Dynamic Modeling and Analysis of NBU Macroeconomic Forecasts

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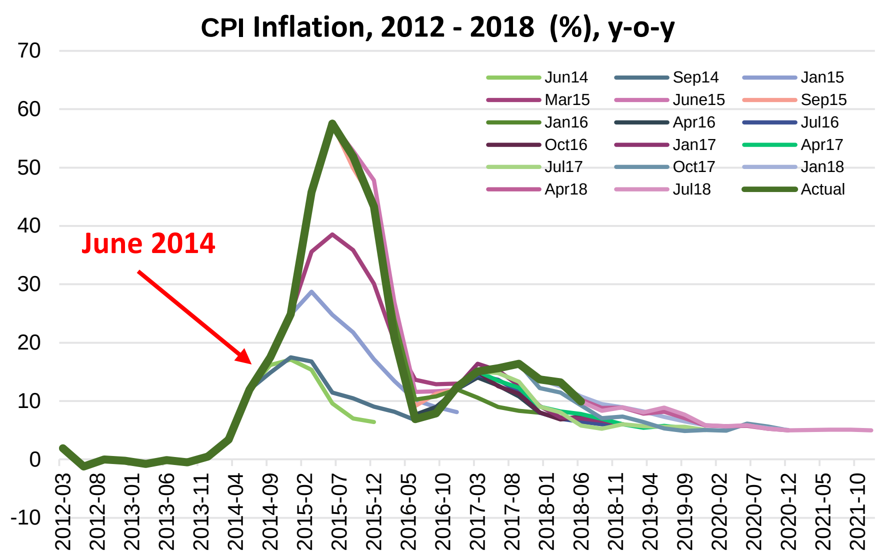
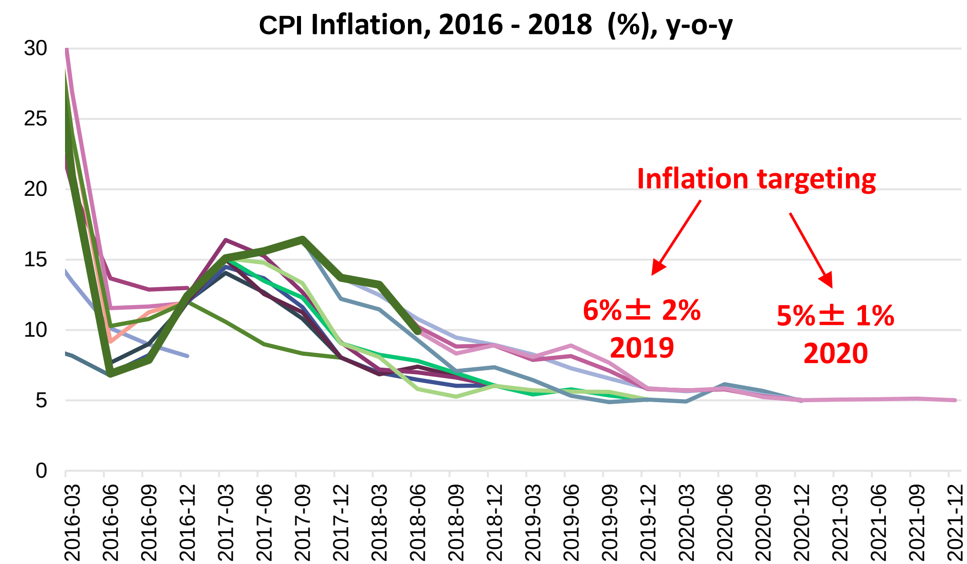
Lviv, 19 **December**, 2018

Motivation





- The main goal of monetary policy is to achieve price stability in the country. In order to meet this goal, The National Bank of Ukraine applies Inflation targeting. The NBU uses the inflation forecast to set a discount rate at the level that will bring expected inflation to target values at the policy horizon. So, it is very important to analyze inflation forecast errors.

