ANALYZING AND PRICE FORECASTING FOR SELECTED GRAIN CLASSIFIED AS BIOMASS FEEDSTOCK ON THE EU MARKETS

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Abstract

The paper deals with the price trends of biomass feedstock used as renewable energy sources. Special attention is paid to kind of grain classified as the particular sort of biomass in Poland. The comparative prices analysis of some selected kind of grain on the markets of the EU countries is presented in this paper. Also there was demonstrated validity of two forecast models in order to forecast the prices for one month. After the forecasting, the accuracy was evaluated as well as the validation forecasts allowing for evaluation.

Keywords: Real renewable energy sources, biomass, prices, electric power system, modeling, short-term forecasting

Introduction

The development of low-cost, sustainable, and renewable energy sources is critical to meet the growing environmental concerns and energy demands. Biomass is an abundant renewable source and thermo-conversion of biomass is one of the leading near-term options for renewable hydrogen production.

There are many different ways in which the abundance of energy around us can be stored, converted and amplified for our use. Energy sources will play an important role in the world's future. The energy sources have been split into three categories: fossil fuels, renewable sources and nuclear sources. The fossil fuels are coal, petroleum and natural gas.

The point where the cost of producing energy from fossil fuels exceeds the cost of biomass fuels has been reached. With a few exceptions, energy from fossil fuels will cost more money than the same amount of energy supplied through biomass conversion. Biomass is defined in the EU Directive 2009/28 as the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste. World production of biomass is estimated at 146 billion metric tons a year, mostly wild plant growth.

Biomass is the name given to all the earth's living matter. Plants absorb solar energy, using it to drive the process of photosynthesis, which enables them to live. The energy in biomass from plant matter originally comes from solar energy through the process known as photosynthesis. The energy, which is stored in plants and animals (that eat plants or other animals), or in the wastes that they produce, is called biomass energy. This energy can be recovered by burning biomass as a fuel. During combustion, biomass releases heat and carbon dioxide that was absorbed while the plant was growing. In nature, all biomass ultimately decomposes to its molecules with the release of heat. The release of energy from the combustion of biomass imitates natural processes. Therefore, the energy obtained from biomass is a form of renewable energy and, in principle, utilizing this energy does not add carbon dioxide to the environment, in contrast to fossil fuels. Of all the renewable sources of energy, biomass is unique in that it is effectively stored solar energy. Furthermore, it is the only renewable source of carbon and is able to be converted into convenient solid, liquid and gaseous fuels.

Biomass can be used directly or indirectly by conversion into a liquid or gaseous fuel. The net energy available from biomass during combustion ranges from about 8 MJ/kg for green wood, to 20 MJ/kg for dry plant matter, as compared with about 27 MJ/kg for coal.

Many biomass fired electricity generators use waste materials, such as straw or poor quality grain. The question is how the price of these commodities will evolve, if we take increased consumption in electricity or heat generation.

Legislative and regional aspects

Renewable sources of energy are becoming a priority for many countries, especially for those belonging to the EU. The EU Directive 2009/28 obligated the Polish economy, mainly power industry sector, to reach a quantitative purpose concerning production of the electric energy and heat with the use of the renewable energy sources (RES). This problem was studied inter alia in National Action Plan of RES and The roadmap to a low carbon economy, indicating the level of difficulties in order to accomplish these goals.

In National Action Plan of RES are mentioned 12 various legal documents concerning issues of RES. The last example is the act of Power Industry Policy of State to 2030 (with attachments) ratified by the Council of Ministers in 2009. In January 2010, the regulation of deputy Prime Minister of Republic of Poland and minister of economy widened the current definition by adding renewable sources of some grain kind to the biomass. The production with the use of renewable sources allows for sale the green certificates i.e. property rights stating that energy was produced with the use of renewable sources of energy. Exploitation of renewable sources of energy in the country is carried out in three areas: generation of electricity, production of heat and bio-components used in liquid fuels and biofuels.

In general, the potential of renewable energy sources in Poland is estimated at approximately 450 PJ i.e. approximately 125 TWh per year. This energy is equivalent to consumption of approximately 15,3 million ton of fuel units and it is equal approximately to 13% of present domestic consumption of primary fuels.

