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CROATIAN NATIONAL BANK

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Summary

Inflation forecasting is an essential component of the Monetary Policy Projection, and there are constant efforts to improve it at the Croatian National Bank. One step is to improve the model of short-term forecasting of the consumer price index with seasonal ARIMA processes, where, along with direct forecasting of the total consumer price index, the attempt is made to forecast changes in the index's components in order to obtain a more detailed insight into the sources of future inflationary or deflationary pressures and to determine whether a forecast of developments in the total consumer price index obtained by aggregating forecasted values of the index's components is more precise than a direct forecast.

JEL: E17, E31, C22

Key words: inflation, forecasting, ARIMA, Croatia

Contents

1 Introduction

In line with the development and scope of the literature on the importance and macro-economic value of price stability, the monetary authorities of a large number of countries have decided that price stability, that is, a low and stable inflation rate, is the main contribution that monetary policy can give to economic growth. The Croatian National Bank Act that came into force in April 2001 has the achievement and maintenance of price stability as its main aim. Like other central banks, the Croatian National Bank uses various monetary policy instruments to achieve this aim. However, the effect of applying particular instruments can be felt only after a certain period of time. Therefore, the monetary authorities are attempting to develop and improve models that provide them with a relatively precise and reliable forecast of the inflation rate so that they can react in time and neutralise inflationary or deflationary pressures that could appear in the future.

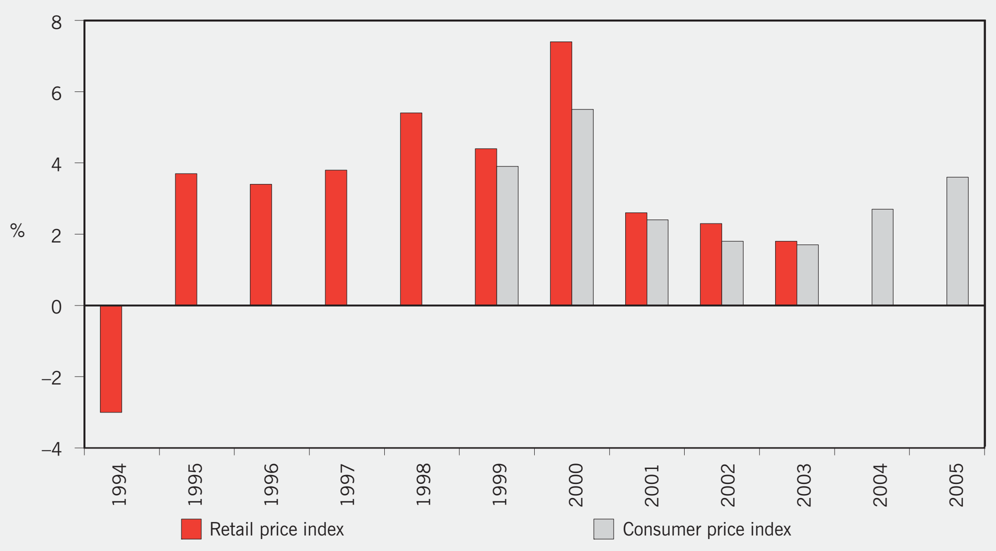
A major problem that researchers who model inflation are faced with in Croatia is the insufficient length of the series of price indices, structural breaks and changes in the method of calculating price indices. The generators and characteristics of inflation in the period of high inflation were different from those in the period after the stabilisation programme. In addition, the transition period saw significant changes in economic policy and economic structure, such as foreign trade liberalisation, significant changes in the tax system, the liberalisation of certain regulated prices and the entry of large chain stores, which had a significant effect on inflation. In the first war years after Croatia declared its independence in 1991, inflation was high: the monthly inflation rate in the first nine months of 1993 averaged almost 28%. The major factors causing inflation in Croatia were the budget deficit, exchange rate depreciation and inert expectations (Anušić et al. 1995). The inflation rate fell sharply after the introduction of the stabilisation programme in October 1993: it fell to only 1.4% in November 1993 and then followed a year of deflation. From 1995 onwards, the annual inflation rate stabilised at low one-digit levels. The anti-inflation programme was based on exchange rate policy (and other instruments of monetary policy) and wage policy and was strongly supported by a fiscal policy aimed at reducing the fiscal deficit.

The main anchor of domestic inflationary expectations is the policy of maintaining a stable nominal exchange rate of the kuna against the euro, which is one of the basic prerequisites for achieving domestic price stability. Croatia has recorded a low and relatively stable inflation rate for thirteen years in a row. The first year in which figures that measure the annual inflation rate of consumer prices according to an internationally comparable indicator (the consumer price index) were available, was 1999,[1] when the inflation rate of 3.9% was recorded at the end of the year. According to the Croatian Bureau of Statistics, the annual inflation rate fell to only 1.8% in December 2002 and 1.7% in December 2003,

1 The base consumer price index (the base being the 2001 average) has been calculated by the Croatian Bureau of Statistics since January 1998.

followed by a small increase to 2.7% in 2004. It rose to 3.6% in December 2005, but this is still within the area of low inflation. The 2005 increase in inflation was largely due to supply side pressures in both the domestic market (food products) and world market (a significant rise in the prices of oil and oil derivatives) and was also greatly influenced by increases in certain administratively regulated prices (electricity, rent and health services).

Figure 1 Retail Price Index and Consumer Price Index, year-on-year rate of change, end of period



In February 2004, the Croatian Bureau of Statistics started publishing the consumer price index (CPI), publishing changes in this index in Croatia in January 2004 and a time series of CPIs from January 2001 to December 2003. A retrograde time series from January 1998 to December 2000 was published a year later.[2] It should be noted that several estimates were used when calculating the retrograde series of CPIs since the prices of some goods in the existing basket for the CPI had not been recorded and so were estimated according to changes in the prices of similar products. The CPI is a comparable measure of inflation at the international level, and the Croatian Bureau of Statistics largely followed the Eurostat method for producing a harmonised CPI.[3]

2 At the beginning of 2005.

3 The domestic consumer price index differs from the harmonised in a few minor segments. The method for calculating the consumer price index in Croatia does not include Eurostat guidelines whereby the index must include spending by foreigners (e.g. tourists) on domestic territory, if significant, and spending by institutional households (e.g. retirement homes).