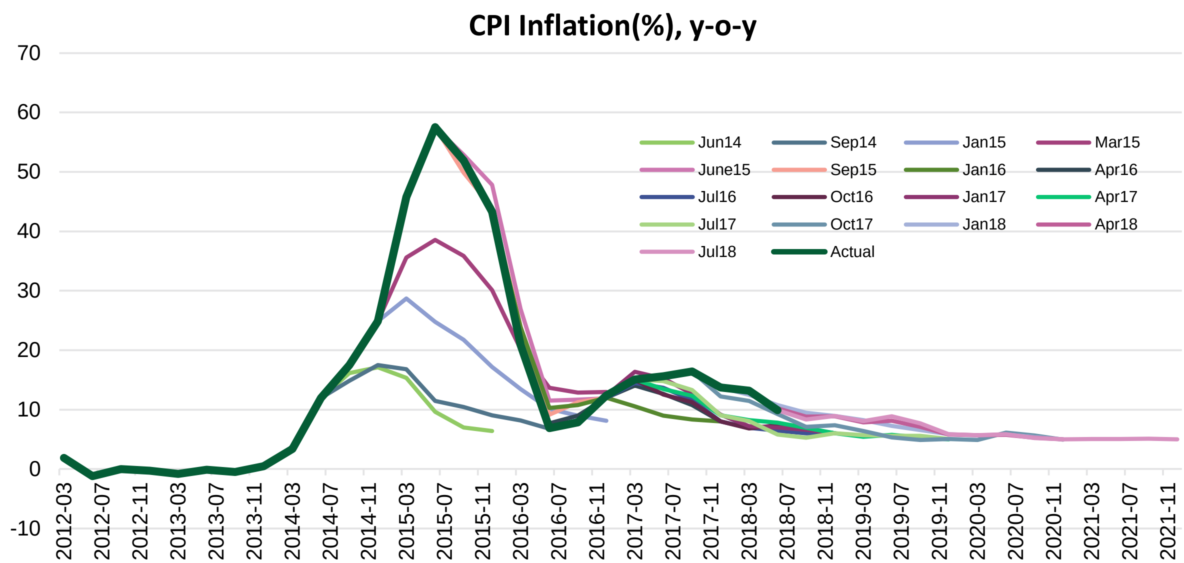
Outline:

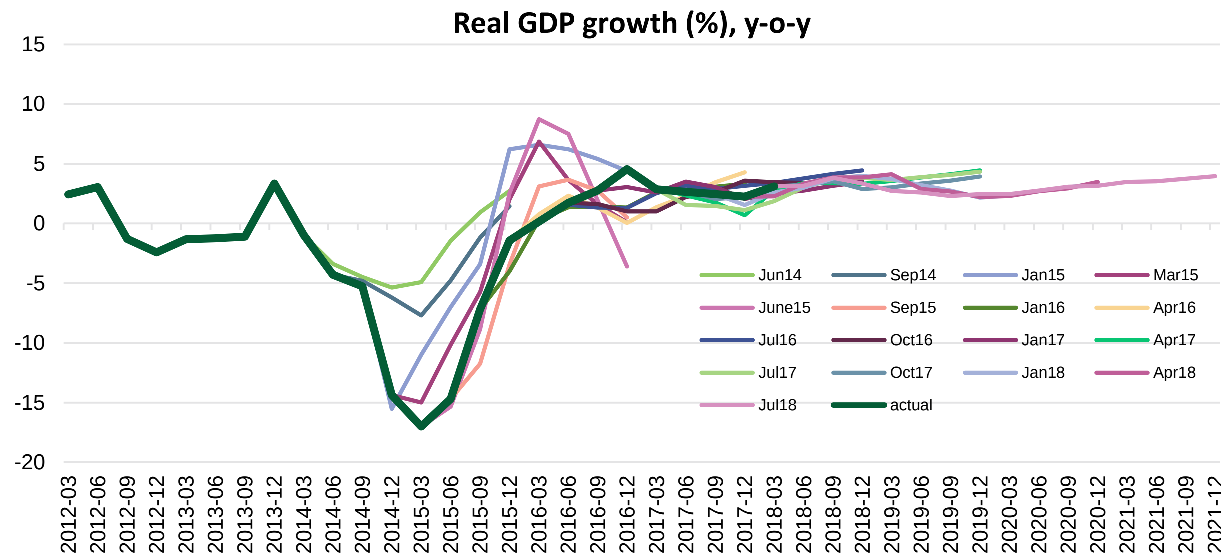
- **Part 1**
  - Evaluating a forecast errors of the NBU
    - Bias, Precision, Accuracy
  - MATLAB implementation
- **Part 2**
  - Comparing forecasts of the NBU and AR models
    - Relative measures
  - MATLAB implementation
- **Part 3**
  - Comparing forecasts of the NBU and other organizations
  - STATA implementation + organizing data