In National Action Plan of RES is emphasized that biomass is the least capital intensive source of renewable energy. In the latest forecast of the International Energy Agency (IEA), the annual increases of energy supply coming from renewable sources are assumed to be approximately equal to 9%. That means that the aforementioned supply will be doubled roughly every 8 years. The percentage of biomass share in the world sources is estimated to be equal to35%, i.e. twice of the wind energy share (17%) and water energy share (also 17%). The increase of biomass consumption in Polish power plant based on brown and hard coal as well as in Polish thermal power stations is significant. For example within 20 months, from January 2007 to September 2008, the biomass consumption in power stations based on brown coal increased more than 7 times. In tab. 1 the consumption of the two most significant renewable energy sources in Polish power industry is given and predicted to the year 2020.

In tab. 1 is shown the biomass consumption share in comparison to generation of the electric energy which is even slightly higher than generation based on wind energy. According to the National Action Plan of RES in Poland are about 0,41 ha of arable lands per person, while in countries of the old EU this value is only 0,19 ha. Therefore Poland should be perspective country with significant biomass production in power industry in the EU. It is estimated that in Poland are from 1,0 to 4,3 million ha of arable lands that may be used to produce the energy plants to 2020 year.

Table 1 Prediction of the generating capacity, generation of electricity gross for the most significant technologies of renewable energy in Poland to the year 2020

	2015		2020	
	MW	GWh	MW	GWh
Wind energy (sum):	3010	6321	6110	13541
Land	3010	6321	6110	13541
Sea	0	0	0	0
Biomass (sum):	504	7489	1425	14383
Solid	196	5852	623	10377
Biogas	308	1637	802	4006

Source: own study on the base: National Action Plan on energy from renewable sources, The Ministry of Economy Warsaw 2010

The power industry sector suggests that the prices of biomass fuels should be dependent on their energetic value comparable with the net calorific value of the hard coal. The previous experiences show that the energy unit of biomass is more expensive for a producer than the unit obtained from hard coal. According to the data originating from producers of electric power, having some experience in co-combustion, it follows that costs of gaining 1 GJ of chemical energy in a plant biomass are at present even 1,5 to 2,5 times higher than costs of gaining 1 GJ of chemical energy in hard coal. It results not only from the various prices of biomass but also from costs of transport dependent on the distance to the source of fuel gaining. The necessity of transporting a biofuel via longer distance can finally regard the possibility of its general usage. The project of introducing the biomass fuels on commodity exchange causes necessity of development of models and tools allowing forecast of prices of these fuels.

An agricultural biomass market in the EU

In Poland only the grain market is systematically and methodically monitored weekly, monthly and yearly, in spite of biomass assortment variety. The prices of the remaining renewable fuels are quoted irregularly and it is difficult to achieve the credible sources on putting prices up. The price quotations concerning among other basic grain and oily plants are prepared by Integrated System of Agricultural Market Information, branches of Agriculture and Countryside Development Ministry, Agricultural Consultancy Centers, Agricultural Chambers, wholesale markets and regional exchanges. The results are given in news bulletins published in publishing houses of Agriculture and Countryside Development Ministry by Department of Agricultural Markets of Agriculture and Countryside Development.

The examples of graphs of putting weekly and monthly prices up for some configurations of countries and grain are presented in order to illustrate the price variation of the considered grain. There are two graphs in Fig. 1.

Graph on the left side shows the prices of fodder wheat in two countries with the lowest and the highest price versus time within the period including 4 years (2007-2010). This graph informs about the price range of the abovementioned grain in the considered period. The highest prices of fodder wheat were quoted in Portugal whereas the lowest was in Slovakia. The prices in the EU are the average prices determined on the basis the prices quoted in the respective countries. Graph to the right side shows the price range of six different kind of grain in Poland. In the further part of the paper the following symbols are used: C1 means the fodder wheat, C2 means the fodder rye, C3 means the fodder barley, C4 means the fodder maize, C5 means the oat and C6 means wheat-rye.

