STOWARZYSZENIE EKONOMISTÓW ROLNICTWA I AGROBIZNESU
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METHODS OF FORECASTING THE PRICES ON THE CROPS MARKET – WINTER'S MODEL

METODY PROGNOZOWANIA CEN NA RYNKU ZBÓŻ – MODEL WINTERSA

Key words: agricultural prices, adaptive models, forecasting
Słowa kluczowe: ceny rolne, modele adaptacyjne, prognozowanie

Abstract. Prices and factors which influence them are measurable thus it is appropriate to apply in this case a method of time series analysis for predicting the agricultural prices in the purchasing centre. In this paper adaptive models, which adjust to the changeable conditions, have been analysed including the changes in the trend level, accidental variations and seasonal variation. With the help of appointed adaptive models the forecast of basic prices in the purchasing centre has been calculated. For the estimation and prediction of model prices the factor of determination has been used as well as an average *ex post* errors of the bygone forecast.

Introduction

In agriculture the variations of economic phenomena are visible and they are due to many different factors. The agricultural production, by far, is determined by bio-technological conditions as well as climate conditions which results in agricultural variations. These changes recur every calendar year and cause seasonality. Seasonality of production in agriculture influences many spheres of agricultural market such as the farmers income or capital expenditure. The seasonal character is visible in agricultural produce supply and as a result it influences the level of prices on the market. The analysis of agricultural prices in time and the measurement of the level of seasonal variations, the ability to predict them enables the making of effective economic decisions. In literature there is a large number of mathematics-statistics methods which allow for the analysis of seasonal and accidental variations are used in forecast of time series.

The situation on the crops market

In the period between January1996 and December 2009 the prices of wheat were within the range of 34 to 92 PLN/dt, and the average price of this crop was on the level of 52 PLN/dt. At the same time the prices of rye were within the range of 25 to 74 PLN/dt, and the average of this crop was 39 PLN/dt. The changes in prices of both crops were similar and differences in prices can be considered small, the factors of change lability were 28% for rye and 22% for wheat. The tendency of the decrease in prices of wheat and rye was visible on the crop market from 1996 to 2004. The turning point was the year 2004 when Poland became the member of European Union. Sudden increase in prices on the crop market was visible then and the prices grew for about 40%. However this situation did not last long because it got worse in the beginning of the year 2005. Within a number of months the prices of crops decreased for about 45% and reached the level they were on before May in 2004. The level of crop prices is strongly connected with its supply on the market. A large number of crops was bought by the purchasing centre during years 2005-2006 which caused the prices to remain on a very low level which was 33 PLN for rye and 41 PLN/dt for wheat. Another turning point on the crops market was September 2006 and from that moment the prices started growing until September 2008. The increase in prices was caused by the insufficient amount of crops in the purchasing centre. From September 2008 we have been observing descending tendency, the prices from the level of 70 PLN/dt of rye in June 2008 decreased to the level of 30 PLN/dt in December 2009, and the prices of wheat decreased from the level of 90 to 47 PLN/dt.

Winters' adaptive model

The characteristic feature of adaptive models is a fact that they show great flexibility and ability to adjust in case of irregular changes in trends or distortions and movements of seasonal variations. This fact makes an adaptive model a short-term prediction tool. In these models a big role is played by information from the past which include the predicted variable and prediction errors. This information allows for a choice of appropriate model and variables ensuring the most exact prediction. In adaptive models there is no set analytic figure, it is presumed that for each period the evaluation of trend and variations is built as a certain average of this kind of prices in previous periods. Adaptive models depend on the amount of information from the past used in determining current evaluations of a trend. More important is the latest information rather then farther past information which means that current signals are more important than outdated events [Nowak 1998]. These models gain more and more meaning as far as prediction of economic phenomena is concerned and are a good tool for prediction of agricultural processing. The group of adaptive models which are known as Winter's model deserve attention. Winter's model is used in case of time series including developing tendency, seasonal variations and accidental variations.

