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# UNCERTAINTY AND DISAGREEMENT IN INFLATION FORECASTING

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***Abstract***

*This paper tries to explain how the new adopted strategy of inflation targeting can help in improvement of inflation forecasting accuracy comparing with the price maker's and consumer's inflation expectations. For the further analysis authors use well known univariate time series models and structural models. However, the same model can produce the opposite results according to the methodology of involved inflation indicator. Therefore, this paper uses compared analysis for two separated inflation indicators, the core inflation and the consumer price index, emphasizing the differences in methodology and forecasting accuracy. Thus, the final goal is to test forecast efficiency by decreasing the errors between inflation expectations and real inflation values.*

***Key words: uncertainty, disagreement, inflation forecasting***

## 1. INTRODUCTION

Expected inflation plays a central role in the analysis of monetary policy and business cycles. Many questions about how much expectations matter, types of expectations, how quickly they respond to changes in policy regime, and many others are opening the issue of expectation importance.

In many macroeconomic models, people share common information set and form expectations based on those information. Therefore, based on our models, we often assume that everyone has same expectations.

The quick literature review we start with Mankiw, Reis and Wolfers (2003) notion that disagreement about inflation is correlated with a host of macroeconomic variables. This view shows consistency with the theoretical models of Lucas (1973) and Townsend (1983) where heterogeneity in agent's beliefs plays a main role. The central explanation of an assumption that agents have heterogeneous information shows that dispersion in beliefs reflects differences in information sets. Also, differences may reflect heterogeneity by the level of updating agent's beliefs. Therefore, Mankiw and Ries (2002) and Caroll (2003) propose an elegant updating model for expectations where only a part of participants update there beliefs every period. Finally, Brock and Hommes (1997) and more recently Branch (2007) analyzed agents who choose between different forecasting models each period.

None of these explanations can provide an entirely satisfactory explanation for the biases observed in inflation expectations and the positive relationships between the cross-sectional dispersion of inflation beliefs and the level of inflation rate.[1]

This paper starts from the point that disagreement about expectations is itself an interesting variable in creating and understanding monetary policy and the business cycle. More important, we seek for the correlations between disagreement about expected inflation and other aggregate variables that are more commonly of interest to economists. Furthermore, the extent of such disagreement varies systematically over time in a way that reflects the level and variance of current inflation. This fact raises the possibility that disagreement may be a key to macroeconomic dynamics.[2]

The central explanation about continuous existence of disagreement between industry leaders, consumers and the financial sector is an assumption that all price-making participants have heterogeneous information so that dispersion in beliefs reflects differences in information sets. Furthermore, differences may reflect heterogeneity in the rate in which market participants update their beliefs.

## 2. MARKET EXPECTATIONS

Differences in market participant's beliefs and their importance in economic analysis have been emphasized by early work of Arthur Cecil Pigou (1927) and John Maynard Keynes (1936)[3]. The market participants have no choice but to forecast at least elements of the future because nearly all economic decisions look toward it. Specifically, investment decisions incorporate the decision maker's expectations concerning factors believed to affect future value

[1] Capistran, C. and Timmermann, A. (2008) Disagreement and Biases in Inflation Expectations, Banco de Mexico Working Paper, 2008-18

[2] Mankiw Gregory, Reis Ricardo, and Wolfers Justin (2003) Disagreement about Inflation Expectations, NBER/Macroeconomics Annual, MIT press, page 210.

[3] Paseran, M.H. and Weale, M. (2006) Survey Expectations. Handbook of Economic Forecasting, North – Holland, Amsterdam

of observed economic indicator. The decision maker finally integrates these views into expectations in addition with possible risk. Hence, the inflation expectation values are higher then the real inflation value, in most cases.

