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TESTING OF BREAKDATES IN AGRICULTURAL PRICES OF SELECTED REPRESENTATIVES OF ANIMAL PRODUCTION

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Abstract

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This paper deals with an investigation of breakdates in agricultural prices. A structural break has occurred if at least one of the model parameters has changed at some date. This date is a breakdate. Ignoring structural breaks in time series can lead to serious problems with economic models of time series. The aim is to determine the number and date of the breakdates in individual time series and connect them with changes in the market and economic environment. The time series of agricultural price relating to animal production, namely the prices of pork, beef, chicken, milk and eggs, are analyzed for the period from January 1996 to December 2011. The autoregressive model (AR) model of Box-Jenkins methodology and stability testing according to Quandt or Wald statistics are used for the purposes of this paper. Multiple breakdates are found in the case of eggs (September 1998, May 2004), milk (October 1999, December 2007) and chicken (October 2002, February 2005) prices. One breakdate was detected in the prices of beef (April 2002) and none in the case of pork prices. The results show the importance of multiple breakdate testing. The Quandt statistic provides one possible way of applying a multiple approach. All breakdates which were confirmed using these statistics can be associated with changes in the agri-food market and economic environment. Information about the date of changes in the time series can be used for other unbiased modelling in more complex models.

breakdate, structural change, AR model, Quandt statistic, stability, multiple testing, agricultural prices, animal production

Detection of structural changes and shocks in time series is a topic that has been discussed for many decades. Ignoring these change points in time series can lead to serious problems with economic models of time series. Hansen (2001) argued that creating a model without considering structural changes in time series can lead to misleading inferences about economic relationships, incorrect policy recommendations, and inaccurate forecasts. Eksi (2009) mentions another problem – distinguishing between a structural break and a nonstationary time series. Therefore, a lot of publications deal with the issue of testing the structural changes or shocks. A structural break has occurred if at least one of the model parameters has changed at some date. This date is a breakdate. The test used most often for stability testing is the Chow test (1960). The essence of this test is to divide the time series into two subsamples, and test the equality of parameters from the subsamples according to the F-test. The test should be used when we have a priori information about the time of the break. However, Hansen (2001) pointed out that the Chow test can be misleading when we use a priori information. The candidate breakdate is correlated with the data, i.e., it is endogenous, thus the test could falsely indicate a break when in fact none exists. Authors from earlier studies such as Zivot and Andrews (1992), or Perron (1997), have pointed out the endogeneity of the shock. Another problem arises when we select the candidate breakdate arbitrarily. In this case, the test can be uninformative; the true breakdate can be missed.

The problem of unknown time of breakdate was solved by Quandt (1960, who designed Quandt statistic (QLR) in order to obtain unbiased results. The QLR statistic is the maximal value of Chow test F-statistics, which are generated for all possible candidate breakdates. When this value exceed the critical value, the breakdate is statistically significant. This procedure has better properties than the Chow test. The QLR statistic is also called as a Wald statistic (for example; Bai, 1997).

Nevertheless, there is another significant problem in testing structural changes – the problem of multiple breakdates. If we consider only one candidate breakdate in a time series, we restrict the analysis with the inappropriate assumption that there is only one breakdate. This issue is discussed in publications such as Chong (1995) and Bai (1997). These authors showed how to estimate multiple breakdates sequentially. Their test is based on repeatedly computing the QLR statistic for different sample sizes. This testing approach is possible to find in Bai and Perron (1998), Hansen (2001), Stock and Watson (2003) and Eksi (2009). Another approach to breakdate estimation is to distinguish between a unit root and a (trend) stationary within regimes specified by the break dates (Perron, 1989, 2005). Besides the mentioned, Lee and Strazicich (2003) applied the minimum Lagrange Multiplier test. The advantage of this test is that it does not suffer from bias and spurious rejections (as in the case of a test where the presence of structural breaks is under the null hypothesis), and is mostly invariant to the size, location, and misspecification of the breaks. The disadvantage is that the test is designed for only two breakdates.