In order to obtain a longer series of price indices as a measure of inflation, it was customary to use the retail price index. However, there was a significant change in method in December 1997. Up until that time, the Croatian Bureau of Statistics calculated the index according to a method inherited from the previous state and its economic system. The differences between the CPI and the retail price index are due mainly to different methods concerning, among others, the calculation of the weights of various groups of products, the choice of formulas, corrections for quality changes and the treatment of seasonal products.

The overall basket of products for calculating the CPI is divided into 12 basic product groups in accordance with the international Classification of Individual Consumption by Purpose[4] (COICOP), so the aggregate CPI is divided into 12 basic sub-indices. Figures on their changes are available from January 1998, while figures on changes in the sub-indices at a lower level of disaggregation are available only from January 2004. At present, the Croatian Bureau of Statistics does not publish the CPI disaggregated in the way used in price analysis and modelling by the European Central Bank and the countries in the eurozone (unprocessed food, processed food, non-energy goods, energy and services). This way is more appropriate for modelling because the product groups are more homogenous, while, in our classification into 12 groups, very different products and services are placed in the same group; for example, the *Transport* group includes oil derivatives, whose price changes greatly depend on changes in the price of crude oil in the world market, vehicles, whose price changes greatly depend on the exchange rate and market competition, and, for example, sea transport services, whose price is administratively regulated and has a significant seasonal component.

Inflation forecasting is an essential component of the Monetary Policy Projection, and there are constant efforts to improve it at the Croatian National Bank. One step is to improve the model of short-term forecasting of the CPI with seasonal ARIMA processes, where, along with direct forecasting of the total CPI, the attempt is made to forecast changes in the components of the CPI in order to obtain a more detailed insight into the sources of future inflationary or deflationary pressures and to determine whether a forecast of developments in the total consumer price index obtained by forecasting aggregated values of the index's components is more reliable than a direct forecast.

The next section presents basic facts about the seasonal ARIMA models we used in CPI forecasts. Then we comment on the procedure for selecting appropriate models. Finally, we compare direct forecasts of the overall index with aggregated forecasts of the components and with forecasts obtained from a naive model where we assume a random walk CPI structure.

4 The aggregate consumer price index is divided into the following 12 basic sub-indices: 01 food and non-alcoholic beverages, 02 alcoholic drinks and tobacco, 03 clothing and footwear, 04 housing, water, energy, gas and other fuels, 05 household equipment, 06 health, 07 transport, 08 communication, 09 recreation and culture, 10 education, 11 catering services and 12 miscellaneous goods and services.

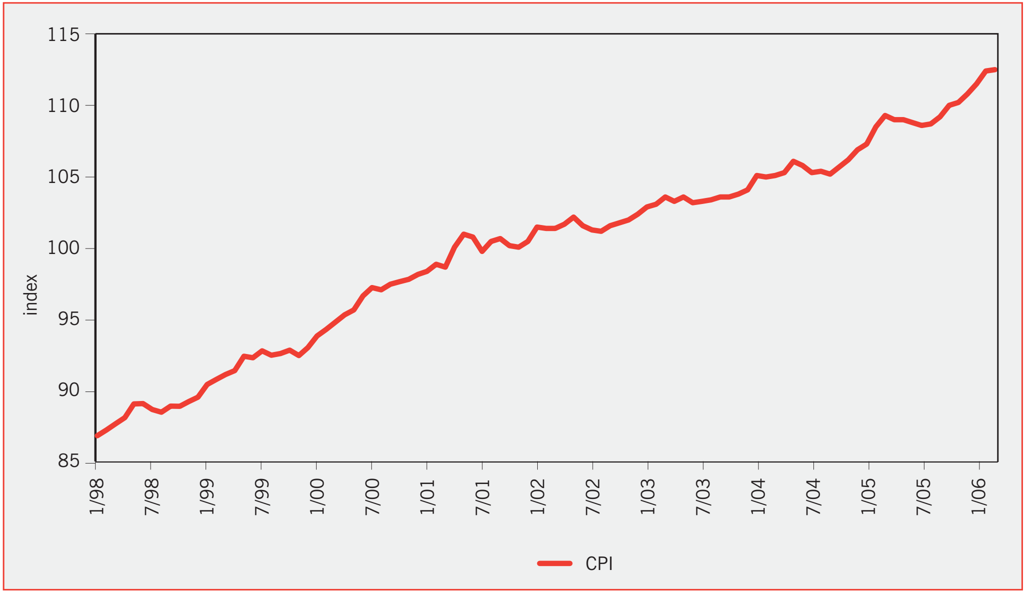
2 Short-Term Forecasting of the Consumer Price Index with Seasonal ARIMA Processes

This section describes the role of the ARIMA method in CPI forecasting in Croatia over a time horizon of 12 months.

There are two standard types of models for describing past changes in the CPI and possibly forecasting future changes – the structural model and the purely statistical model. Both models have their advantages and disadvantages. Structural models are based on economic theory; however, the complex link between economic variables is typically difficult to describe formally, for example, with a cumbersome system of equations. Many statistical models, on the other hand, especially the univariate ARIMA models used here, by their nature offer very little economic logic, but we forecast future values of the variables which these models imitate exclusively from the past behaviour of the series. Thus, a certain analysis is possible despite a lack of additional information, so that such simple models, despite their black box reputation, typically provide relatively good results in their primary task – forecasting.