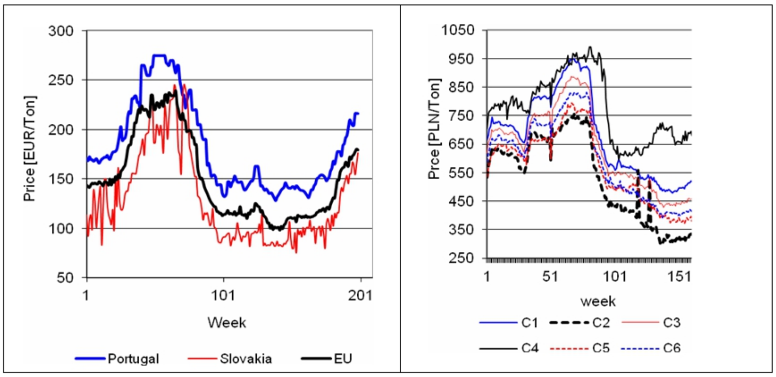

Figure 1 Graph on the left – weekly average prices of the fodder wheat within period 2007-2010 in two countries and the whole EU. Graph on the right – shaping the prices of six different kind of grain in Poland in the same period

Source: own study

The left graph in Fig. 1 does not give the full short-term variation in price. It shows a general tendency only in the presented countries. The short-term fluctuations of prices are clearly seen in Fig. 2 that presents fragment of graph from Fig. 1 including year 2009 and part of 2010, in total 52 weeks. In every yearly variation in prices there are both trend and fluctuations. The lowest fluctuations occur in price variation for the EU. This is the result of their averaging.

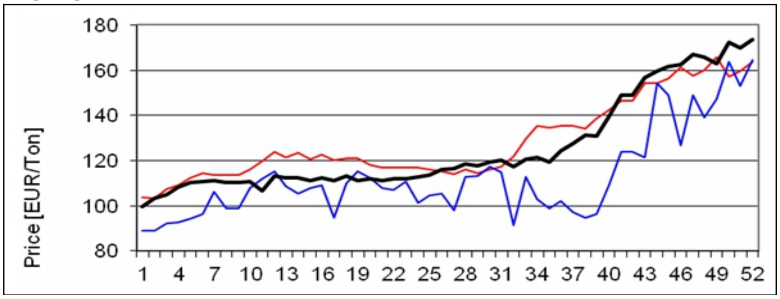

Figure 2 Prices of fodder wheat in Poland, Romania and EU within a year

Source: own study

In practical part of the paper are presented investigations of average monthly prices. The abovementioned prices were obtained by the mechanism of averaging the weakly prices that resulted in the further smoothing of the series.

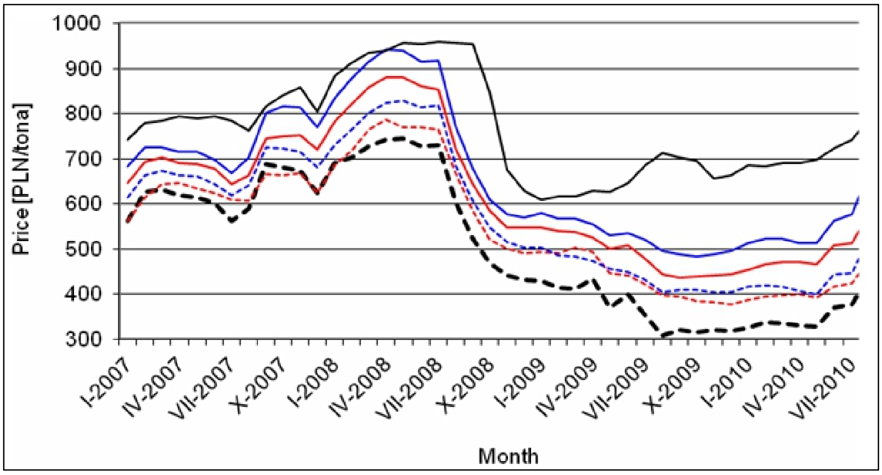

Figure 3 The average monthly prices of six different kind of grain in Poland
Source: own study

In Fig. 3 the variation is shown in average monthly prices of six different kind of grain in Poland within almost four years. The graphs are similar to each other in the price variation. Only the magnitude of the prices of the respective corns varies. Similar variability is found in the other countries.

Methodology and Theoretical basis

The example of modeling and forecasting the prices of Polish biomasses is presented for two types of grain: fodder wheat (C1) and oat (C5). Those models were constructed for the average monthly prices. Series of prices include period 2007, 2008, 2009 and part of 2010. Models were taught on the basis of data coming from two-year period of 2008-2009 i.e. 24 months. Valid forecasts were carried out for 4 months of 2010. The calculations in order to estimate parameters and determine errors of expired forecasts were carried out using the abovementioned models.