The multiple breakdate estimate approach according to Bai (1997) and Hansen (2001) is used in this paper as a convenient procedure, because we do not know the number of breakdates in the time series, and it is assumed that more breakdates could be present in one time series. In addition, this procedure allows for testing of breakdates of unknown timing. The aim of this paper is to determine significant breakdates in the agricultural prices of selected representatives of animal production from January 1996 to December 2011, and to specify the number of breakdates and their dates within an individual time series. Then, we will try to connect the estimates of breakdates with changes in the agri-food market or economic environment which took place in the analyzed period.

MATERIALS AND METHODS

Time series of agricultural prices relating to animal production were selected for analysis. Prices of pork, beef, chicken, milk and eggs are explored in the period from January 1996 to December 2011 with monthly frequency (192 observations in total). Data was gathered from the Czech Statistical Office.

Declaration of variables

AP_pork.............. agricultural prices of pork, slaughter SEU in vivo, CZK/kg
AP_beef............... agricultural prices of beef, slaughter A in vivo, CZK/kg
AP_chicken......... agricultural prices of slaughter poultry chicks I, CZK/kg
AP_milk .... agricultural prices of cow's milk, class I, CZK/ton
AP_eggs............... agricultural prices of chicken eggs, CZK/thous. pc.

Multiple breakdate estimates are used in this paper. The approach taken is a little bit modified compared with traditional testing of structural changes. Two time series are usually used for estimating structure changes, for example it is possible to determine changes in the food vertical structure using agricultural and producer prices of milk. The aim is not to determine changes in the structure according to multiple time series, but rather to investigate significant changes in the individual time series of prices. Therefore, the stochastic process of individual time series – as a representative of natural relationships of price development – is estimated and afterwards it is determined whether or not there is a significant change or changes (breakdates) in this process. Autoregressive (AR) models according to Box-Jenkins methodology are used for stochastic process estimation.

First of all, the presence of seasonality was examined, because significant seasonality could affect the breakdate results. The F-test for the presence of seasonality and the test of moving seasonality were used to investigate both types of fluctuation (stable and unstable). Since there is a strong possibility that the time series is not normal, the nonparametric Kruskal-Wallis test was also applied. Tests were carried out using the EViews software, module Census X12. (EViews, 2009). For evaluation of the tests a level of significance $\alpha = 0.05$ was selected. Data with significant seasonality were adjusted. In the case of significant seasonality according to the F-test or Kruskal-Wallis test only, stable seasonal factors were used. In the case of significant moving seasonality, seasonal factors were built on the basis of the moving seasonality ratio.

The modelling of stationary time series is a fundamental assumption of the AR process. The order of integration of time series was determined on the basis of the Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test (Dickey and Fuller, 1979; Phillips-Perron, 1988). With respect to the development of the analyzed time series, all tests contain a constant. The ADF test with a constant and a trend, and the PP test with a trend were used, if the trend was significant. The optimal lag of ADF test was determined on the basis of an automatic selection of Schwartz Info Criterion (SIC), where maximum lags are twelve. The spectral estimation method of the PP test was based on Bartlett Kernel method. These test statistics were estimated using the EViews software, version 7. If the order of integration is greater than zero, appropriate differences are utilized for creating the model.

Next, an AR model for each time series was created. The number of lags was determined on the basis of the partial autocorrelation function (PACF) and, in addition, the lag was verified using statistical parameter testing according to the t-test. Each model was tested to determine whether it is consistent with the assumptions of the linear regression model. The Breusch-Pagan test of heteroskedasticity, Breusch-Godfrey test of autocorrelation, RESET test of function form, and Jarque-Bera test of normality of the random term were applied (Green, 2007; Hill, 2008). Fulfilment of the stated, tested assumptions was the main criterion for selecting the most suitable model. A 5% level of significance was selected for evaluation of the tests.