An intrinsic problem when applying ARIMA class models, and all stochastic models, to a macroeconomic series is that they are, by their nature, short, with frequent changes in structure, and contain changeable and sometimes unclear seasonality. This is particularly true when applied to Croatian series, so, when developing CPI forecast models, we pay particular attention not only to the model's good in-sample characteristics (the goodness of fit) but also to its out-of-sample characteristics (quality of forecast) and to the number of parameters that appear

Figure 2 Consumer Price Index (2001=100)



in the model, which we reduce to the smallest possible number.[5] We made a preliminary selection of models with satisfactory inter-relation between in-sample errors and number of parameters by minimising Akaike's Information Criteria. The highest ranked models then underwent further testing, such as evaluating their forecasting characteristics and the stability and significance of their parameters. Many central banks pay special attention to the question of disaggregation when developing models for indices of price movements (Meyler et al. 1998, Fritzer et al. 2002). The CPI is a linear combination of the indices of 12 product groups (sub-indices) that enter the calculation of the level of consumer prices:

$$CPI_t = \sum_{i=1}^{12} w_i CPI_{it}, \qquad w_i > 0, \sum_{i=1}^{12} w_i = 1, \tag{1}$$

where CPI_{it} is the level of the ith CPI component at time t and w_i=1,...,12 of the corresponding weights. This index construction naturally raises the question of whether there is any point in separately forecasting the individual sub-indices that constitute the CPI and then to aggregate these forecasts as in (1). It is not clear a priori whether this approach would provide an improvement on an ARIMA forecast based on the total CPI. Like Fritzer et al. (2002) and Hubrich (2003), we attempt to answer the question: should we forecast the aggregate or aggregate the forecasts? Treating each component as a separate model certainly brings additional information about the total index, but it is often difficult to model certain components because of an unclear autocorrelational structure and changeable seasonality.

2.1 SARIMA – Seasonal ARIMA Processes

The time series is $\{y_t\}_{t\in Z}$ SARIMA$(p,d,q)\,(P,D,Q)[S]$ process if it satisfies the following difference equation[6]:

$$\phi(\mathrm{B})\Phi(\mathrm{B}^S)(1-B)^d(1-B^S)^D y_t = \theta(B)\Theta(\mathrm{B}^S)\varepsilon_t \tag{2}$$

where B is the standard backward shift operator,[7] Φ and Θ the seasonal *moving average* (MA) and *autoregressive* (AR) polynomials of order P and Q in variable B^S:

5 A large number of parameters often results in very good in-sample characteristics, in that the model describes well the dynamics of the data in the sample, but it does not guarantee the ability of the model to forecast successfully, which is our primary aim.

6 A detailed description of the (S)ARIMA model, the conditions of stationarity, invertibility etc. can be found in e.g. Brockwell & Davis (1991, 2002); here we define only the basic model and point out certain facts.

7 $By_t = y_{t-1}, B^2 y_t = B(By_t) = By_{t-1} = y_{t-2}$ and analogically further. In particular, $B^S y_t = y_{t-S}$, is the seasonal shift.

$$\Phi\left(B^S\right)=1-\Phi_1 B^S-\Phi_2 B^{2S}-\ldots-\Phi_P B^{PS} \tag{3}$$

$$\Theta\left(B^S\right)=1+\Theta_1 B^S+\Theta_2 B^{2S}+\ldots+\Theta_Q B^{QS}, \tag{4}$$

ϕ and θ the standard *moving average* (MA) and *autoregressive* (AR) polynomials of order p and q in variable B:

$$\phi(B)=1-\phi_1 B-\phi_2 B^2-\ldots-\phi_p B^p \tag{5}$$

$$\theta(B)=1+\theta_1 B+\theta_2 B^2+\ldots+\theta_q B^q, \tag{6}$$

d and D are orders of integration and $\left\{\varepsilon_t\right\}_{t\in Z}$ normal (Gaussian) white noise.[8]

For example, the SARIMA $(1,0,1)(0,1,1)[4]$ model is a multiplicative model of the form:

$$\left(1-\phi_1 B\right)\left(1-B^4\right)y_t=\left(1+\theta_1 B\right)\left(1+\Theta_1 B^4\right)\varepsilon_t. \tag{7}$$

Using the properties of operator B, it follows that:

$$y_t=\phi_1 y_{t-1}+y_{t-4}-\phi_1 y_{t-5}+\varepsilon_t+\theta_1\varepsilon_{t-1}+\Theta_1\varepsilon_{t-4}+\theta_1\Theta_1\varepsilon_{t-5}. \tag{8}$$

Similarly, every SARIMA model has a standard ARIMA representation. Type (2) models are suitable for modelling time series that include seasonality,[9] both changeable and deterministic, which is otherwise normally modelled by introducing seasonal dummy variables, trigonometric functions and the like. A frequent dilemma that we meet in practice is how best to model seasonality in series. For example, Kaiser and Maravall note that it is difficult to differentiate in practice the following two models for quarterly data:

(a) $$y_t=\mu+\beta_1 D_{t1}+\beta_2 D_{t2}+\beta_3 D_{t3}+\beta_4 D_{t4}+\varepsilon_t$$

(b) $$\left(1-B^4\right)y_t=\left(1-0{,}99B^4\right)\varepsilon_t,$$

where $D_{t1},\ldots,D_{t4}$ are seasonal dummy variables. This means that the SARIMA (0,0,0)(0,1,1) specification in (b) can mean that seasonality series y_t is deterministic. We see that deterministic seasonality can be interpreted as an extremely stable stochastic seasonality, so it is enough in most cases to use SARIMA models when modelling a series with marked seasonality. However, the reverse generally does not hold true, that is, model (b) does not imply a necessarily deterministic

8 White noise is a series of uncorrelated random variables with zero expectation and equal variance.

9 S = 12 for monthly data; S = 4 for quarterly data.

seasonality in y_t. A seasonal MA root close to -1 can suggest overdifferencing. By detecting the presence or absence of determinisitic seasonality through regressing series y_t on the seasonal dummy variables $D_{t1},\ldots,D_{t4,}$ we find which of the above two cases really is the cause of the seasonal parameter in model (b).

2.2 Models for Forecasting the Consumer Price Index

In this section, we shall try to answer the question raised in the introduction: whether it is better to forecast individual CPI components and then to aggregate these forecasts in a total index according to (1) or whether to directly model the total CPI.

Eight of the twelve CPI components are suitable for modelling using statistical models,[10] while the remaining four product groups[11] are greatly under the influence of central or local administration and there is little likelihood that they have a correlation structure suitable for modelling with SARIMA processes (Figure 3). Accordingly, we investigated two models.