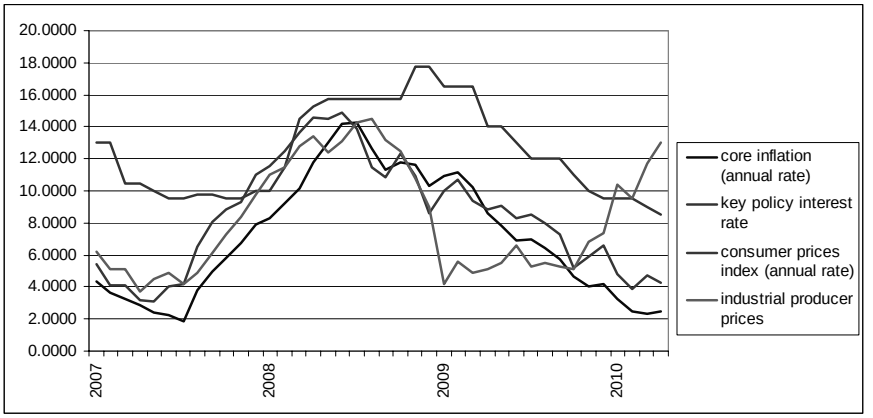
The range of problems in forecasting inflation expectations can frustrate an analyst. One of the problems could be the limitation of economic data where the time lag plays an important role in understanding present market situation. The next problem shows the biases in data measurement of series according to applied method or available data set. These or similar problems cause a series of misunderstandings in forecasting expectations, but at the other side create a space for the future research.

# 3. INFLATION FORECASTING

## 3.1. Preliminary review of core inflation and consumer prices

In September 2006, Central bank of Serbia (NBS – Narodna Banka Srbije) adopted the new monetary police framework in regime of core inflation as means in the transition period towards complete implementation of inflation targeting strategy. According to maintaining the price stability, the Central bank designs inflation movements using one of the most popular monetary tools, the key policy interest rate.

There are many types of inflation dependent on the group of product or service prices included into the calculation of the inflation. Therefore, the proposed types of inflation could provide certain information, but they also exist as objects of possible manipulations. Especially, the core inflation, as one of the important pillars in executing modern inflation targeting strategy, excludes some prices with strong influence on household budgets with purpose of decreasing unpredictable movements in forming final prices. Hence, the core inflation creates a controllable price level by omitting the seasonal food prices, the structural changes in oil price and government regulated prices. According to previous notions, many authors have considered the core inflation as an incomplete image of the total market price movements and suggest the consumer price index, which reflects the prices of final goods.




*Source: http://www.nbs.rs/export/internet/cirilica/80/index.html*

Figure 1. The review of the three types of inflation and the key policy rate

The key policy rate, as an important monetary policy tool, is being adjusted according to the level of prices and represents one of the factors in future price movements affecting indirectly the aggregate demand by regulating lending and deposit interest rates level.

## 3.2. Univariate time series modeling and forecasting

As we mentioned the different types of inflation, there are also different inflation models showing diversity of the forecasting properties between models over the periods that covers the changes. There is no ground for choosing a policy model on the basis of forecasting performance alone, but different models can be useful for different purposes.

After the preliminary review of the data, the first step in inflation modeling is an implementation of univariate time series model, which only use information enclosed in their own past values and possibly current and past values of an error term. The presented model forms will be able to detect future values of price levels due to past inflation and its regularities tracking process.

An appropriate model building approach involvs three steps:
Identification – determining the order of the model required to capture the dynamic features of the data
Estimation – calculating the parameters of the model
Diagnostic checking – determining whether the model specified and estimated is adequate.

Using iteration process mentioned before, we create two model forms that capture in the possible best way the regularities in core inflation and consumer price indices.

The model form used in detecting time variation features of the core inflation combines the autoregressive and moving average process. The general model could be written as:

$$y_t = \mu + \sum_{i=1}^{p} \phi_i y_{t-1} + \sum_{i=1}^{q} \theta_i u_{t-1} + u_t$$

(1)

where the specific univariate core inflation model estimated for Serbia in period January 2007 – April 2010 contains the following form:

$$\hat{y}_t = 0{,}7963 + 0{,}4688 \cdot y_{t-1} + 0{,}1758 \cdot u_{t-1} - 0{,}8196 \cdot V_t$$

(2)

where

$y_t$ – the continuous returns of core inflation

$u_{t-1}$ – the lagged white noise

$V_t$ – dummy variable (to exclude high changes in core inflation)

According to the presence of non-stationarity in time series detected in the first step of the model building, we took two correction decisions. First, the original time series are transformed in the continuous compounded returns in order to achieve variable stationarity. Second decision involved introduction of a dummy variable, $V_t$, in the model estimation process. The dummy variable was used to select appropriate data for further analysis by eliminating extremely high changes of the core inflation over time; for example, the value of core inflation in august 2007 was increased for 69% compared to the previous month.