Subsequently, the most suitable model was tested for parameter stability, i.e., a determination was made of the existence and period of statistically significant structural breaks. There is a possibility that a statistically significant breakdate in the time series could affect the linear regression model assumptions mentioned above, such as heteroskedasticity. However, in this paper we try to find the most convenient model which represents the stochastic process of the time series, and then afterwards investigate whether or not there is a significant change in this best-approximated stochastic process. Ignoring the linear regression model assumption could also lead to an incorrect determination of the breakdate time.

The least-squared estimation of multiple breakdates is applied according to Bai (1997) and Hansen (2001). Bai (1997) showed that the change point $\hat{k}$ is defined as a sum of the squared residuals minimum $S_T(k)$, which is estimated for the sub-period divided into potential breakdates k. The estimator obtained by minimizing the sum of squared residuals is the same as maximizing the Wald or QLR statistic, i.e.

$$\hat{k} = \arg\min_k S_T(k) = \arg\max_k W_T(k). \tag{1}$$

The whole procedure of stability testing is as follows. An AR model is estimated for the time series in the period from January 1996 to December 2011. Subsequently, a sequence of Chow test F-statistics is generated in the estimated sample with 15% trimming from both sides of the time series (trimming is necessary to obtain a sufficient number of observations to estimate the F-stat). Therefore, the time periods at the beginning and end of the time series cannot be investigated with regard to the presence of a breakdate. The highest value of the generated F-statistics is the QLR statistic, which is compared with the critical value (Stock and Watson, 2003). If the breakdate is significant, the time series is divided into two sub-samples at this breakdate point. Each sub-sample is again tested individually for the presence of breakdate. RATS, version 7 was used for estimating the models, as well as for econometric verification and stability testing.

RESULTS AND DISCUSSION

The results of seasonal testing are shown in Tab. I. Statistically significant seasonality was detected for all time series. Moving seasonality test showed statistically significant seasonality in the case of the time series of pork (1% level of significance), beef (5% level of significance) and milk (1% level of significance). These time series were adjusted using moving seasonality ratio factors. In the case of the time series of chicken and eggs, p-value of the moving seasonality test is higher than considered 5% level of significance, nevertheless, there is statistically significant seasonality according to the traditional F-test and Kruskal-Wallis test, therefore the time series were adjusted using stable seasonality factors.

Tab. II contains the results of the ADF test, and Tab. III shows the results of the PP test. The time series of milk and eggs are stationary at 5% and 10% levels of significance, according to both tests. The time series of beef and chicken are stationary according to the ADF test, but the PP test indicates the order of integration I(1) at both significance

I: *Seasonality Testing of Agricultural Prices, Period 1996:01–2011:12*

	Test for the Presence of Seasonality		Nonparametric Test for the Presence of Seasonality		Moving Seasonality Test		Adjustment Method
	F-Value	**p-value**	*K-W stat* [1]	**p-value**	**F-value**	**p-value**	***M or S*** [2]
AP_pork	29.879	0.00000	124.9353	0.00000	3.040	0.00024	M
AP_beef	1.633	0.92774	20.5846	0.03794	1.865	0.03009	M
AP_chicken	2.051	0.02615	25.8826	0.00676	1.620	0.07325	S
AP_milk	19.912	0.00000	134.6998	0.00000	8.785	0.00000	M
AP_eggs	110.679	0.00000	163.841	0.00000	0.798	0.67869	S

Note: [1] K-W stat = Kruskal-Wallis statistics
[2] M = adjustment based on the moving seasonality ratio, S = adjustment based on stable seasonal factors
Source: author, SW EViews

II: *Augmented Dickey-Fuller Test of Agricultural Prices, Period 1996:01–2011:12*

	ADF test					
	Original Time Series		First Differences		Result α = 0.05	Result α = 0.1
	t-stat	p-value	t-stat	p-value		
AP_pork	–2.642	0.086	–10.651	0.000	I(1)	I(0)
AP_beef	–3.248	0.019	x	x	I(0)	I(0)
AP_chicken	–3.973	0.002	x	x	I(0)	I(0)
AP_milk	–4.346	0.001	x	x	I(0)	I(0)
AP_eggs	–3.124	0.026	x	x	I(0)	I(0)

