas and yields, the obtained ARIMA models were determined by specificities of the observed areas or countries and could not have been applied to others. The methodology of this paper was conditioned to available pieces of information and specificities of the subject-matter, which directed the direction of models development.

RESULTS AND DISCUSSION

Areas sown with wheat

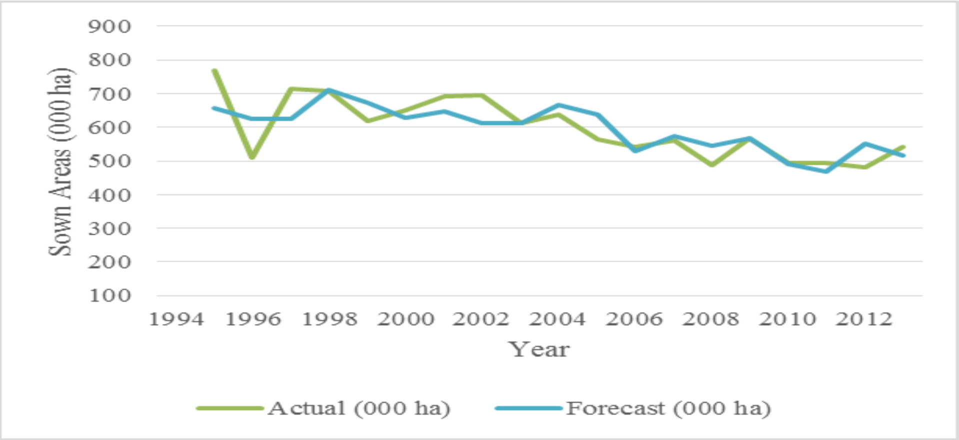
Using data for the period 1994–2013 on areas sown with wheat (in thousands of hectares), purchase prices (din kg^{-1}) and subsidies (din kg^{-1}) in Serbia, the authors developed a dynamic model and calculate an equation (1) for sown areas. Purchase prices adjusted for subsidies were deflated by grain price indices. Among a number of models, the authors chose one that met all the above mentioned criteria, leading to the following equation:

$$\hat{A}_t = 91.645 + 0.310A_{t-1} + 1.853P_{t-1} \quad (1)$$
$$(0.155) \quad (0.582)$$

Where:
$\hat{A}_t$ – area sown,
A_{t-1} – area sown in the previous year,
P_{t-1} – purchase price in the previous year.

The model was highly significant, R=0.75, F=10.239 (P<0.01). The coefficient 0.310* was on the edge of statistical significance at the 0.05 level, whereas the coefficient 1.853** was highly significant (P<0.01).

The value of the Durbin–Watson *d*-statistic was DW=2.498^{nz}. However, because of the autoregressive character of the equation, the authors used the Durbin *h*-statistic with an asymptotic normal distribution for testing the autocorrelation of the residuals. The results showed h=1.483<1.96, which implies that no first-order autocorrelation was detected. The authors came to the same conclusions after conducting the sign test. Graph 1 shows the forecast and actually sown areas:



Graph 1. Trend of the forecast and actually sown areas, Republic of Serbia, period 1994–2013

After the equation (1) was extrapolated, the result showed that 507 000 ha of areas were to be sown in 2014. The dynamic model of sown areas shows its dependence on two factors – sown areas and the purchase price from the previous year, adjusted for subsidies. Several models were developed, yet only the one that included subsidies was significant, where purchase prices were adjusted for subsidies from the period 2004–2013. In the current business environment, subsidies represent measures for reducing costs, and thereby for increasing profits. In research (Munćan and Božić, 2013) conducted in 2007–2011 in Serbia on farms with crop production, field crops, and primarily wheat, showed a high level of dependence on subsidizing, which has been confirmed by this model. The model implies that production depends on the purchase price from the previous year. In addition to it, the price can fluctuate due to preliminary forecasts and market impacts that occur in different periods of a year. Hence the government should subsidize the production of this strategic crop and, especially, promote export-oriented production (Marković *et al.*, 2013). Regarding the purchase price for wheat and export-oriented production, it is important to mention the interdependence between Serbian purchase prices and prices on commodity markets, primarily on the commodity market in Budapest, the biggest in South–East Europe. Prices in Serbia follow Budapest market prices with a delay of 30–60 days (Simić and Saković, 2008).