MODEL 1 We evaluated eight SARIMA models, one for each CPI sub-index whose prices are not administratively regulated (or are only partially regulated) and, as such, can be used in likelihood models. We aggregated the individual forecasts and compared the result with the values of a modified CPI (CPImod) where we excluded the remaining four components. This implementation allows the inclusion of the remaining components in the model in two ways. First, it can be assumed that these components remain unchanged during the period to which the forecast applies, which is not completely unreal when applied to a short time horizon; second, an estimate of their change can be directly included in the model.

MODEL 2 We aggregated the eight forecasts as in MODEL 1 but also modelled the remaining components for the following reasons. A linear combination of the four remaining sub-indices CPIadmin, constructed with the help of the corresponding weights from the CPI definition, seems to show a certain regularity of change despite the fact that certain components do not have this characteristic (Figures 3 and 4). We therefore find that an ordinary linear regression model (with AR(1) error) satisfactorily explains the CPIadmin aggregate. Forecasts obtained from this simple model were then added to the aggregate of the eight (predominantly) non-administrative components. The aggregated forecasts were then compared with the actual total CPI.

In addition, both forecast models were compared with a model where we assume a random walk structure of the total CPI. For example, in MODEL 2 we have:

$$CPI_t = CPI_{t-1} + \varepsilon_t,$$

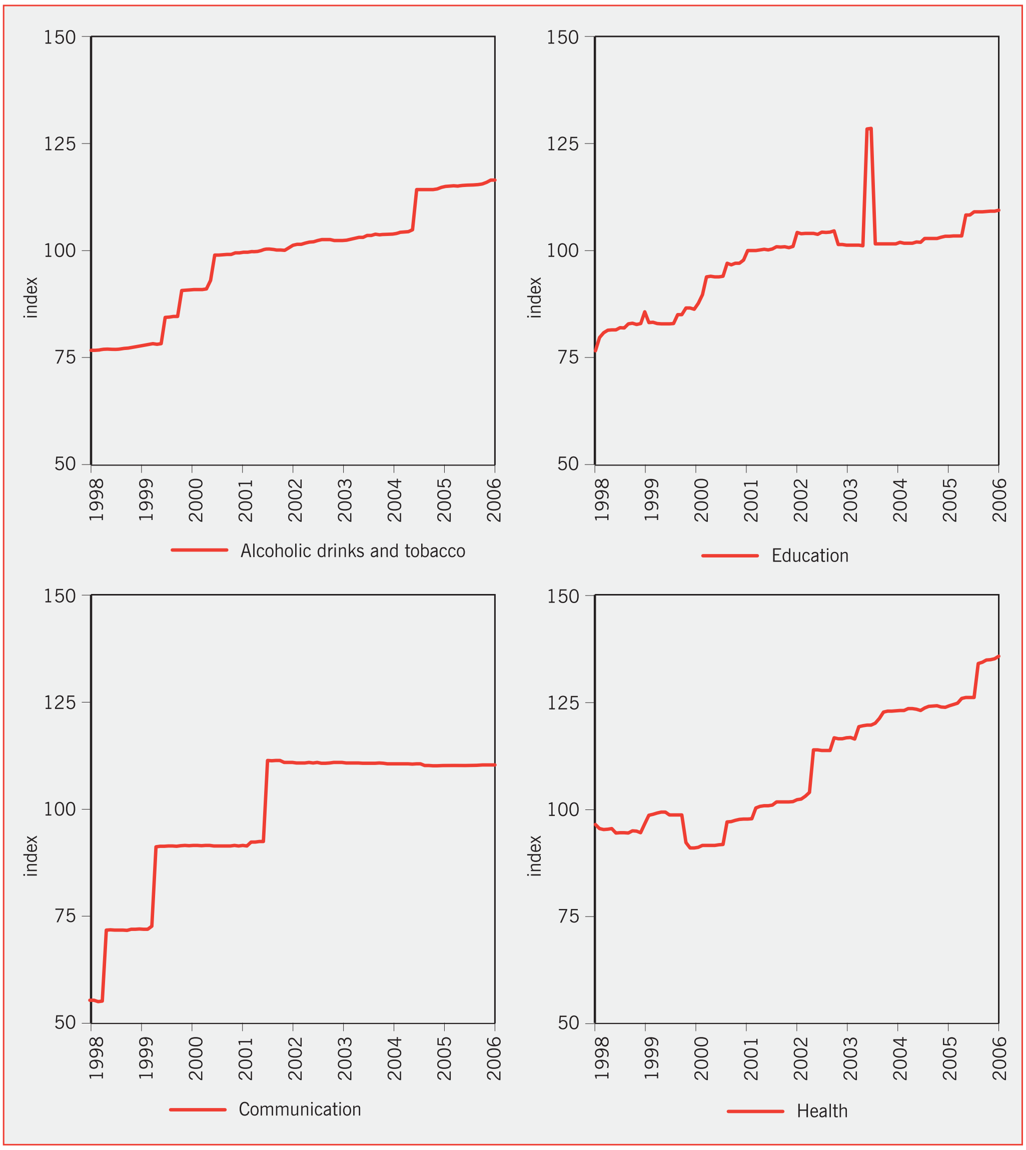
10 Transport, recreation and culture, household equipment, miscellaneous goods and services, food and non-alcoholic beverages, clothing and footwear, catering services, and water, energy, gas and other fuels.

11 Education, health, communication and alcoholic drinks and tobacco.

where ε_t is white noise. In the random walk model, all forecasts of the index that are performed at time t are equal to the values of the index at time t (CPI_t),[12] analogous with MODEL 1.