Note: items, which are marked by a cross were irrelevant for testing
Source: author, SW EViews

III: *Phillips-Perron Test of Agricultural Prices, Period 1996:01–2011:12*

	PP test					
	Original Time Series		First Differences		Result α = 0.05	Result α = 0.1
	t-stat	p-value	t-stat	p-value		
AP_pork	–2.825	0.057	–10.113	0.000	I(1)	I(0)
AP_beef	–2.265	0.185	–6.244	0.000	I(1)	I(1)
AP_chicken	–2.195	0.209	–9.512	0.000	I(1)	I(1)
AP_milk	–2.899	0.047	x	x	I(0)	I(0)
AP_eggs	–3.249	0.019	x	x	I(0)	I(0)

Note: items, which are marked by a cross were irrelevant for testing
Source: author, SW EViews

levels. The results of the PP test are taken as conclusive, because this test was modified so that it would not be influenced by serial correlation, and the test is robust towards common types of heteroskedasticity. Pork prices are stationary I(0) at a 10% level of significance; however, both tests indicate non-stationarity at a 5% level of significance. A more stringent level is taken into account for model estimates. An AR model for time series I(1) will be estimated for the first differences. One small problem with this transformation is that it reduces information from the time series. Nevertheless, if there is a significant change in the time series, it should become evident in a differentiated model as well.

The final number of lags in the AR process and the testing of linear regression assumptions are shown in Tab. IV. An AR model with one lag was used in the case of the first differences in beef prices. An AR model with four lags was applied for the modelling of milk prices. Prices of other commodities were estimated using an AR with two lags. A 5% level of significance was selected for evaluation of the assumption fulfilment of the linear regression model. All models fulfil the assumption of no autocorrelation for residuals, homoskedasticity, and selection of the proper functional linear form in comparison with the quadratic form. Normally distributed residuals are not fulfilled in most cases, except for the model used for eggs. These models have the best results of the mentioned model assumptions (in comparison with other models, which have been tested) and were finally tested for stability using QLR statistics.

IV: *Final Number of Lags in the AR Process and Linear Regression Assumption, Testing of Individual Price Models, Estimation for the Period 1996:01–2011:12*

Time series	Lag in AR model according to PACF	Final lag in AR model*	Breusch-Godfrey test		Breusch-Pagan test		RESET test (quadratic form)		Jarque-Bera test	
			test.stat.	p-value	test.stat.	p-value	test.stat.	p-value	test.stat.	p-value
dAP_pork	2	2	0.2121	0.6451	6.6279	0.0848	1.1476	0.2854	22.343	0.0000
dAP_beef	1	1	0.1787	0.6725	0.3152	0.9571	1.1308	0.2890	203.970	0.0000
dAP_chicken	2	2	0.0159	0.8997	3.7169	0.2937	1.3723	0.2429	10.587	0.0050
AP_milk	2	4	0.5816	0.4457	3.9497	0.2669	1.8176	0.1793	1247.471	0.0000
AP_eggs	2	2	0.8708	0.3507	3.0993	0.3766	0.0142	0.9052	1.995	0.3689

Note: * The final lag, which was used for the estimation of a model, was selected according to its significance and suitability of the model with respect to fulfilment linear regression assumptions.
Source: author, SW RATS

V: *Results of Breakdate Testing, Agricultural Prices of Eggs*

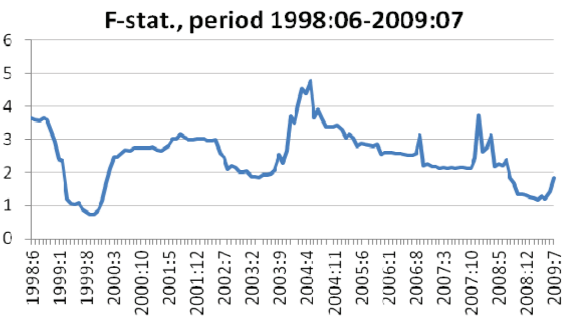
Sample for Model Estimation		Sample for QLR Statistics Estimation			QLR statistics	Critical Value [2]		Time of Breakdate
Period	Num. of Obs.	Trim 15 % [1]	Period	Num. of Obs.		α = 0.1	α = 0.05	
1996:01–2011:12	192	29	1998:06–2009:07	134	**4.7642**	4.09	4.71	**2004:05**
1996:01–2004:04	100	15	1997:04–2003:01	70	**4.99874**	4.09	4.71	**1998:09**
2004:05–2011:12	92	14	2005:07–2010:10	64	**2.0459**	4.09	4.71	–
1998:09–2011:12	160	24	2000:09–2009:12	112	**4.13374**	4.09	4.71	**2004:05**