The univariate core inflation model presented above is known as ARMA(1,1), but it also includes dummy variable for eliminating big changes in time series. This model explains 72,79% of the core inflation variability and with statistical significance of all four coefficients could be of great help in forecasting the future value of core inflation.

The explained manipulation feature of core inflation enforces the researchers to repeat the above mentioned procedure on consumer price index time series. The step-by-step model specification approach guides us to the final univariate time series model for the consumer price index (same period, for Serbia):

$$\pi_t = 0{,}5489 + 0{,}4758 \cdot \pi_{t-1} - 0{,}2844 \cdot \pi_{t-2} + 0{,}4189 \cdot \pi_{t-3} + 0{,}2131 \cdot \pi_{t-4} - 0{,}2657 \cdot \pi_{t-5} +$$
$$+ 0{,}1518 \cdot \pi_{t-6} - 1{,}4586 \cdot u_{t-1} - 0{,}5711 \cdot V_t$$

(3)

where

$\pi_t$ – the continuous returns of consumer price indexes

The information criterion, which represents the adjusted residual variance for the number of degrees of freedom, like Akaike info critetion or Schwarz – Bayesian info criterion, is minimized according to the specified model form known as ARMA(6,1) with correction for extremely high changes in

consumer price index over time. Explaining 85,99% of the total consumer price index changes and with statistical significance of all model coefficients, the ARMA(6,1) model creates a good base for observing time development of the future retail prices.

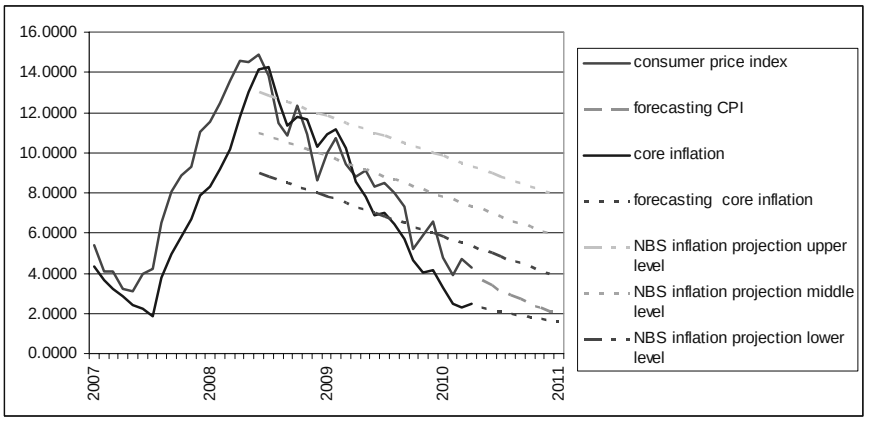



Figure 2. Forecasting core inflation and consumer price index

The above presented graphical example indicates the disagreement between univariate time series model forecasting and NBS inflation projection. The inflation projection and targeting process of NBS reclines on the assumption that the inflation level will return to the range between projection borders in the second part of year, regardless to the low level of inflation in the last couple of months in 2009 and first five months in 2010.

The possible disagreement could be explained by the fact that the univariate time series models are usually a-theoretical, implying that their construction and use is not based upon any underlying theoretical model of the behavior of a variable. Instead, time series models are an attempt to capture empirically relevant features of the observed data that may have arisen from a variety of different structural models[4].

## 3.3. Structural inflation modeling

According to the National Bank inflation projection which includes many of the possible macroeconomic changes in national economy and abroad, the potential analysis in this section will be directed to the structural models. The possible set of macroeconomic variables could be divided between variables with immediate influence on the monetary policy and variables with indirect impact on

[4] Brooks Chris (2004) Introductory Econometrics for Finance, Cambridge University Press, Cambridge, page 229.

the future price changes. Nevertheless, each of them has to be equally positioned in the next structural models.

Using the "general to specific" approach in adequate model form selection, we create a potential model for the in-sample and out-of-sample forecasting which assists in inflation projection process.

The structural modeling process encompasses the core inflation and the consumer price index both depending on the series of macroeconomic variables, written in the following form.