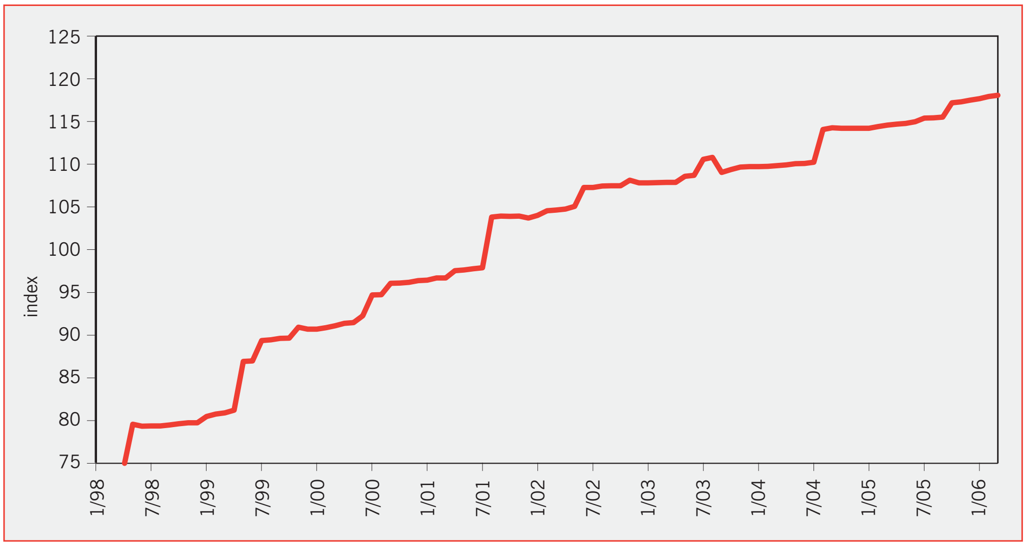
Special attention was paid to estimating the parameters of the *SARIMA*(p,d,q)(P,D,Q) model. The estimation was performed on a log series of base price index (2001=100). In order to achieve stationarity, all the series were

Figure 3 Changes in the Four CPI Sub-Indices Whose Values Are Greatly Under the Influence of Central or Local Administration (2001=100)



12 For h step in advance: $\widehat{CPI}_{t+h} = E[CPI_{t+h} | I_t] = E[CPI_t + \varepsilon_{t+1} + \ldots + \varepsilon_{t+h} | I_t] = CPI_t$, where I_t is the information available at time t. Details about the best linear predictor can be found in e.g. Brockwell & Davis (1991, 2002).

Figure 4 Linear Combination of the Four Administrative Components of the CPI (Education, Communication, Alcoholic Drinks and Tobacco, Health) (2001=100)



differenced with both a regular $1-B$ operator and a seasonal $1-B^{12}$ operator, so $d = 1$ and $D = 1$. Here there is the danger of overdifferencing, since the seasonal operator $1-B^{12} = (1-B)(1 + B + \ldots + B^{11})$ as a factor already contains $1-B$; however, many studies (Gustavsson, Nordström, 2001) empirically show that this does not harm the forecast to a significant extent.

There still remained the task of estimating the remaining parameters p, q, P and Q for each SARIMA model. Like F. Fritzer et al. (2002), we tried to automate this part to a certain extent. We ranked a series of different models for each series according to Akaike's Information Criteria (AIC). $SARIMA(p,1,q)(P,1,Q)$ was defined for $p,q \in \{0,\ldots,4\}$ and $P,Q \in \{0,1\}$, then the corresponding AIC was calculated, and finally all the AIC statistics were sorted from the lowest to the highest for each series.[13] The degree of data and model closeness for the observed data and given model can be measured by, for example, a log likelihood function. On the other hand, we wanted to reduce the number of parameters of the model to the minimum, and the model with a small amount of AIC statistics has the two desired qualities – well-explained data with a reasonable number of parameters.[14] To make the final selection, several models with the lowest AIC statistics underwent further testing to investigate the autocorrelational structure of the residuals, the stability and significance of the parameters and out-of-sample characteristics.

13 This is 5*5*2*2=100 models for each series. A total of 1200 SARIMA specifications were taken into consideration for the 8 non-administrative series, the CPI series, CPImod and the GOODS and SERVICES series.

14 The expression for AIC: $AIC = -2\frac{l}{N} + 2\frac{k}{N}$, where k is the number of unknown parameters, N the number of observations and l the log likelihood function.

Table 1 Specifications of the SARIMA Model

Series	Model
CPItotal	SARIMA(1,1,1)(0,1,1)
CPIgoods	SARIMA(1,1,0)(1,1,1)
CPIservices	SARIMA(1,1,0)(1,1,1)
CPInon-admin	SARIMA(1,1,1)(1,1,1)
CPIadmin	lin. trend
Household equipment	SARIMA(0,1,0)(0,1,0)
Miscellaneous goods and services	SARIMA(0,1,0)(1,1,1)
Transport	SARIMA(0,1,0)(0,1,1)
Recreation	SARIMA(1,1,1)(1,1,1)
Housing	SARIMA(0,1,0)(1,1,1)
Catering	SARIMA(0,1,3)(1,1,1)
Food and non-alcoholic beverages	SARIMA(0,1,3)(1,1,1)
Clothing and footwear	SARIMA(0,1,3)(1,1,1)

2.3 Evaluation of the Quality of the Consumer Price Index Forecasts Provided by the Models

We analysed data from January 1998 to March 2006, amounting to 99 monthly observations for each series. This number is relatively small for reliable statistical analysis, and when we take into account the extreme right segment of samples left for evaluating the out-of-sample characteristics of the models, the segment for analysis has a length of only 72 observations. However, we expect better results in applying the models when a sample with a length of more than 100 observations is available for estimating the parameters.

We estimated the parameters on data from January 1998 to December 2003, while the period from January 2004 to March 2006 was used for forecasting and for comparing the obtained forecasts with the actual values of overall CPI and CPImod. The procedure for each of the 12 series (CPI, CPImod, 8 non-administrative components and the GOODS and SERVICES series) was as follows. First, we forecast the values for the period from January 2004 to December 2004 (12-month forecast) and put the first in the series **1 step ahead**, the second **2 steps ahead** and so on to twelve. Then we added the data for January 2004 to the model, re-estimated the model and forecast the values from February 2004 to January 2005 and put the forecasts in the last place in the series **1 step ahead**, **2 steps ahead** etc. In this way, each of the forecast series received 12 series obtained as forecasts from 1 month ahead to 12 months ahead, which we then compared with the actuals. A series of a length of 16 observations was generated for each time horizon. We tested the quality of the obtained forecasts against two standard measures: Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE), which were defined as follows. If $x_1,...,x_n$ are actuals and $\hat{x}_1, \ldots, \hat{x}_n$, are forecast values of random variable x, then:

$$MAE = \frac{1}{n}\sum_{i=1}^{n}\left|x_i - \hat{x}_i\right|$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \hat{x}_i\right)^2} \quad .$$

Table 2 shows the forecast statistics. The results of the RMSE analysis are similar in both models. Direct ARIMA forecasts of the total CPI and CPImod give better results than the aggregate forecasts for the time horizon up to 4 months. For longer horizons, from 5 to 12 months, the aggregate forecast somewhat better describes the changes in the index, while, as expected, the random walk models permanently show the weakest results. Disaggregation of the CPI only for GOODS and SERVICES did not improve the forecasts.