Note: [1] number of observations, which are trimmed from both side of the time series
[2] critical values according to Stock and Watson (2003)
Source: author, SW RATS

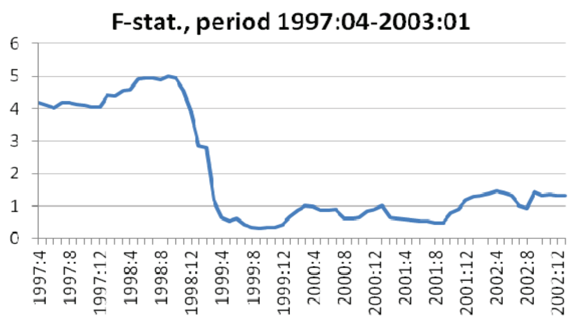
The following paragraphs contain the results of an investigation of breakdates in individual time series, and a discussion regarding estimated changes and changes in the economic environment which took place in the analyzed period. The results of stability testing in the case of eggs prices are shown in Tab. V. The overall process of testing will be explained with regard to this output.

Firstly, the breakdate for the model, which is estimated for whole period from January 1996 to December 2011, was tested. Since it is necessary to have a sufficient number of observations in order to compute Chow F-statistics, the F-statistics were not calculated for 29 observations (15% trimming) at the beginning and at the end of the time series. An F-statistic was generated in the period from June 1998 to July 2009. In this period we can find a QLR statistic in May 2004, where the sequence of F-stats has a maximum. The estimated value is 4.7642, which is higher than the critical values at both levels of significance. A statistically significant breakdate was detected in May 2004. The appropriate graph is shown in Fig. 1.

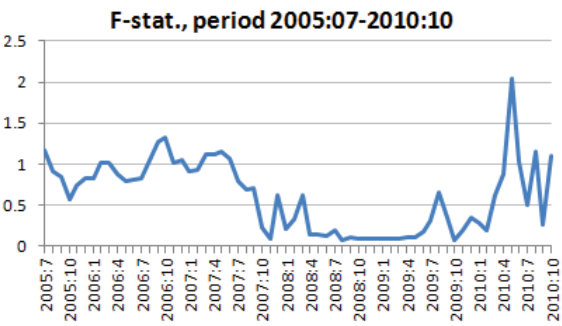
However, this time series could contain other breakdates which are hidden behind the shock in May 2004. Therefore, the time series is divided at this point into two sub-samples. The first sub-sample covers the period from January 1996 to April 2004. The second sub-sample contains the period from May 2004 to December 2012. We perform the required trimming in the first sub-sample and compute the sequence of F-statistics in the period from April 1997 to January 2003. In this period we can find another statistically significant QLR statistic in September 1998 (test statistics = 4.999). By contrast, the second sub-sample QLR statistic did



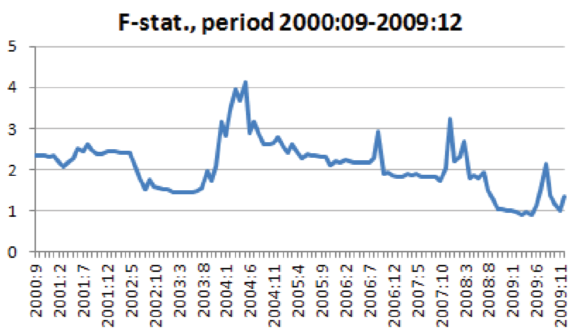
Note: AR model is estimated in the period 1996:01–2011:12



Note: AR model is estimated in the period 1996:01–2004:04



Note: AR model is estimated in the period 2004:05–2011:12



Note: AR model estimated in the period 1998:09–2011:12

1: *F-statistics of Chow Test, Variable AP_eggs, Different Periods*
Source: author, Tab. V

not exceed the critical value, and thus there is no significant breakdate.