Part 1

(Evaluating a Forecast Errors of the NBU)

Forecasts NBU: CPI Inflation and Real GDP Growth
(forecast period: June 2014 – July 2018)



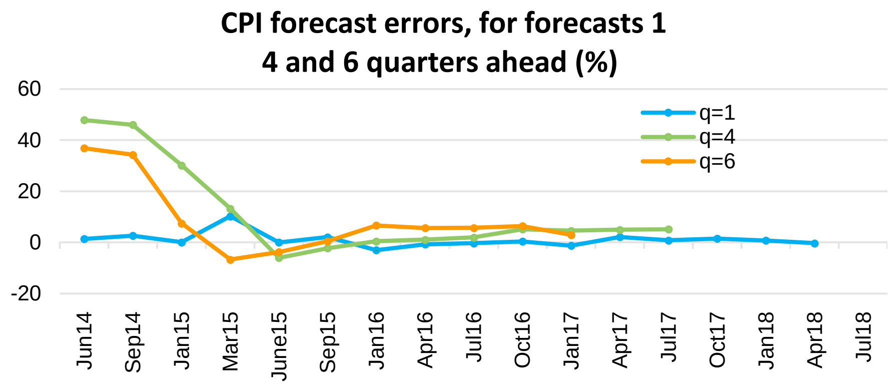


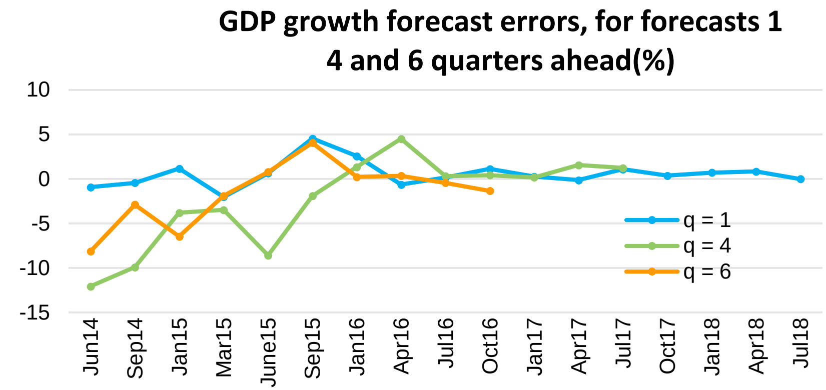
Forecast Errors

Forecast errors are define as actual data minus forecast:

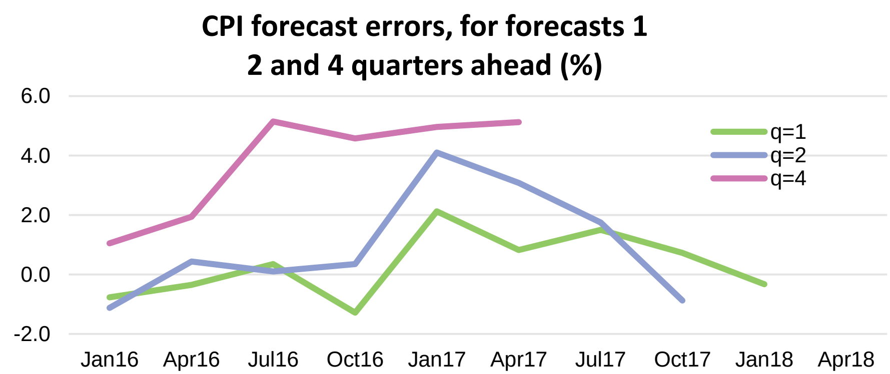
$$\varepsilon_{it,q} = y_t - \hat{y}_{it,q}$$