The model of harmonic components with consideration of a trend or a constant level of variability is the first example. A general form of variable obtained from harmonic model is given as follows:

$$y_t = \alpha_0 + \sum_{i=1}^{i=INT(n/2)} \left[\alpha_i \sin\left(\frac{2\pi}{n} it \right) + \beta_i \cos\left(\frac{2\pi}{n} it \right) \right] \qquad (1)$$

The matching average percentage error ex-post marked as MAPE and expressed in % is calculated as follows:

$$MAPE = \frac{1}{T}\frac{\left|C_t - \hat{C}_t\right|}{C_t}\cdot 100 \quad (2)$$

where: C_t is actual variable at the moment t, $\hat{C}_t$ is variable obtained from the model at the moment t.

The model of dynamic regression with the use of lag variables is the second one. A general form of variable determined from the regression model with lag variables is given as follows:

$$\hat{y}_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + ... + \alpha_k y_{t-k} + \varepsilon_t \quad (3)$$

Considering introduced in the paper symbols, the form of multidimensional regression is given as follows:

$$\hat{C}_{mt} = \alpha_{m0} + \alpha_{m1} C_{m,t-1} + \alpha_{m2} C_{m,t-2} + ... + \alpha_{m,k} C_{m,t-k} + \varepsilon_t \quad (4)$$

where: $\hat{C}_{mt}$ is price of m-th fuel obtained from the model, $C_{m,t-k}$ is price of m-th fuel lagged by k units of time, $\alpha_{m0}, \alpha_{m1}, \alpha_{m,k}$ are structural parameters of models.

The models of the multidimensional regression were determined using the Gretl program.

Price forecast models for selected biomass fuels

The investigation into possibility of detecting and extracting the sort of components is required in order to choose the models or forecasting methods concerning the studied processes. The matter is occurrence of development tendency, periodic fluctuations or cyclical fluctuation. An analysis of graphs as well as using only time series of biomass prices allow applying two forecasting models for practical calculations. The results are given in Tab. 2 to Tab. 1, respectively.

Model of harmonic components

Parameter α_0 for model of harmonic components equal to the variation average level for the respective variables together with values of the matching average percentage error (MAPE) is given in Tab. 2.

Table 2 Prediction of the generating capacity, generation of electricity gross for the most significant technologies of renewable energy in Poland to the year 2020

Model for variable	C1	C5
α0	685,6	577,9
MAPE [%]	3,21%	3,54%

Source: own results

Table 3 The error distribution with respect to the average error

Variable	C1	C5
Number of errors less than average error	69,4%	66,7%

Source: own results

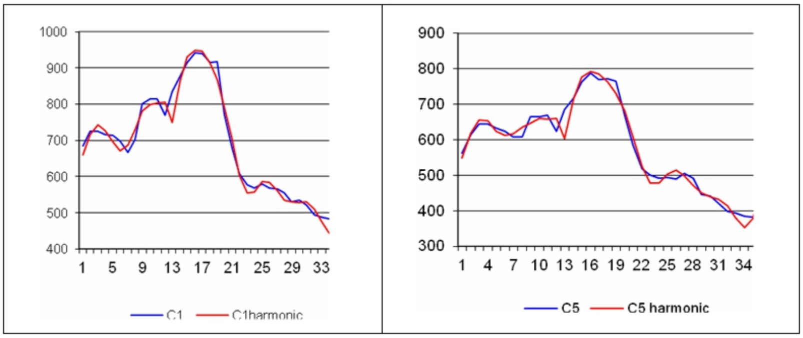

Figure 4 Real variations of variables C1 and C5 and variations obtained from the harmonic model Source: own study

Dynamic model of multidimensional regression

The results of the carried out estimation of variable C1 are given in Tab. 4. Models were constructed from beginning of the maximal number of lags. A criterion of model acceptability was determined by two parameters: the significance of structural parameters (statistics of t-Student, statistics of Fisher Snedecor) as well as the information criterion of Akaike (Tab. 4 and Tab. 5).

Evaluation of the estimated model for variable C1 is given in Tab. 6 where the number of significant lags and the obtained accuracies for variables C1 and C5 are included.