Wheat for seed

Using data on the amount of wheat used for seed (in thousands of tonnes), sown areas (thousands of hectares), purchase prices (din kg^{-1}) and subsidies (din kg^{-1}) in Serbia for the period 1994–2013, the authors developed a dynamic model and calculate an equation (2) for consumed wheat seed. Purchase prices adjusted for subsidies were deflated by grains price indices. Among a number of models, the authors chose one that met all the above mentioned criteria, leading to the following equation:

$$\hat{S}_t = -10.2763 + \underset{(0.059227)}{0.135414 A_{t-1}} + \underset{(0.221208)}{0.544447 P_{t-1}} \quad (2)$$

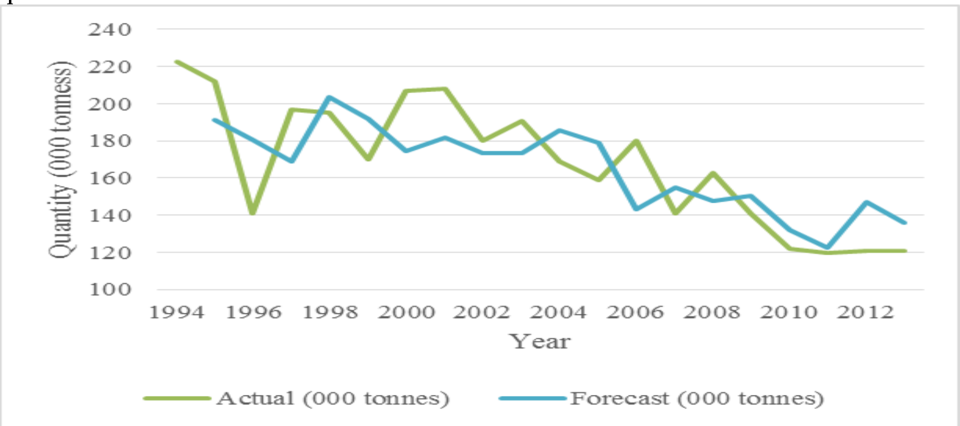
Where:

$\hat{S}_t$ – amount of seed,

A_{t-1} – area sown in the previous year,

P_{t-1} - purchase price in the previous year.

The model was highly significant, R=0.72, F=8.414 (P<0.01). The coefficients 0.059227* and 0.221208* were significant at the 0.05 level. The value of the Durbin–Watson *d*-statistic was DW=2.499 ^{nz}, which implies that no first-order autocorrelation was detected. The authors came to the same conclusions after conducting the sign test. Graph 2 shows the forecast and actual quantities of seed:



Graph 2. Trend of forecast and actual quantity of wheat used for seed, Republic of Serbia, period 1994–2013

After the equation (2) was extrapolated, the result showed that 89 000 tonnes of wheat were to be used for seed in 2014. According to previous estimations (Denčić *et al.*, 2009), the average quantity of wheat used for seed amounted to approximately 300 000 tonnes, which significantly differs from the values given by the model. The difference is due to the fact the model only took into account the quantity of declared seed placed on the market but not mercantile wheat, still widely used on farms with non-commercial production.

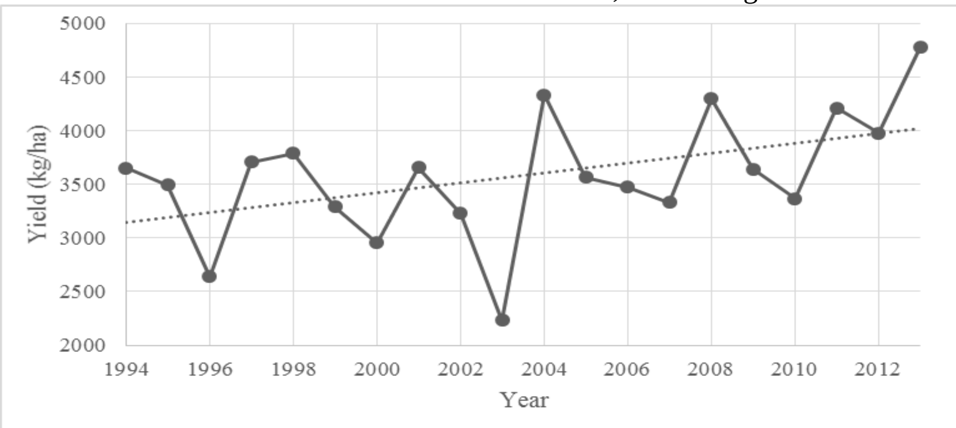
The dynamic model of seed consumption shows its dependence on two factors – areas sown in the previous year and the purchase price from the previous year, adjusted for subsidies.

Wheat yields and production

Sown areas and yields are the basic factors for crop production. Because this research focused on developing some models that comprise economic factors and their effect, the authors could not have developed a proper model for forecasting yields that would be significant.

Sown areas are mostly determined by economic factors, whereas yields are more determined by cropping practice, assortment potential and, most importantly, climate (Denčić *et al.*, 2009). Climate is an inevitable factor when it comes to wheat production. Studies have shown that wheat yields largely depend on the quantity of April-through-May precipitation. Results of regression and correlation analyses showed that in most parts of Vojvodina, April-through-May precipitation and yields were highly correlated, whereas in other months these factors had a negative coefficient of correlation (Marković and Jovanović, 2011).

Graph 3 shows the average wheat yields in the observed period (1994–2013). In general, the yields had an increasing trend at the time, with some fluctuations. The lowest value was recorded in 2003, and the highest in 2013.