The original time series is again divided into two sub-samples, but in this step it is done in September 1998 (the second significant breakdate). There are an insufficient number of observations in the first period from January 1996 to September 1998, so it is not possible to compute unbiased F-statistics. When we investigate the second period from September 1998 to December 2011, we can detect a statistically significant breakdate in May 2004. The appropriate graphs are shown in Fig. 1.

One thing should be mentioned. The breakdate is related, for example, to May 2004, but if we want to be precise, the change happened between the fourth and fifth month of that year with regard to the calculation and properties of Chow F-statistics. The scale is so small that we can talk about change in May 2004, but it is good to keep in mind that a change in the economic environment could have taken place around this month.

In summary, two breakdates were found in the investigated period from 1996 to 2011. The breakdate in May 2004 was confirmed twice. Another candidate is September 1998. The change in 1998 could be connected with the Russian crisis, which also affected prices in other countries. The other, more important breakdate was detected in May 2004; however, if we look at Graph 1, we can see that the F-statistics also exceed the critical values in March and April of that year. This period is related to the Czech Republic's accession to the EU, and to political changes in the rules regarding poultry commodities from 1 May 2004. According to the annual Situational and Outlook Report for poultry and eggs (Ministry of Agriculture, 2004, 2005), the primary changes were in customs tariffs and the mechanisms of foreign trade, in connection with implementation of the European common market. Agricultural prices of eggs had been increasing since September 2003 and peaked in February 2004. The decrease took place from March to November 2004. The monthly level of egg imports being at its highest, along with very low import prices, explains the low egg prices in the Czech domestic market. These imports made up for lower production in the domestic market and replenished the required consumption. On account of low import prices, which rivalled internal agricultural prices, a lot of producers went out of business. According to the results of the stability test, we can see that changes related to Czech accession were immediately and significantly reflected in the time series of egg prices.

The following Tab. VI contains the results of breakdate testing for the agricultural price time series for chicken.

Two significant breakdates can be found in the time series of chicken prices in the investigated period from 1996 to 2011. The breakdate in October 2002 was confirmed twice. Another breakdate occurred in February 2005. The second breakdate could again be connected with the EU effect. The highest price around this period was in December 2004. Therefore, the shock could be related to this period. In this period the price increased despite a large amount of exports. The higher level of exports was due to market access following Czech accession to EU. Prices decreased from December 2004 to May 2006. The main reason for this situation can be attributed to permanently low prices in neighbouring countries. Whenever prices increased considerably in the Czech Republic, more chicken was imported into the domestic market, because the union of free markets meant that market barriers were no longer a problem. After this occurred, it is highly likely that sales of domestic chicken decreased (Ministry of Agriculture, 2004, 2005). Another breakdate was in October 2002. Because of the decline in prices during this period, an additional duty was placed on chicken imports. Prices declined until September 2002. This situation ended in October, when there was a revival in prices (Ministry of Agriculture, 2002a). It should be noted that in contrast to chicken prices, egg prices immediately felt the effects of accession to the EU and the organization of a common market.

The model results of first differences for pork prices are shown in Tab. VII.