Table 1

Core inflation and consumer price index structural models

| Variable | Core inflation | Consumer price index |
|---|---|---|
| Intercept | -18,2167 | -17,2293 |
| Inflation expectations ($E_t\pi_{t+1}$) | 0,3702 | 0,5822 |
| Key policy interest rate | 0,8249 | 0,3603 |
| Average earnings | 0,0001 | 0,0001 |
| Oil price | 0,0463 | 0,0598 |
| Currency exchange rate (EUR/RSD) | 0,0452 | 0,0888 |
| Adjusted $R^2$ | 0,9361 | 0,8652 |

Before the general to specific variable selection approach has been started, the initial modeling process involved eleven macroeconomic variables, which influence the monetary policy creation. After eliminating multicollinearity between involved independent variables and achieving the statistical significance of remaining variables, we got two separated models presented in Table 1.

The presented table shows the same independent variables included in explaining the level of inflation, where the first model explains seven percentages more of dependent variable variability then the second model. Also, the second model provides seven percentages less of how well future outcomes are likely to be predicted by the model. The models demonstrate bigger influence of the inflation expectations on the consumer price index then on the core inflation, while the central bank policy interest rate indicates a stronger impact on the core inflation. Furthermore, the significant influences of the oil price movements and the currency exchange rate on dependent variable are more visible in the second model. According to previous analysis, a possible inference shows more government prevalence in regulating future core inflation then in the consumer price index which is more market determined. Hence, the consumer price index is less explainable then the government controllable core inflation.

On the other hand, modeling inflation expectations can be of great help in tracking possible changes in price maker's decisions. As we mentioned before, the inflation expectations have a big influence on inflation level. Hence, modeling process is inevitable in cognition what kind of market changes cause the

movements in market participant's opinion. Therefore, the following model form in Table 2. fulfills all statistical requirements using the one leg variables.

Table 2

Inflation expectations structural model

| Variable | Inflation expectations | t - statistic |
|---|---|---|
| Intercept | 7,4525 | 3,0251 |
| Consumer price index (-1) | 0,0034 | 0,4119 |
| Inflation expectations (-1) | 0,9503 | 11,1927 |
| Exchange rate (-1) | -0,0685 | -2,6781 |
| Key policy interest rate | -0,0901 | -1,1336 |
| $R^2$ | 0,9464 | |

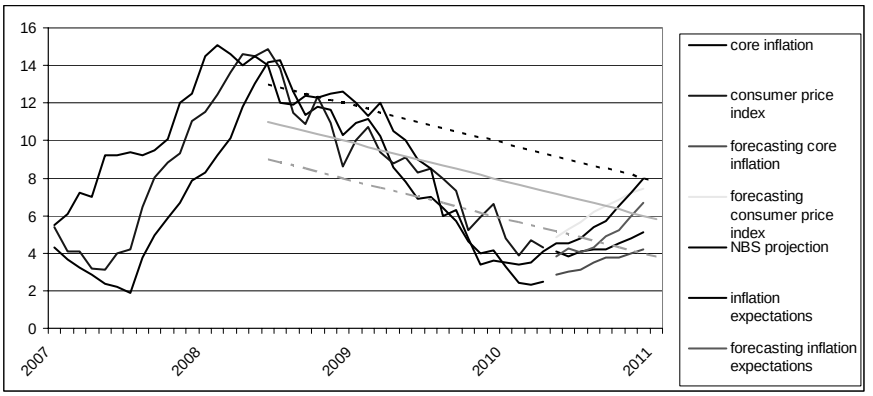
The inflation expectations are price or policy maker's opinion about future inflation movements. Consequently, the expectations are created using the previous macroeconomic indicators. Reviling the possible expectations helps the policy makers particularly in the process of inflation targeting.

## 3.4. Comparison of forecast dominance between time series and structural models

As we mentioned before, a-theoretical time series models use the same data as in the model building process for a forecasting and provide simplicity in future values estimation. On the other hand, structural model because of a chain of the involved independent variables has the problem to create out-of-sample forecast accuracy. One of the possible solutions is to create an initial assumption based on several independent forecasting analyses executed by a number of macroeconomic competent institutions.

The forecasting process from the structural model is based on the assumptions of frozen wages in public sector and unexpressed growth in private sector until the end of year 2010. It also relies on assumptions of powerful impact on inflation level due to the price makers and consumer inflation expectations and global environment reflected through an accelerated growth in crude oil prices. If demand continuously keeps an achieved low level, it is expected that the Central Bank will impoverish current monetary restrictions and persist in decreasing the key policy interest rate. On the other side, the strategy of Central Bank is to keep actual exchange rate and to undertake every possible monetary action to stop a further devaluation of domestic currency.