Graph 3. Trend of average wheat yields, Republic of Serbia, period 1994–2013 (RZS)

According to previous research (Todorović and Filipović, 2010), wheat is mostly produced on family farms. Results have shown that only farms with over

7.5 t ha^{-1} of yields make profits. This particular study raises an issue of cost effectiveness and profitability of wheat production, as well as a necessity of additional subsidizing of this type of production, having in mind the economic importance of wheat and undisputable importance of food safety for each country. On the other hand, wheat production implies a considerable cost of inputs. The cost of inputs indirectly affects profits, and high costs can lead to reduced use of some inputs (Sayre and Hobbs, 2004).

CONSCLUSIONS

Taking into account time series data for the period 1994–2013 on sown areas, purchase prices, subsidies and wheat used for seed, the authors developed a dynamic model to forecast sown areas and wheat to be used for seed. The model meets the given criteria – it is significant, independent and without first-order autocorrelation. For 2014, it forecast 507000 ha of areas to be sown and 89000 tons of wheat to be used for seed. Economic factors have a dominant impact on sown areas and quantities of wheat used for seed, and the model confirms that subsidies are a necessary measure in wheat production. This research focused on developing some models that comprise economic factors and their impact, and the authors could not have developed a proper model for forecasting yields that would be significant because yields are mostly affected by agro–ecological factors.

The model provides information that are a good starting point to make good agrarian policy decisions, having in mind that the largest part of the agrarian budget is allocated for direct payments. The possibility to forecast production parameters can lead to surpluses in wheat production that can be aimed for exporting.

ACKNOWLEDGEMENTS

The results are part of the project TR–31066, financially supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia

REFERENCES

Amin, M., Amanullah, M., Akbar, A. (2014): Time series modeling for forecasting wheat production of Pakistan. The Journal of Animal & Plant Sciences, 24(5): 1444-1451.

Braun, H.J., Dixon, J., Crouch, J., Payne, T. (2008): Wheat research to serve the future needs of the developing world. Proc. Intern. Sump. “Conventional and molecular breeding of field and vegetable crops” 24-27 Nov. Novi Sad, Serbia. 28-32.

Denčić, S., Kobiljski, B., Mladenov, N., Pržulj, N. (2009): Proizvodnja, prinosi i potrebe za pšenicom u svetu i kod nas / Wheat production, yields and demands worldwide and in. our country. Proceeding of papers. Institute of Field and Vegetable Crops, vol. 46(2): 367-377 [In Serbian].

Karim, R., Awal, A., Akhter, M. (2005): Forecasting of wheat production in Bangladesh. Journal of Agriculture & Social Sciences, 1: 120-122.

Marković, J., Prodanović, R., Mutibarić, J. (2013): Proizvodnja i promet pšenice u Srbiji / Production and trade of wheat in Serbia. Ekonomika, 59(2): 92-100 [In Serbian].

Marković, T. & Jovanović, M. (2011): Uticaj količine padavina na prinos pšenice i kukuruza kao proizvodni bazni rizik / Impact of precipitation sums on wheat and maize yields as a production-related basis risk. Field and Vegetable Crops Research, 48 (1): 207-212 [In Serbian].

Munćan, P. & Božić, D. (2013): The effects of input subsidies on field crop production in Serbia, Economics of Agriculture, 60(3): 585-594.

Prabakaran, K., Sivapragasam, C., Jevapiya, C., Narmatha, A. (2013): Forecasting cultivated areas and production of wheat in India using ARIMA model. Golden Research Thoughts, 3(3).

Prindycke, R.S. & Rubinfeld, D.L. (1981): Econometric models and economic forecasts, 2nd ed. New York, McGraw-Hill, USA.

RZS (1994-2014): Statistički godišnjak Republike Srbije / Serbian Statistical Yearbook/. Statistical Office of the Republic of Serbia, Belgrade. From 2015 available at http://webrzs.stat.gov.rs/WebSite/public/ReportView.aspx, homepage of database)

Sabir, H.M. & Tahir, S.H. (2012): Supply and demand projection of wheat in Punjab for the year 2011-2012, Interdis. J. Contemp. Res. 3: 800-808.

Saeed, N., Saeed, A., Zakria, M., Bajwa, T.M. (2000): Forecasting of wheat production in Pakistan using ARIMA models. International Journal of Agriculture & Biology. 352-353.

Sayre, K.D. & Hobbs, P.R., (2004): The raised bed system of cultivation for irrigated production conditions. In R. Lal, P.R. Hobbs, N. Uphoff, D.O. Hansen, (eds.) Sustainable agriculture and the international rice-wheat system. New York: Marcel Deker. pp. 337-355.

Simić, R. & Saković, V. (2008): Aktuelna kretanja u proizvodnji i trgovini pšenice / Topical tendencies in wheat production and trade. Proceeding of papers. Institute of Field and Vegetable Crops, 45(2): 33-45.

Todorović, S. & Filipović, N. (2010): Economic analysis of wheat production on family farms. Journal of Agricultural Sciences, 55(1): 79-87.