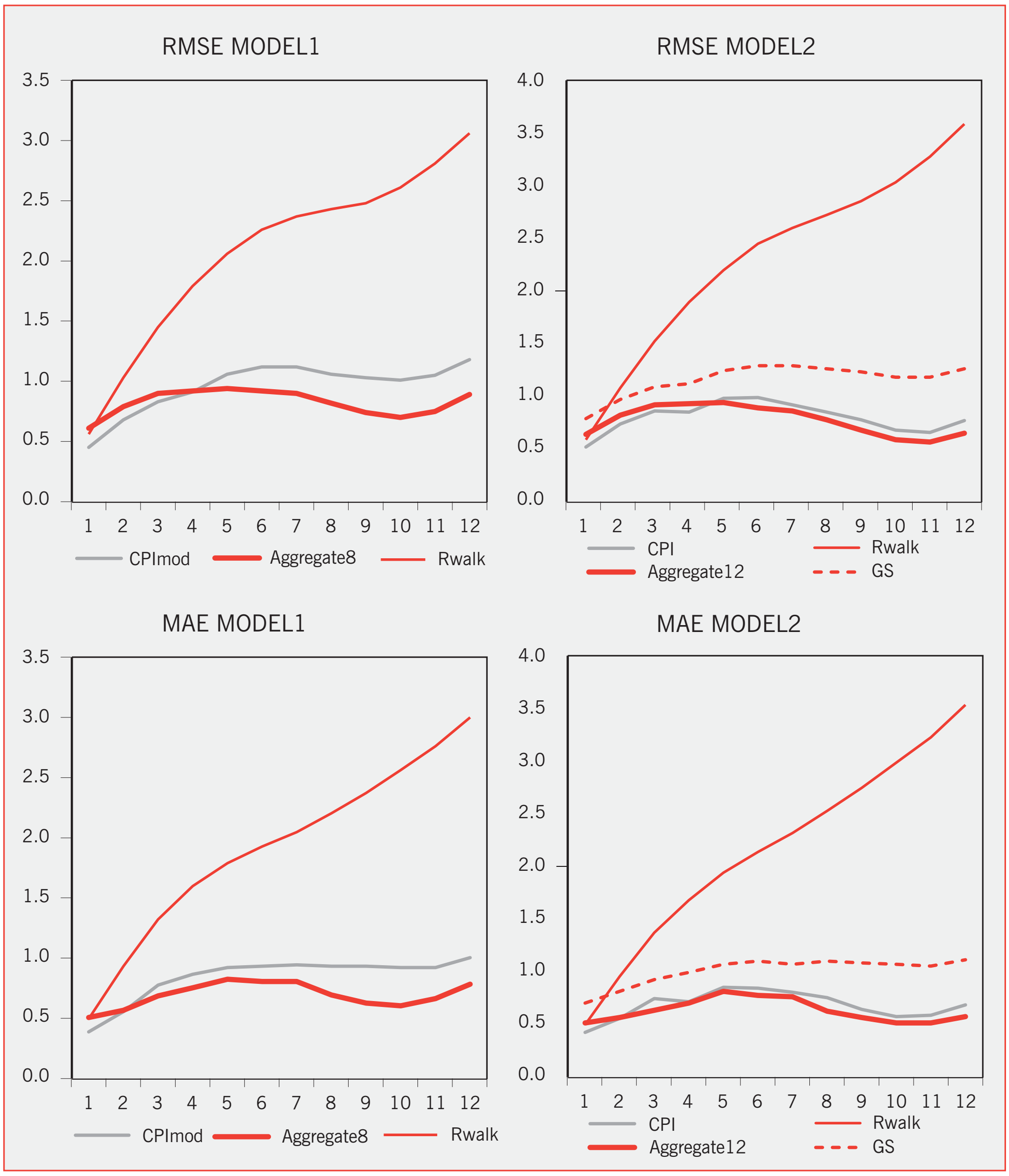
Concerning the MAE analysis, direct ARIMA forecasts of the total index give better results on a short horizon (now 1 to 2 months ahead) in both models, while it appears that disaggregation improves the results on a longer horizon. Again, the random walk models and aggregate forecasts of the GOODS and SERVICES series show the weakest results.

Table 2 RMSE and MAE Statistics of MODEL 1 and MODEL 2

RMSE	MODEL1			MODEL2			
Horizon	CPImod	Aggregate8	Rwalk	CPI	GS	Aggregate12	Rwalk
1	0.45	0.61	0.56	0.52	0.79	0.64	0.59
2	0.68	0.79	1.03	0.74	0.97	0.82	1.08
3	0.83	0.9	1.45	0.86	1.09	0.92	1.52
4	0.91	0.92	1.79	0.85	1.12	0.93	1.89
5	1.06	0.94	2.06	0.98	1.24	0.94	2.19
6	1.12	0.92	2.26	0.99	1.29	0.89	2.44
7	1.12	0.9	2.37	0.92	1.29	0.86	2.59
8	1.06	0.82	2.43	0.85	1.26	0.78	2.71
9	1.03	0.74	2.48	0.78	1.23	0.68	2.84
10	1.01	0.7	2.61	0.68	1.18	0.59	3.02
11	1.05	0.75	2.81	0.66	1.18	0.57	3.26
12	1.18	0.89	3.06	0.77	1.26	0.65	3.57
MAE	**MODEL1**			**MODEL2**			
Horizon	CPImod	Aggregate8	Rwalk	CPI	GS	Aggregate12	Rwalk
1	0.35	0.47	0.46	0.41	0.69	0.5	0.48
2	0.52	0.53	0.9	0.54	0.8	0.55	0.94
3	0.74	0.65	1.29	0.73	0.91	0.62	1.36
4	0.83	0.72	1.57	0.7	0.98	0.69	1.67
5	0.89	0.79	1.76	0.84	1.06	0.8	1.93
6	0.9	0.77	1.9	0.83	1.09	0.76	2.13
7	0.91	0.77	2.02	0.79	1.06	0.75	2.31
8	0.9	0.66	2.18	0.74	1.09	0.61	2.52
9	0.9	0.59	2.35	0.63	1.07	0.55	2.74
10	0.89	0.57	2.54	0.56	1.06	0.5	2.98
11	0.89	0.63	2.74	0.57	1.04	0.5	3.22
12	0.97	0.75	2.98	0.67	1.1	0.56	3.53