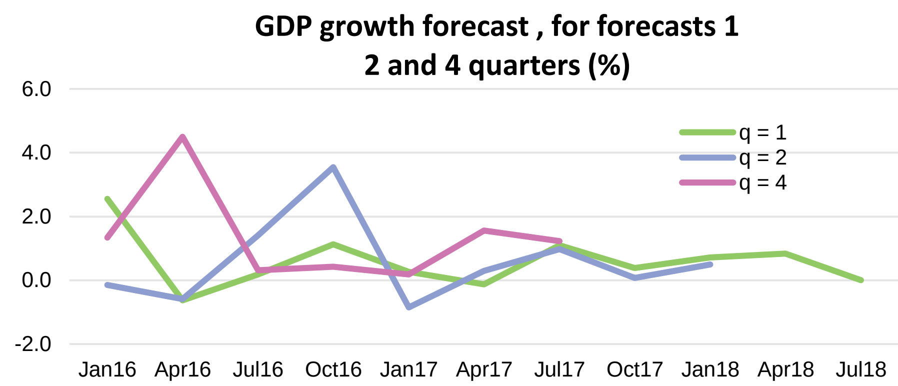
Forecast period: June 2014 – July 2018





Forecast period: January 2016 – July 2018

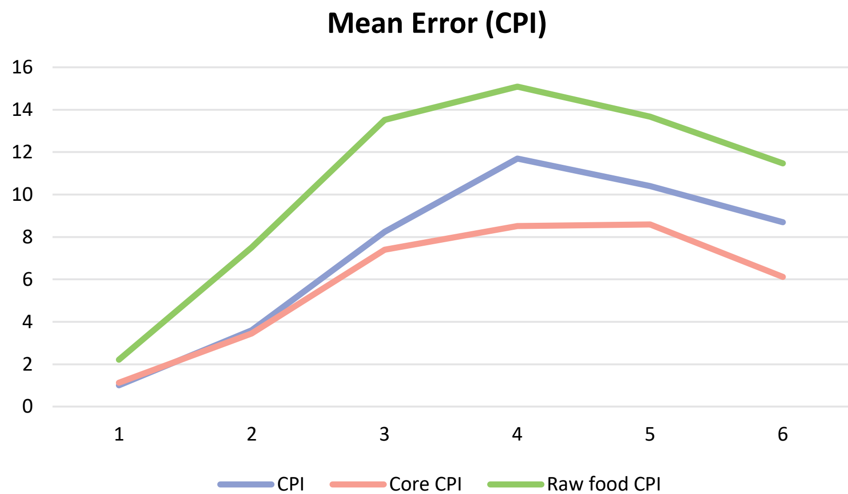


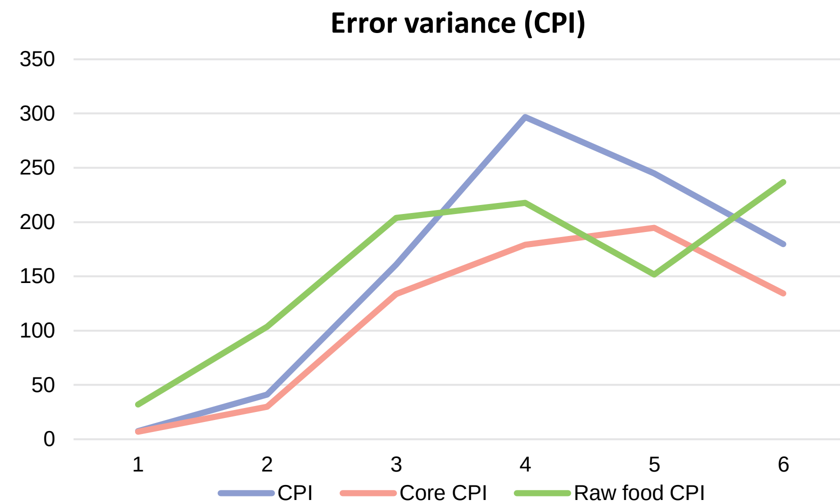