Table 4 Estimation by the model of regression, dependent variable: C1

Lag of variable	Coefficients – structural parameters of the model	Standard error	Statistics of t-Student	Value p	Signifi-cance
C1(-1)	1,46767	0,15782	9,300	1,76e-01	***
C1(-2)	-0,47462	0,15645	-3,034	0,0048	***

Source: own results

Thus, for variable C1 the form of model is following:

$$\hat{C}_{1t} = 1{,}46767C_{1,t-1} - 0{,}47462C_{1,t-2} + \varepsilon_t \qquad (5)$$

Table 5 Evaluation of the estimated model, dependent variable C1

Arithmetic mean of dependent variable	683,27	Standard deviation of dependent variable	154,46
Sum square of remainders	45536,3	Standard error of reminders	38,331
Determ. Factor R^2	0,997	CorrectedR^2	0,997
Test of Fisher Snedecor	F(2, 31) 488,488	Value p for F-test	2,95e-40
Autocorrelation of remainders – rho 1	0 ,00404	Statistics h of Durbin	0,05072
Mean error of prediction ME	1,349	Mean-square error MSE	1379,9
Root-mean-square error RMSE	37,15	Mean-absolute error MAE	23,582
Mean percentage error MPE	0,1343	Mean-absolute percentage error MAPE	3,299
Information criterion of Akaike	336,23	Criterion bayes. Schwarz	339,22

Source: own results

Table 6 Calculated significant parameters of the model of regression

Variable of model	C1	C5
Significant lags	1,2	1,2
Matching average percentage error MAPE [%]	3,30%	2,24%

Source: own results

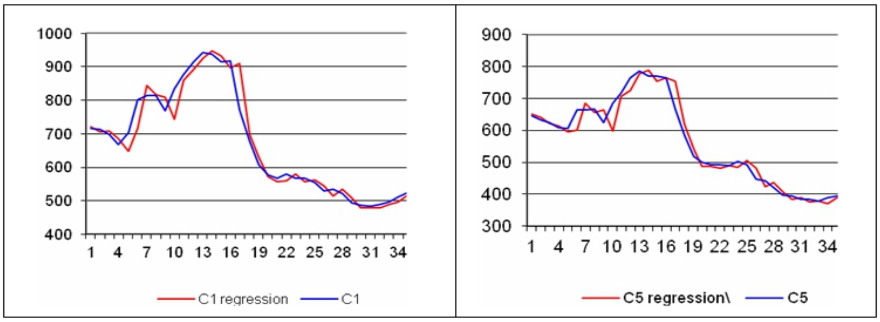

Figure 5 Variation of variables C1 and C5: actual and obtained from the model of multidimensional regression *Source: own study*

Table 7 Error distribution related to the average error

Variable	C1	C5
Number of errors lower than the average error	63,9%	66,7%

Source: own results

The values of errors lower than the average error are included in Tab. 3. Tab. 7 shows the supplement of information about the matching average percentage error of models and allows evaluating approximate error distributions.

Combination of forecasts

There is a rule to make several tests in order to increase an inference efficiency in the case of carrying out the statistic tests for investigation of the determined feature concerning population or process. In the case of carrying out forecasts using several models the connection process may be made using various forecast combinations, as in the previous case. In the literature sources there are the following names: forecast combination, forecast hybrid and forecast committee. There is minimum of three features of forecast combination (Dittmann, 2004):

- forecasts determined in this way are more objective
- the forecast load is reduced at least partially
- the evaluation subjectivism is minimized.

Numbers of works and tests have been made which show that errors ex post of forecast combinations are often lower than errors of each individual forecast (Dittmann, 2004; Fuller 1996; Hutner, Bednarzik, 1990). Such case occurs if there are systematic errors of individual forecasts or if the errors have different sign. The combined forecasts may be determined as simple averages but oftener they are determined as weighted averages. The weights are determined on the basis of errors ex post of forecasts carried out using various models by minimization of the mean-square error of a combined forecast (Janicek, 2010). The forecast combination carrying out using method of weights selection is studied in the paper as the example. The mean-square error of variable C1 is minimized at the same time. The results are given in Tab. 8.

Table 8 The matching average errors for the investigated models and variable C1

Variable	Harmonic model	Regression model	Forecast combination
C1	3,21%	3,30%	3,09%

Source: own results

The result in Tab. 8 indicates the slight improvement at decreasing the average error. Possible decreasing the error can result from occurrence of two factors impacting the considered process. The systematic error is the first factor whereas the second factor is that forecasts are loaded but errors have different signs.

In Tab. 9 and Tab. 10 are given the valid forecasts made for two investigated biomass fuels. The abovementioned forecasts are given together with accuracies determined by MAPEs for each from four forecasted months as well as average errors for the forecasted period.