Considered every presented forecast assumption as whole, we create an out-of-sample analysis and compare it with previous time series forecasting (presented in Figure 2.) and also with the Central Bank projection and the price makers inflation expectations (both shown below in Figure 3.)




*Source of inflation expectations: Market agencies Strategic Marketing, Rojters and IZIT*

Figure 3. NBS inflation projection and structural model forecasting

The projection of NBS and forecasting process using structural models both present a return into the inflation targeting with established upper and lover level. A moderate growth is present in every employed structural model. The difference between forecasting using time series models and structural models are essential because time series models do not recognize the movements in economic environment especially indicators highly correlated with inflation.

## 4. DISAGREEMENT AMONG INFLATION EXPECTATIONS

One of the goals in this paper is to test forecasting efficiency by decreasing the errors between inflation expectations and real inflation values. Comparing these sometimes-confronted values, we tend to a suitable model and to more predictable errors.

There are many tests of forecast efficiency commonly found in the literature providing complementary evidence based on the estimates of inflation expectations is a sample. In Tables 3-6. four different efficiency tests on both errors in core inflation and consumer price index are presented. The followed methodology is takeover from the Mankiw, Reis and Wolfers (2003) working paper[5] with an application about inflation movements at Serbian market.

[5] See Mankiw Gregory, Reis Ricardo, and Wolfers Justin (2003) Disagreement about Inflation Expectations, NBER/Macroeconomics Annual, MIT press, pp 228-229

Table 3

Testing for biases

| | Core inflation | Consumer price index |
|---|---|---|
| α (mean error) | -1,0573 | -2,3186 |
| t - statistic | (-3,1421) | (-6,0045) |

Using the model formulation $\pi_t - E_{t-1}\pi_t = \alpha$, where $\pi_t - E_{t-1}\pi_t$ represent a disagreement between real inflation value and inflation expectations or a forecasting error, we took the first efficiency test for biases and shown the statistical significance of mean error coefficients in both, the core inflation and the consumer price index. The above presented results declare the stationarity in difference between real inflation data and inflation expectations through time and show the small magnitude of the bias.

Table 4

Regressing the forecast error and inflation expectations

| | Core inflation | Consumer price index |
|---|---|---|
| α | 0,9157 | -0,6279 |
| t - statistic | (1,0252) | (-0,5936) |
| β | -0,2081 | -0,1783 |
| t - statistic | (-2,3641) | (-1,7107) |
| $R^2$ | 0,1282 | 0,0715 |

The following form $\pi_t - E_{t-1}\pi_t = \alpha + \beta \cdot E_{t-1}\pi_t$ regresses the forecast errors, as a difference between inflation values and inflation expectations, and inflation expectations. Table 4. tests whether there is information in price makers inflation expectations that can be used to predict forecasting errors. Both models show no predictive power and weak influence of the inflation expectations on the forecast errors.

Table 5

Persistence of forecast errors

| | Core inflation | Consumer price index |
|---|---|---|
| α | -0,2296 | -0,2965 |
| t - statistic | (-0,9364) | (-1,1231) |
| β | 0,7822 | 0,8778 |
| t - statistic | (7,5979) | (11,2315) |
| $R^2$ | 0,6094 | 0,7732 |

The following form $\pi_t - E_{t-1}\pi_t = \alpha + \beta \cdot (\pi_{t-1} - E_{t-2}\pi_{t-1})$ is asking whether current month errors can be forecasted based on previous month errors. Statistically, this regression shows the autocorrelation model form that exploits the last month forecasting errors in creating an evidence of the future errors. Both models have statistical significance in slope coefficient and high level of dependent variable explanation, although there is only one lagged variable

included. Experimenting with longer lags does not change these results significantly. $\beta_{t-1}$

Table 6a

Utilization of macroeconomic data in forecasting core inflation errors

| Variable | Coefficient | t – statistic |
|---|---|---|
| Intercept α | 13,8201 | 5,3295 |
| Unemployment (-1) β | -0,0169 | -5,5144 |
| Inflation expectations (-1) γ | -0,0966 | -1,3449 |
| $R^2$ | 0,4811 | |