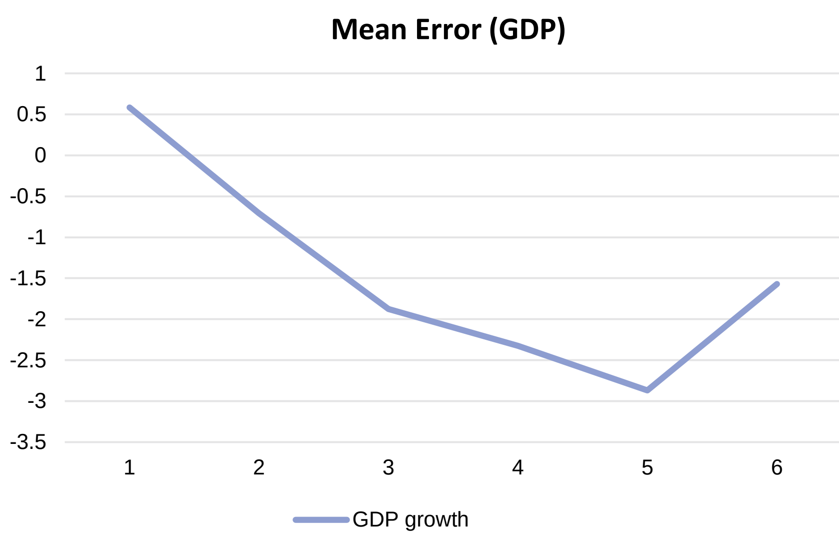
Estimation of Forecast Quality: Unbiasedness & Precision
(forecast period: June 2014 – July 2018)

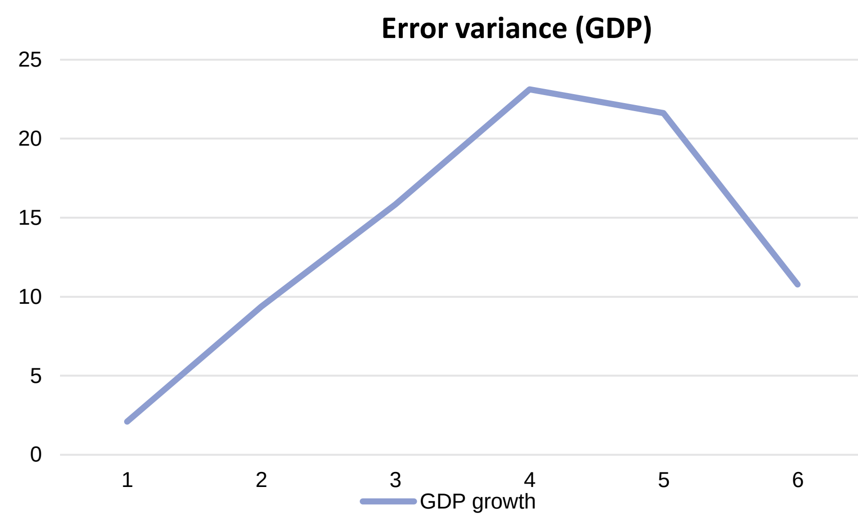
$$ME = \frac{1}{N}\sum_{t=1}^{N}\left(e_{t+q|t}\right)$$