Table 9 Valid forecast results for variable C1

Data	C1	*M1*	*M2*	*M3*	*MAPE1*	*MAPE2*	*MAPE3*
January_2010	512	522	520	500	1,97%	1,55%	2,26%
February_2010	524	541	504	509	3,32%	3,73%	2,85%
March_2010	524	551	509	517	5,22%	2,74%	1,28%
April_2010	513	514	580	512	0,22%	13,11%	0,14%
Average error					**2,68%**	**5,28%**	**1,63%**

Source: own results

Table 10 Valid forecast results for variable C5

Data	C5	*M1*	*M2*	*M3*	*MAPE1*	*MAPE2*	*MAPE3*
January_2010	388	430	394	409	10,80%	1,51%	9,79%
February_2010	395	438	397	413	11,02%	0,62%	9,12%
March_2010	397	452	384	408	13,98%	3,13%	7,77%
April_2010	399	447	426	437	11,95%	6,67%	11,06%
Average error					**11,94%**	**2,98%**	**9,44%**

Source: own results

Symbols in Tab. 9 and Tab. 10:
M1 – model of harmonic components
M2 – model of regression
M3 – combination of models
The errors: MAPE1, MAPE2, MAPE3 are assigned to the models M1, M2 and M3, respectively.

The carried out statistic tests of the expired forecasts errors and the obtained results allow formulating the conclusions concerning usefulness of the investigated models to forecast the monthly prices for two chosen biomass fuels. The forecast combination for the case C1 caused decreasing the average error. Decrease was not found in the case of C5 due to the significant difference in errors for two used models. Using more than two models could positively affect the forecast resulting from combination. A step forecast with monthly step or actualization of models after several months, e.g. a quarter, should also be considered. Generally, the step models, i.e. the models actualized with fixed period, are usually recommended. Costs of actualization or work as well as the other considerations can be the reason hindering such proceedings.

Conclusion

Poland has significant technical potential of energy possible to obtain from the biomass. In present legal status obligating the distribution companies to buy the electric energy coming from RES and electric energy generated in association with heat is an effective tool in increasing the supply of energy coming from renewable sources. The project of establishing the blocks working in co-generation in each village, will also have a big share in increasing the demand for fuels coming from RES. Considering all of Poland RES, biomass is the most important fuel. Therefore, its share in consumption of renewable fuels will increase. Introducing biomass fuels to Poland Commodity Exchange will affect significantly increasing of prices of these fuels.

The main goal of the paper was to indicate the problem of forecasting the prices of biomass fuels, especially grain considered as fuel. With increasing consumption of renewable fuels will increase the interest in putting the prices up. It may be expected with high level of confidence that purchase of renewable fuels by producers of electric energy and heat will be in progress in two ways. The purchase and sale of renewable fuels will be carried out on Commodity Exchange apart from long-term contracts of purchases of renewable fuels. Thus, it is worth taking the attempts of application the models and tools supporting execution of such forecasts.

Two relatively simple models of short-term price series were presented. However, it is worth saying about different step averages used in order to monitor the trend and simultaneously filtering the noise in the form of the random changes of prices. It is especially meaningful in construction of models forecasting the long-term prices as direction of trend may change. From the mathematical point of view an application of moving average corresponds with application of linear filter for white noise. The technical analysis uses the step averages calculated for example for: opening and closure prices, the highest and the lowest price, the average daily price so-called typical price. It also formed series of moving averages with the use of distributed weights. Such moving averages laid on the analyzed price series indicate the actual direction of a trend. The intersection of the average line and the graph of price series may be treated the most often as a signal of possible change. Intersecting the graph of price from bottom gives the signal about reduction of the price.

Generating such information may be useful in constructing the presented models. Presented model could be enriched with binary variables of zero-one type introducing the additional information originating from analysis of graphs. It should be noted that the same two models applied to two types of grain showed different properties in context of the obtained accuracies for valid forecasts. In case of grain C1 (wheat), the model of harmonic components provided higher accuracies in comparison to the case of grain C5 (oat) regression model. In the case of grain C1 the combination of forecasts explicitly improved the forecast. In the case of grain C5 the combination of forecasts did not improved the forecast due to high difference in errors of components forecasts. The combination of forecasts that suggests an application of higher number of components was described in detail by Dittmann P.

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