Table 6b

Utilization of macroeconomic data in forecasting consumer price index errors

| Variable | Coefficient | t – statistic |
|---|---|---|
| Intercept α | -6,5151 | -1,5844 |
| Inflation rate (-1) β | 0,2046 | 2,7069 |
| Gross Domestic Product (-1) γ | 0,000027 | 1,6348 |
| BELEX15 (-1) δ | -0,0018 | -5,4412 |
| Wages (-1) ω | -0,0001 | -1,7493 |
| $R^2$ | 0,6667 | |

Table 6a. presents the forecasting core inflation errors model form for best exploited macroeconomic data as $\pi_t - E_{t-1}\pi_t = \alpha + \beta \cdot u_{t-1} + \gamma \cdot E_{t-1}\pi_t$
Where $u_{t-1}$ shows the one lagged unemployment variable.

Table 6b. shows the forecasting consumer price index errors model form for the best utilize macroeconomic data

$$\pi_t - E_{t-1}\pi_t = \alpha + \beta \cdot \pi_{t-1} + \gamma \cdot gdp_{t-1} + \delta \cdot belex15_{t-1} + \omega \cdot w_{t-1}$$

(4)

According to this type of efficiency testing the researchers are able to estimate the influence of the publicly available information on decreasing forecasting errors. Due to the general to specific model specification approach and correlation among macroeconomic variables and forecasting errors, there are different model forms dependent on involving the core inflation or the consumer price index.

Table 6a. shows that with changes of an unemployment rate in previous month there are opposite movement of forecasting errors, just like in case of one lag inflation expectations. Table 6b., on the other hand, presents totally different model form by showing the same direction of one lag consumer price index and gross domestic product with forecasting errors. Also, model contains two lagged variable with opposite direction, the Serbian stock market index BELEX15 and wages. The presented variables are mostly used in updating future economy decisions. However, both models leave too much of empty space in explanation forecasting errors showing that the models are 51,89% and 33,33% explained by

the stochastic factors. In both cases the macroeconomic data suggesting that inflation expectations do not adequately account for recent available information. One of important conclusions in this section is to notice a difference in making a decision between real sector and financial sector. The mentioned independent variables in previous two tables indicate the data that cause disagreement between these two most important sectors of economy.

## 5. UNCERTAINTY ABOUT DISAGREEMENT

Forecast uncertainty about disagreement is playing an increasingly important role in monetary policy making. As far as we know, there are no published information about uncertainty by official policy makers especially information that declare two separated components of uncertainty, component common to all forecasters or systematic part ($\lambda_{th}$) and idiosyncratic errors ($\varepsilon_{th}$).

$$e_{th} = \lambda_{th} + \varepsilon_{th} \tag{5}$$

$$\lambda_{th} = \sum_{j=1}^{h} u_{tj} \tag{6}$$

The sum of all components is presented as $e_{th}$. The common component ($\lambda_{th}$) represents the cumulative effect of all shocks that occurred in $h$ periods. Equation (5) specifies $\lambda_{th}$ as the accumulation of all monthly aggregate shocks $u_{tj}$ over the forecast horizon.

On the other hand, the idiosyncratic errors capture forecaster heterogeneity due to the difference in information acquisition and processing, interpretation and judgment of forecasting models. Additionally, the common component and idiosyncratic disturbances are assumed to be uncorrelated.

The further analysis requires the involvement of observed disagreement ($d_{th}$) among decision makers as the variance of their point, given in the following form

$$d_{th} = \frac{1}{N-1}\sum_{i=1}^{N}(\varepsilon_{th} - \frac{1}{N}\sum_{i=1}^{N}\varepsilon_{th})^2 \tag{7}$$

The sample variance $d_{th}$ is the random variable prior to observing forecasts. Using expectations, we get the non random disagreement, denoted as $D_{th}$.

$$D_{th} = E(d_{th}) = \frac{1}{N}\sum_{i=1}^{N}\sigma^2_{\varepsilon|ith} \tag{8}$$

Thus, $D_{th}$ is determined by the average variance of idiosyncratic errors.

The uncertainty of any specific individual is measured by the variance of individual forecast error, and can be expressed as

$$U_{th} = Var(\lambda_{th} + \varepsilon_{th}) = \sigma^2_{\lambda|th} + \sigma^2_{\varepsilon|th}$$

(9)

The forecast uncertainty (equation (8)) is comprised of two components, perceived uncertainty associated with forthcoming common shocks and idiosyncratic shocks.