$$EV = \frac{1}{N}\sum_{t=1}^{N}\left(e_{t+q|t} - ME\right)^2$$







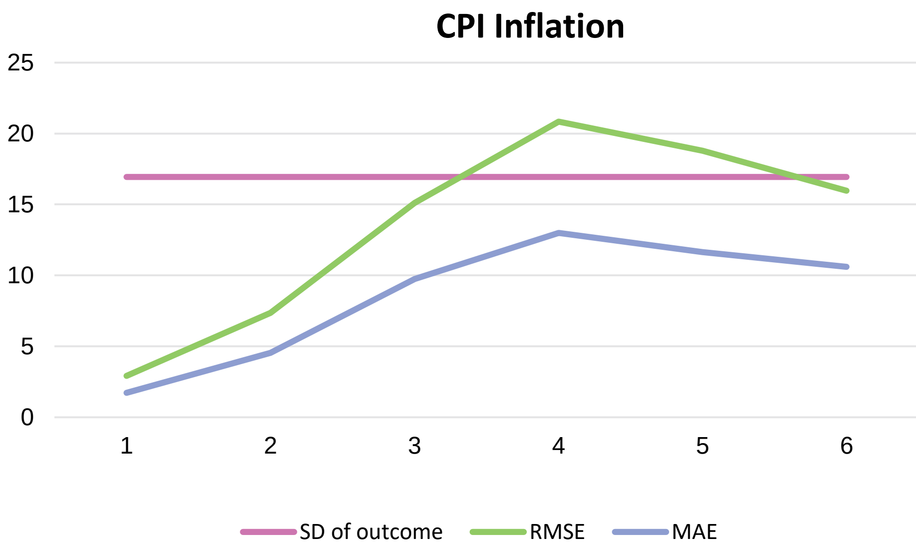


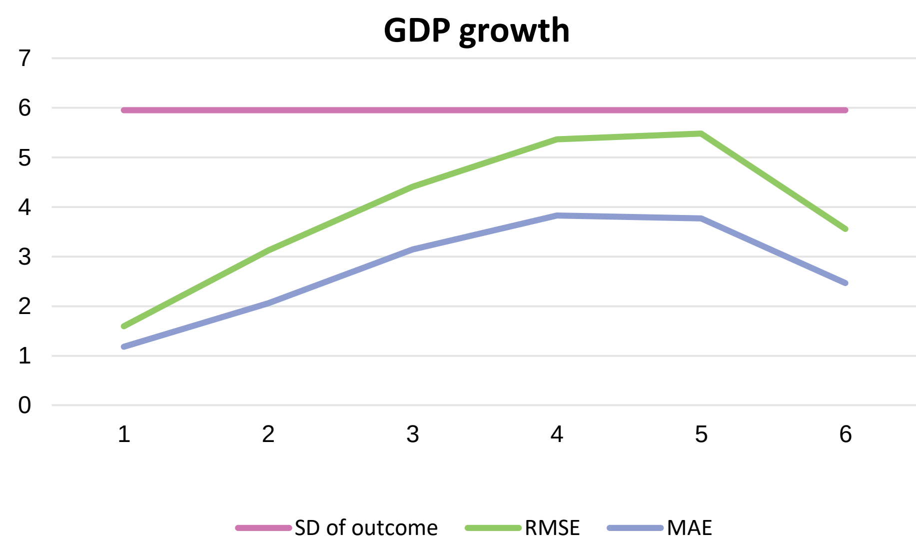
Measures of Accuracy
(forecast period: June 2014 – July 2018)

$$MAE = \frac{1}{N}\sum_{t=1}^{N} |e_{t+q|t}| ; \quad RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{N}(e_{t+q|t})^2}$$