Due to the over fitting of seasonal variations there are two types of Winters model: additive model and multiplicative model. They are presented as follows:

Additive Winter's model

$$F_{t-1} = \alpha\left(y_{t-1} - C_{t-1-r}\right) + \left(1-\alpha\right)\left(F_{t-2} - S_{t-2}\right)$$

$$S_{t-1} = \beta\left(F_{t-1} - F_{t-2}\right) + \left(1-\beta\right)S_{t-2}$$

$$C_{t-1} = \gamma\left(y_{t-1} - F_{t-1}\right) + \left(1-\gamma\right)C_{t-1-r}$$

Multiplicative Winter's model

$$F_{t-1} = \frac{\alpha \cdot y_{t-1}}{C_{t-1-r}} + \left(1-\alpha\right)\left(F_{t-2} + S_{t-2}\right)$$

$$S_{t-1} = \beta\left(F_{t-1} - F_{t-2}\right) + \left(1-\beta\right)S_{t-2}$$

$$C_{t-1} = \frac{\gamma \cdot y_{t-1}}{F_{t-1}} + \left(1-\gamma\right)C_{t-1-r}$$

where:

F_{t-1} – *smooothened value of the variable predicted in moment t-1,*
S_{t-1} – *evaluation of the trend growth for moment t-1,*
C_{t-1} – *evaluation of the seasonality factor for moment t-1,*
r – *the length of season cycle (the number of cycle phases),*
α – *constant of the smoothness of the trend level,*
β – *constant of the smoothness for trend changes,*
γ – *constant of the smoothness for seasonal variations,*
y_t^* – *forecast for moment t>n.*

Parameters α, β, γ have their values set within the <0, 1> limit. In literature there are different suggestions concerning the estimation of F_1, S_1 C_1 starting values thus it is suggested to accept as follows:

F_1 – the first value of forecasted variable, which is y_1, or the average of changeable variable in the first cycle,

S_1 – the difference of first and second value of the predicted variable that is y_2-y_1, or the difference of the average values of the changeable variable set in the first and second cycles.

C_1 – the average of differences on the basis of time sequence, (for additive model) or quotient (for multiplicative model) referring to the same phase of the season cycle of the values of the predicted variable as well as the smoothened values of the trend.

The estimation of α, β, γ parameters is based on experiments dealing with the minimisation of the average error in the past forecast, for the forecast with one-cycle advance. The forecast for each model is estimated according to the formulas:

Additive Winter's model : $y_t^* = F_n + S_n(t-n) + C_{t-r}$

Multiplicative Winter's model: $y_t^* = \left[F_n + S_n(t-n)\right] \cdot C_{t-r}$

where n is the number of items in time sequence of the forecast variable [Cieślak 2004].

The measure of the forecast accuracy

The quality of forecast is linked to the forecast accuracy on the basis of ex post errors. The aim of this measurements is a synthetic description of the empirical distribution of the deviation of the forecasted variable realisation reached in the past in the period of time from which the statistic data was collected. To measure the quality of the forecast the following measurements have been used: the prediction load (*u),* standard deviation of the forecast errors (S_p), relative forecast error (*w*)* and Thiel factor (I^2):

$$u = \frac{1}{m} \sum_{t \in I_p} \left(y_t - y_t^* \right)$$

$$w^* = \frac{S_p}{\bar{y}_{t \in I_p}}$$

$$S_p = \sqrt{\frac{1}{m} \sum_{t \in I_p} \left(y_t - y_t^* \right)^2}$$

$$I^2 = \frac{m S_p^2}{\sum_{t \in I_p} y_t^2}$$

where:

I_p *–the period of empirical verification of the forecast*

These measurements allow for deciding whether the forecast is acceptable and establish the rate of the deviation of the forecasted variable in comparison with ready formed forecast [Zeliaś 1997].

Adaptive models and forecasts of the agricultural prices in the purchasing centre

In this paper the configuration of the prices in the purchasing centre of the basic crops in Poland has been examined during the period from January 1996 to December 2009.