Note: MODEL 1 shows the characteristics of ARIMA forecasts of the CPI modified for administrative prices (CPImod), aggregate ARIMA forecasts of the 8 non-administrative components (aggregate8) and random walk models (Rwalk). MODEL 2 evaluates ARIMA forecasts of the CPI, aggregates of the GOODS and SERVICES groups (GS), and aggregates of forecasts of the 8 non-administrative components increased by aggregate forecasts of the 4 administrative components (aggregate12).

Figure 5 RMSE and MAE for MODEL 1 and MODEL 2



Note: CPI and CPImod refer to ARIMA forecasts of the total index (CPI) and the index modified for administrative prices (CPImod). Aggregate8 refers to the aggregate of the 8 non-administrative components, and aggregate12 refers to the aggregate forecasts in MODEL 2. Aggregate G&S refers to the CPI with only goods and services disaggregated.

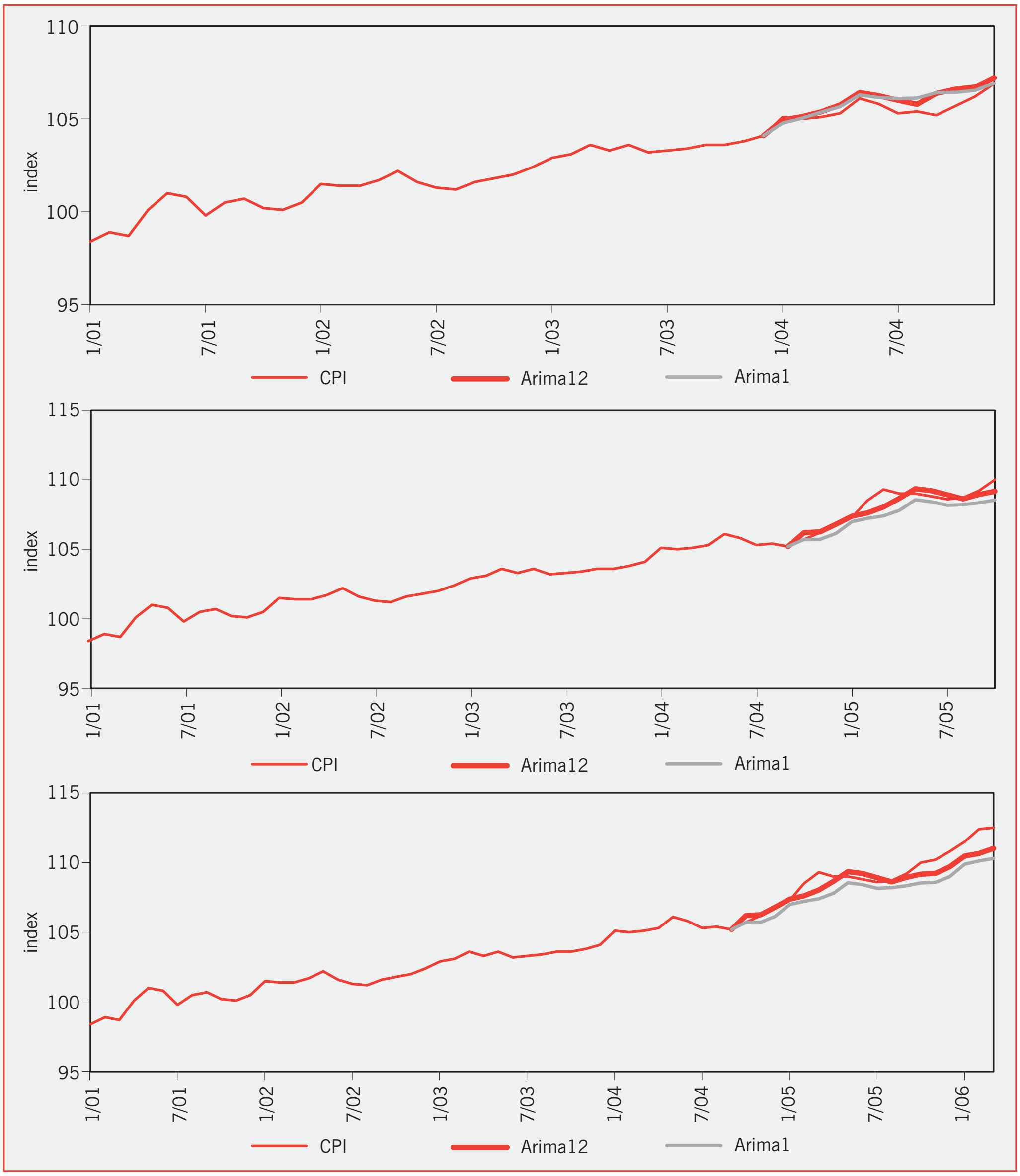
3 Conclusion

This paper describes a method of forecasting the consumer price index by using univariate seasonal ARIMA models, forecasting future values of the variables from the past behaviour of the series, and attempts to examine whether separate modelling and aggregating of the sub-indices improves the final forecast of the total index. In the beginning of the paper, we considered the main problems associated with the characteristics of the CPI series in Croatia (length of the series, changes in the methodology, structural breaks) to be taken into account when analysing the results. In addition, while the four indices are unsuitable for modelling with SARIMA processes as their prices are mostly administratively regulated, we established that their linear combination could be modelled. Accordingly, we set up two models, one in which administratively regulated prices were not modelled, and the other in which their linear combination was modelled. We compared the aggregated forecasts with total CPI performances and a model with an assumed random walk structure of the total index. Our analysis suggests that, given a somewhat longer time horizon (three to twelve months) in both models, the most precise forecasts of CPI developments are obtained by first forecasting the index's components and then aggregating them in the total index. However, we should not jump to conclusions, as the repeatedly mentioned problem of the length of the series most probably affected the result of our decisions in this analysis several times, and especially in two cases. We measured the closeness of a model with a log likelihood function, while we performed the final evaluation of the quality of the forecasts on a small group of errors, which we averaged (RMSE, MAE). Evaluations of closeness to the true model and of quality of forecast become more reliable if we increase the elements of the sample, and we expect a true evaluation of the forecasting abilities of the model in the near future.