VI: *Results of Breakdate Testing, Agricultural Prices of Chicken*

Sample for Model Estimation		Sample for QLR Statistics Estimation			QLR Statistics	Critical Value [2]		Time of Breakdate
Period	Num. of Obs.	Trim 15 % [1]	Period	Num. of Obs.		α = 0.1	α = 0.05	
1996:01–2011:12	192	29	1998:06–2009:07	134	**6.78419**	4.09	4.71	**2002:10**
1996:01–2002:09	81	13	1997:02–2001:08	55	**2.19651**	4.09	4.71	–
2002:10–2011:12	111	17	2002:10–2011:12	77	**5.55232**	4.09	4.71	**2005:02**
1996:01–2005:01	109	17	1997:06–2003:08	75	**10.39496**	4.09	4.71	**2002:10**
2005:02–2011:12	83	13	2006:03–2010:11	57	**1.81800**	4.09	4.71	–

Note: [1] number of observations, which are trimmed from both side of the time series
[2] critical values according to Stock and Watson (2003)
Source: author, SW RATS

VII: *Results of Breakdate Testing, Agricultural Prices of Pork*

Sample for Model Estimation		Sample for QLR Statistics Estimation			QLR Statistics	Critical Value [2]		Time of Breakdate
Period	Num. of Obs.	Trim 15 % [1]	Period	Num. of Obs.		$\alpha = 0.1$	$\alpha = 0.05$	
1996:01–2011:12	192	29	1998:06–2009:07	134	**2.92647**	4.09	4.71	–
1996:01–2002:07	79	12	1997:01–2001:07	55	**2.82851**	4.09	4.71	–
2002:08–2011:12	113	17	2004:01–2010:07	79	**3.31509**	4.09	4.71	–

Note: [1] number of observations, which are trimmed from both side of the time series
[2] critical values according to Stock and Watson (2003)
Source: author, SW RATS

VIII: *Results of Breakdate Testing, Agricultural Prices of Beef*

Sample for Model Estimation		Sample for QLR Statistics Estimation			QLR Statistics	Critical Value [2]		Time of Breakdate
Period	Num. of Obs.	Trim 15 % [1]	Period	Num. of Obs.		$\alpha = 0.1$	$\alpha = 0.05$	
1996:01–2011:12	192	29	1998:06–2009:07	134	**6.26547**	5.00	5.86	**2002:04**
1996:01–2002:03	75	12	1997:01–2001:03	75	**2.27372**	5.00	5.86	–
2002:04–2011:12	117	18	2003:10–2010:06	81	**3.00378**	5.00	5.86	–

Note: [1] number of observations, which are trimmed from both side of the time series
[2] critical values according to Stock and Watson (2003)
Source: author, SW RATS

IX: *Results of Breakdate Testing, Agricultural Prices of Milk*

Sample for Model Estimation		Sample for QLR Statistics Estimation			QLR Statistics	Critical Value [2]		Time of Breakdate
Period	Num. of Obs.	Trim 15 % [1]	Period	Num. of Obs.		$\alpha = 0.1$	$\alpha = 0.05$	
1996:01–2011:12	192	29	1998:06–2009:07	134	**5.58828**	3.26	3.66	**1999:10**
1999:10–2011:12	147	23	2001:09–2010:01	101	**6.04926**	3.26	3.66	**2007:12**
1996:01–2007:11	143	22	1997:11–2006:01	99	**12.66783***	3.26	3.66	–

Note: [1] number of observations, which are trimmed from both side of the time series
[2] critical values according to Stock and Watson (2003)
* the given period cannot be identified as breakdate with respect to the development of statistics (see text below)
Source: author, SW RATS

In the case of pork prices, the QLR statistic is found in August 2002, but the statistics do not exceed the critical value. Therefore, a statistically significant breakdate cannot be proved. Nevertheless, the time series was divided at this point in order to investigate the sub-samples individually. A breakdate did not occur in any of them.

The following Tab. VIII contains the results of the first differences in beef prices.

Only one significant breakdate, in April 2002, was discovered for the case of agricultural prices of beef. The testing of sub-samples did not lead to detection of subsequent changes in the time series. Prices of slaughter bulls increased from February to April of that year, but afterwards, as well as before, a gradual reduction took place. The unfavourable trend in prices can be attributed to the recurrence of BSE in the Czech Republic (Ministry of Agriculture, 2002b).

The results of stability testing of the agricultural prices of milk are shown in Tab. IX.