To forecast the prices of the crops the Winter's additive and multiplicative models have been used. Model parameters α, β, γ were chosen by the method which deals with the minimisation of the value of the $\sum_{t=1}^{n} \left(y_t - y_t^* \right)^2$. The values of model's parameters as well as determination factor (which was used as a tool of evaluation of the quality of model's adjustment) are presented in table 1. On the basis of the value of the determination factor is has been observed that all of the models describe well the configuration of the forecasted variable in time-its value is not less than 0,8. In the case of all models the values of these factors vary slightly thus it is difficult to show a model which describes the changes of agricultural prices in time in the best manner.

Table 1. The parameters of Winter's model

Symbols	Wheat		Rye	
	(a)	(m)	(a)	(m)
α	1,00	0,51	1,00	0,00
β	0,21	1,00	0,06	1,00
γ	0,00	0,00	0,00	0,28
$\sum_{t=1}^{n} \left(y_t - y_t^* \right)^2$	2372,55	2391,27	1789,21	1789,21
R^2	0,90	0,89	0,91	0,91

a – additive y, m – multiplicative.
Source: own study.

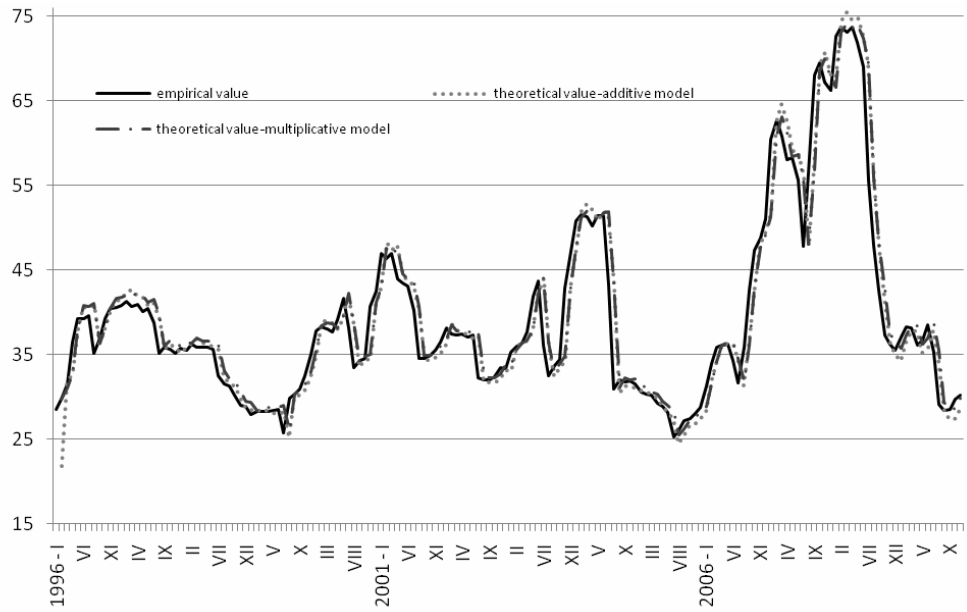

Figure 1. The actual and forecasted prices of wheat based on the Winter's method of equalisation
Source: own study.