Appendix

Graphs Presenting Forecasts of CPI and Inflation

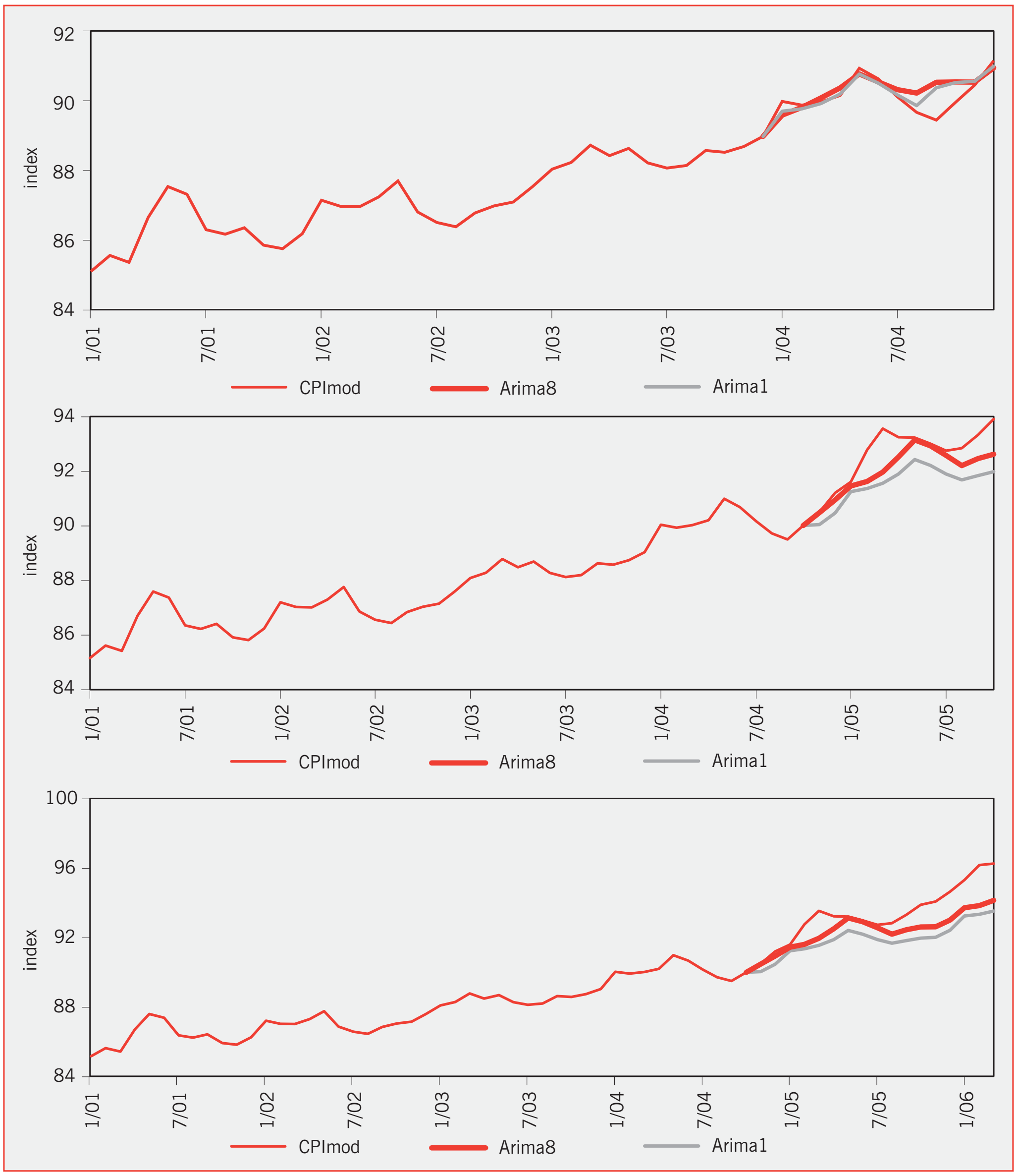
Figure 6 Forecast and Actual CPI for Three Horizons[a]



[a] January 2004 – December 2004; November 2004 – October 2005; November 2004 – March 2006.

Note: CPI refers to actuals, arima1 to ARIMA forecasts of the total index and arima12 to the aggregate forecasts from MODEL 2.

Figure 7 Forecast and Actual CPImod for Three Horizons[a]



[a] January 2004 – December 2004; November 2004 – October 2005; November 2004 – March 2006.

Note: CPImod refers to actuals, arima1 to ARIMA forecasts of the total index and arima8 to the aggregate forecasts from MODEL 1.

Figure 8 Forecast and Actual CPImod Inflation for Two Horizons[a]

[a] January 2004 – December 2004; November 2004 – October 2005.

Figure 9 Forecast and Actual CPI Inflation for Two Horizons[a]

[a] January 2004 – December 2004; November 2004 – October 2005.

The graphs show that the forecasts for 2004 are of significantly better quality than those for later periods. This is because the identification of the models, i.e. the choice of numbers p, d, q, P, D, Q in the SARIMA specifications, was performed on the period up to January 2004. After that only re-estimation was performed. This means that the parameters for the selected $SARIMA(p,d,q)(P,D,Q)$ specification were estimated again by adding new data into the sample while the SARIMA model remained the same. This result is in line with the standard recommendation that these models should be re-identified at yearly intervals.

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