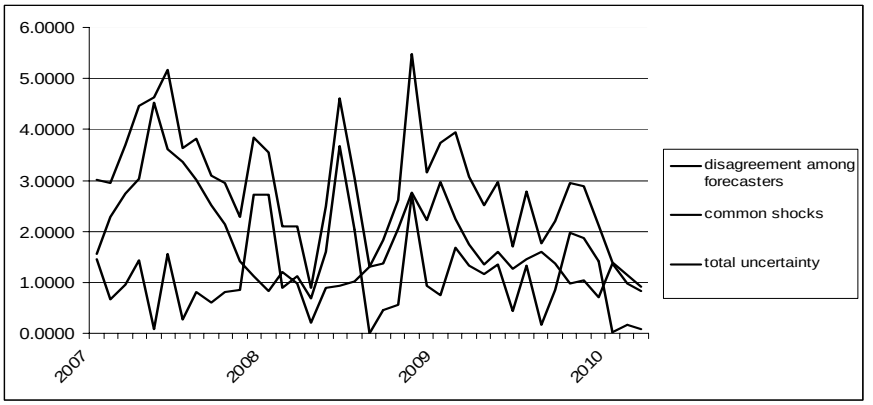



Figure 4. Components of forecast uncertainty

The figure 4. shows that there were not only changes frequently occurred in total expectations uncertainty through the observed time horizon, but also often changes in level of uncertainty between two separated components. It means that there were some changes in monetary policy and market environment especially during the last two years facing with the consequences of world economic crises.

During the first observed year it is obvious the high level of total disagreement variance mostly caused by individual forecasting errors. Also, the systematic part of uncertainty about disagreement was on a low level showing the government policy stability, but at the same time a suspicion of the price makers towards presented monetary and macroeconomic stability. Furthermore, year 2008 depicted the stability in individual beliefs mostly caused by the fall of global financial system which brings us a decreasing of the aggregate demand. At the same time, the government struggled to maintain achieved level of market stability but they succeed only in short term returning on high level of expectation's uncertainty. Year 2009 and few months in 2010 show relatively stable movements of both (systematic and idiosyncratic) components of uncertainty, especially when analyzing uncertainty among forecasters.

# 6. CONCLUSION REMARKS

The comprehensive analysis presented in this paper involves not only a forecasting of two types of inflation level, but also a further analysis of inflation expectations, uncertainty and disagreement of expectations.

Global and local macroeconomic indicators affect the monetary policy and force it to adjust according to mentioned indicators. Therefore, structural modeling process is inevitable in forecasting future state. However, one of the most significant impacts on the inflation level is driven by the opinions of price makers, consumers, and other market participants, known as inflation expectations. The inflation expectations are also followed by the previous movements in government policy and further modeling process is able to provide an information about which indicator causing the most an update in market participants expectations. The uncertainty about disagreement is particularly strong in first two observed year causing low predictive power of modeling disagreement level.

At the end of this paper we would like to indicate on the lack of inflation forecasters and adequate database of inflation expectations at Serbian market, particularly in analyzing disagreement between price makers, financial sectors and final consumers.

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# NEIZVJESNOST I NESLAGANJE U PREDVIĐANJU INFLACIJE

## *Sažetak*

*U ovom članku nastoji se objasniti kako nova strategija ciljanja inflacije može pomoći u poboljšanju točnosti predviđanja inflacije u usporedbi s inflacijom koju očekuju kreatori cijena i potrošači. U daljnjoj analizi autori koriste dobro poznate univarijatne modele vremenskih nizova i strukturne modele. Ipak, isti model može dati suprotne rezultate ovisno o metodologiji primijenjenog indikatora inflacije. Stoga se u ovom članku koristi usporedna analiza dva odvojena indikatora, temeljna inflacija i indeks potrošačkih cijena, s naglaskom na razlike u metodologiji i preciznosti predviđanja. Konačni cilj je testirati učinkovitost predviđanja smanjujući greške između vrijednosti očekivane i stvarne inflacije.*

***Ključne riječi: neizvjesnost, neslaganje, predviđanje inflacije.***

***JEL klasifikacija: E31***