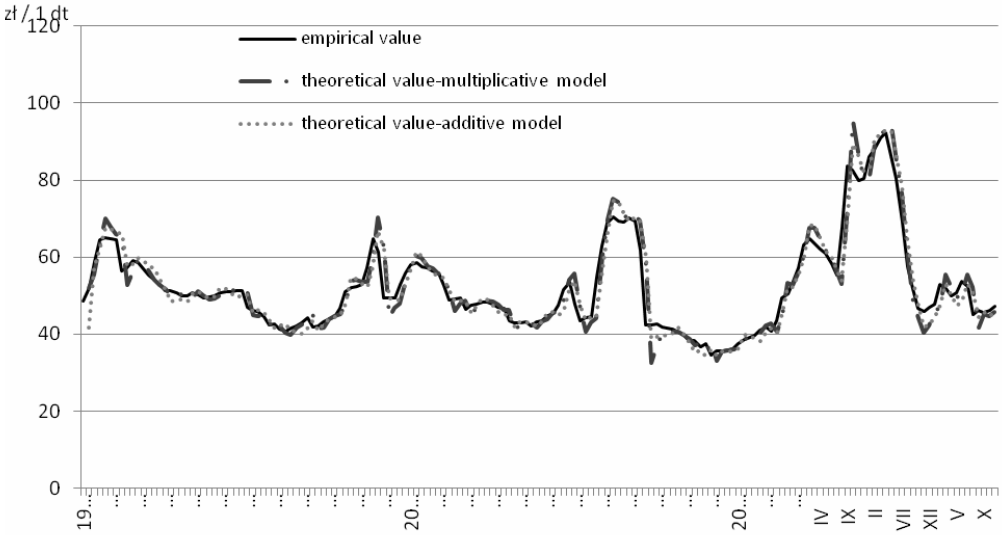

Figure 2. The actual and forecasted prices of rye based on the Winter's method of equalisation
Source: own study.

Tabela 2. The forecast of the crops prices for 2010

Crops		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average
Rye	a	29,17	28,19	27,21	26,23	25,25	24,27	23,30	22,32	21,34	20,36	19,38	18,40	23,78
	m	30,31	30,31	30,47	30,63	30,79	30,95	31,10	31,17	31,26	31,42	31,58	31,74	30,98
Wheat	a	47,33	47,50	47,68	47,85	48,03	48,20	48,38	48,55	48,73	48,91	49,08	49,26	48,29
	m	47,61	47,61	48,06	48,52	48,97	49,43	49,89	50,34	50,80	51,26	51,71	52,17	49,70

Source: own study.

Table 3. The measurements of the forecast accuracy according to Winter's model

Symbols	Wheat		Rye	
	(a)	(m)	(a)	(m)
u	-0,04	-0,09	-0,15	-0,47
S_p	3,77	3,78	3,27	3,23
w* [%]	0,08	0,18	0,39	1,18
I^2	0,00	0,005	0,01	0,01
I	0,07	0,07	0,08	0,08

Source: own study.

The estimated models allow for the determination of theoretical values and their comparison with their actual values figures 1 and 2.

On the basis of the estimated models the forecast of the crops prices Has been calculated for the year 2010 (tab. 2).

To determine the quality of forecasts, the standard deviation of the forecast errors has been calculated (S_p), relative forecast error (w*), load of prediction (u) and Thiel factor (I^2). The results for each model are presented in table 3.

Conclusions

Comparing the values of each measurements for every product we can come to conclusion that:

1. The forecasted prices of wheat and rye were slightly higher than the actual (the negative value of u parameter), the differences in prices were on the average of 3.77 PLN/100 kg for wheat and 3.2 PLN/100 kg for rye, calculated according to each model of the forecast and they can be accepted due to the fact that the relative forecast error shows the values near 1%.
2. The value of Thiel factor (I^2) equal 0 for every model and every type of crop allows for the recognition of the forecast as a very accurate. The square root of Thiel factor (I), informing about the average error of prediction is the basis for deduction that the forecasts based on adaptive models are very accurate.

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Streszczenie

Ceny oraz czynniki na nie wpływające mają charakter mierzalny zatem właściwe jest stosowanie metod analizy szeregów czasowych do prognozowania cen rolnych w skupie. W pracy zastosowano modele adaptacyjne, które dobrze dopasowują się do zmieniających się warunków, uwzględniają zmiany poziomu trendu, wahania przypadkowe oraz wahania sezonowe. Za pomocą wyznaczonych modeli adaptacyjnych obliczono prognozy cen podstawowych produktów rolnych w skupie. Do oceny modeli i prognoz wykorzystano współczynnik determinacji oraz średnie błędy ex post prognoz wygasłych.

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