A breakdate in time series of milk prices was found in October 1999. When the time series was divided into two sub-samples at the first detected breakdate, the first sub-sample, before October 1999, did not have sufficient observations for unbiased testing. A significant breakdate was found in the second sub-period, from October 1999 to December 2012, and occurred in December 2007. The time series was divided again, but this time in December 2007. There were insufficient observations in the sub-sample after December 2007, therefore it was only possible to test the sub-sample before December 2007. This sample for QLR statistics estimation included the period from November 1997 to January 2006 (due to trimming). The sequence of F-statistics in this period showed an increasing trend. The highest value of QLR statistics (12.66783) was found in the last counted period. This value exceeded the critical value; nevertheless, a breakdate cannot be determined at this point, because we have an increasing function without an extreme point. We cannot be sure that this point is the maximum. The sequence could increase, for example, until December 2007, but we do not have observations for this testing.

The breakdate in December 2007 was caused by the situation in the global market. A rapid increase in prices began in October 2007, when prices reached an 11-year high. Prices increased until January 2008, and afterwards started to decrease. Increased demand in Asia and Europe was the reason for this price shock. Czech, German and Italian producers led the increase in demand in Europe. A subsequent large drop in prices, which continued until 2009, added to the significance of the shock. The year 1999, in which a breakdate was found in October, is related to the rapid drop in prices.

CONCLUSION

The prices of selected representatives of animal production were analyzed in the period from January 1996 to December 2011 using Box-Jenkins AR models and stability testing according to QLR statistics. Two significant breakdates were confirmed in the price of eggs, namely in September 1998 and May 2004. The shock in 2004 was confirmed twice. In the case of the time series of chicken, breakdates were found in October 2002 and February 2005. The latter breakdate was also confirmed twice in the case of egg prices. Only one breakdate, in April 2002, occurred in the time series of beef prices. The stability testing of pork prices did not lead to a confirmation of any breakdate. Finally, two breakdates were detected in the time series of milk prices, in October 1999 and December 2007. The confirmed breakdates could be connected, for example, with the Russian crisis in the case of eggs, the recurrence of bovine spongiform encefalopathy (BSE) in the case of beef prices, and the open market and changes in certain rules following accession of the Czech Republic to the EU in the case of egg, milk and chicken prices.

The results show the importance of multiple breakdate testing. More than one breakdate was found in most of the time series of agricultural prices. The QLR statistic provides one possible way of applying a multiple approach. All breakdates which were confirmed using these statistics can be associated with changes in the agri-food market and economic environment.

This determination of breakdates cannot give us information about the source of the shock, but it does provide an answer to the question of which shocks are important for modelling time series. It is possible to avoid the biased results of other models when we know the date of the breakdate, and add this information to the model.

SUMMARY

This paper deals with an investigation of structural breaks in time series of agricultural prices. A structural break has occurred if at least one of the model parameters has changed at some date. This date is marked as a breakdate. Significant breakdates in the agricultural prices of selected representatives of animal production are determined. Prices of pork, beef, chicken, milk and eggs are explored in the period from January 1996 to December 2011 with monthly frequency. The multiple breakdate estimate approach according to Bai (1997) and Hansen (2001) is used. The test is based on repeatedly computing the Quandt (QLR) statistic for different sample sizes of time series. Autoregressive models according to Box-Jenkins methodology are used for model estimation. Two significant breakdates – September 1998 and May 2004 – were confirmed in the price of eggs. In the case of the time series of chicken, breakdates were found in October 2002 and February 2005. Two breakdates were detected in the time series of milk prices, in October 1999 and December 2007. Only one significant breakdate, in April 2002, was discovered for the case of agricultural prices of beef. A statistically significant breakdate cannot be proved in the case of the pork prices. The confirmed breakdates are connected with changes in the agri-food market or economic environment which took place in the analyzed period. The breakdates could be connected with the effect of open market and changes in certain rules following accession of the Czech Republic to the EU in the case of egg, milk and chicken prices. The results of multiple breakdate testing can be used for other unbiased modelling in more complex models.

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