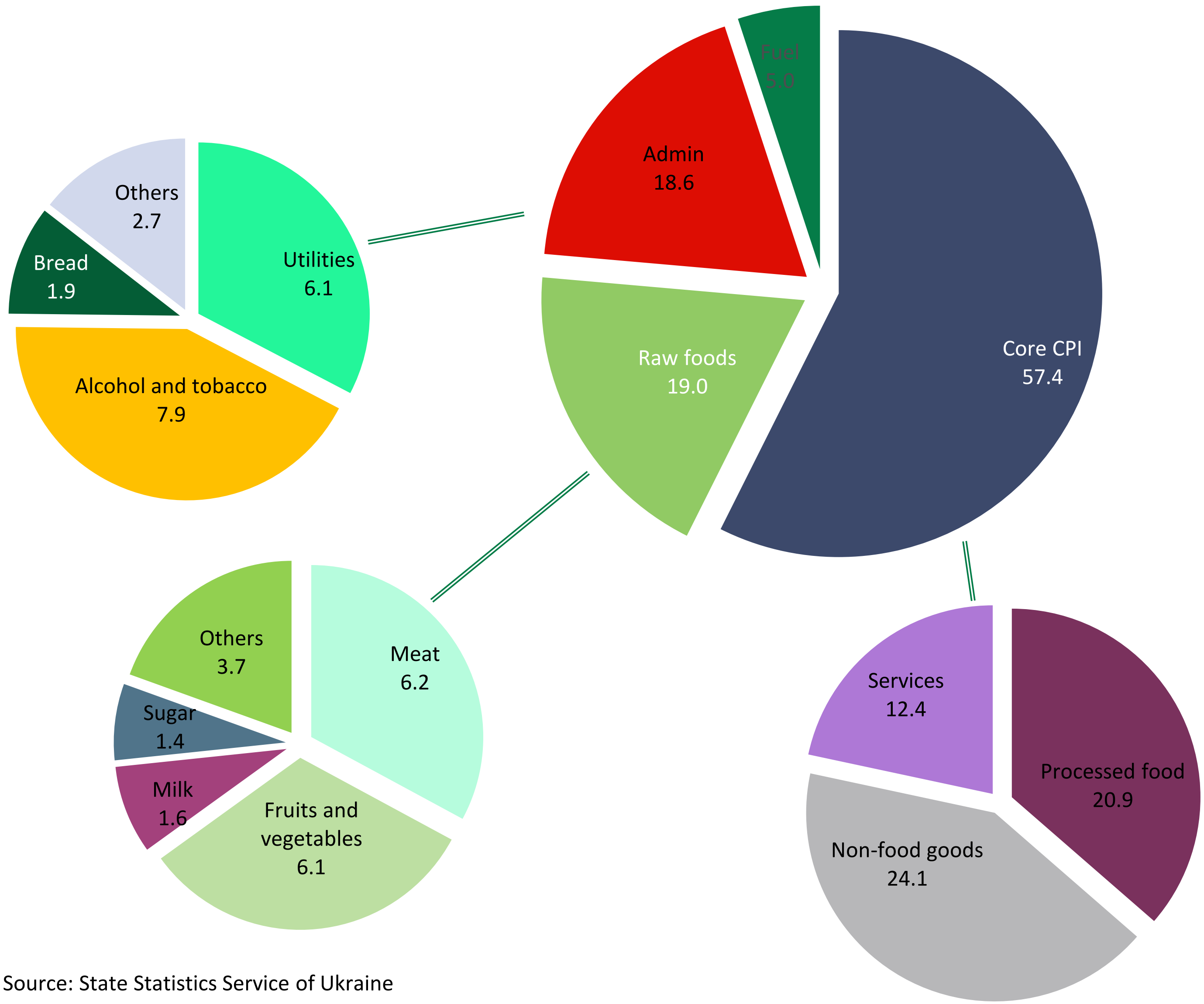
RMSE have the following relation to variance and bias:

$$RMSE = \sqrt{EV + ME^2}$$





CPI Structure, %

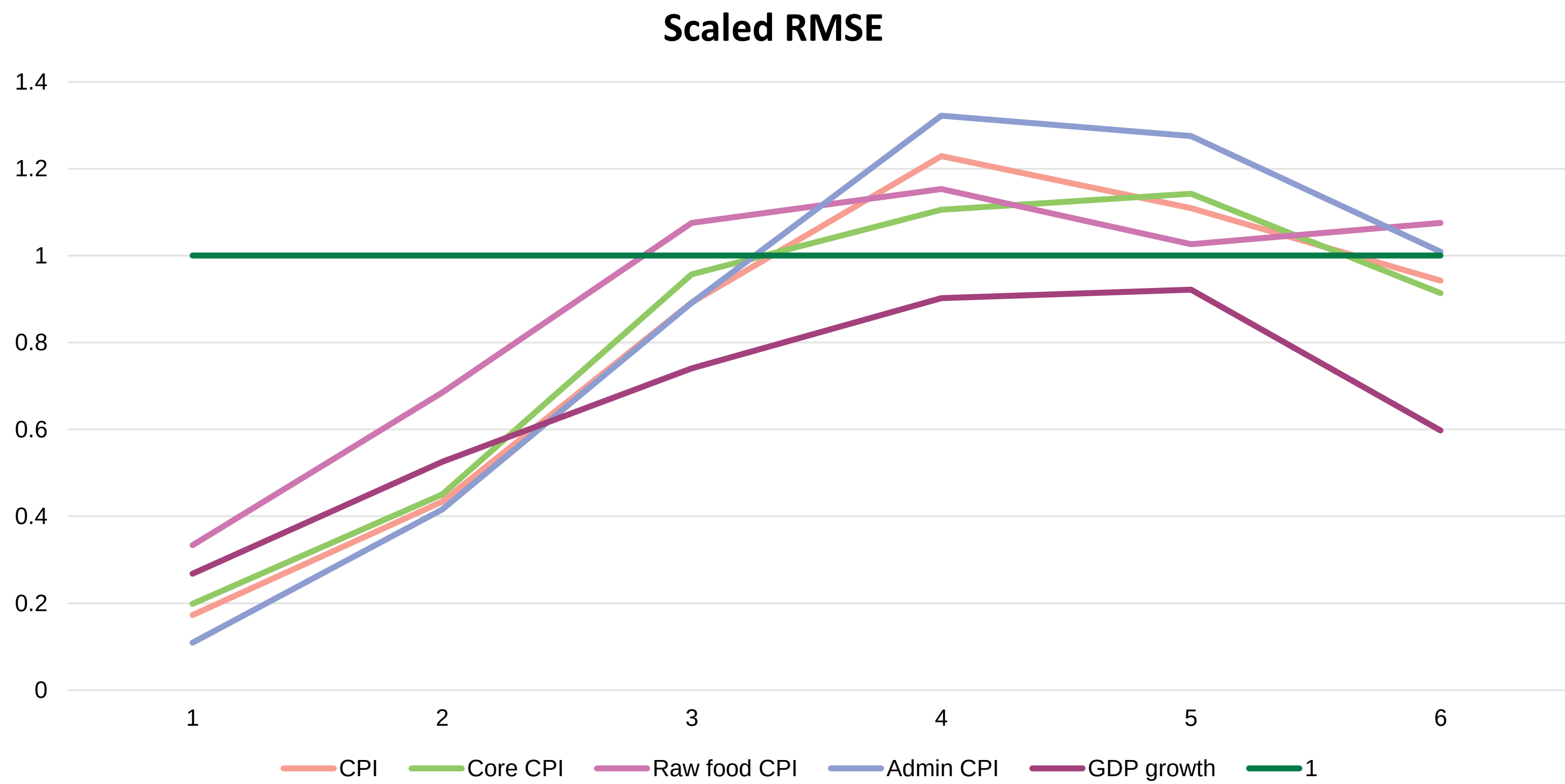


Source: State Statistics Service of Ukraine

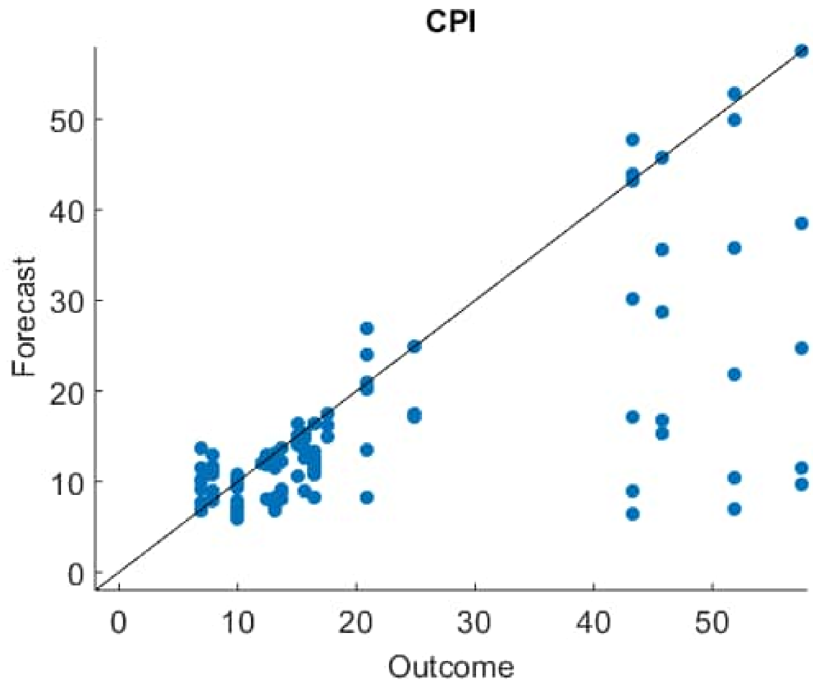
Compare Accuracy across Variables
(forecast period: June 2014 – July 2018)

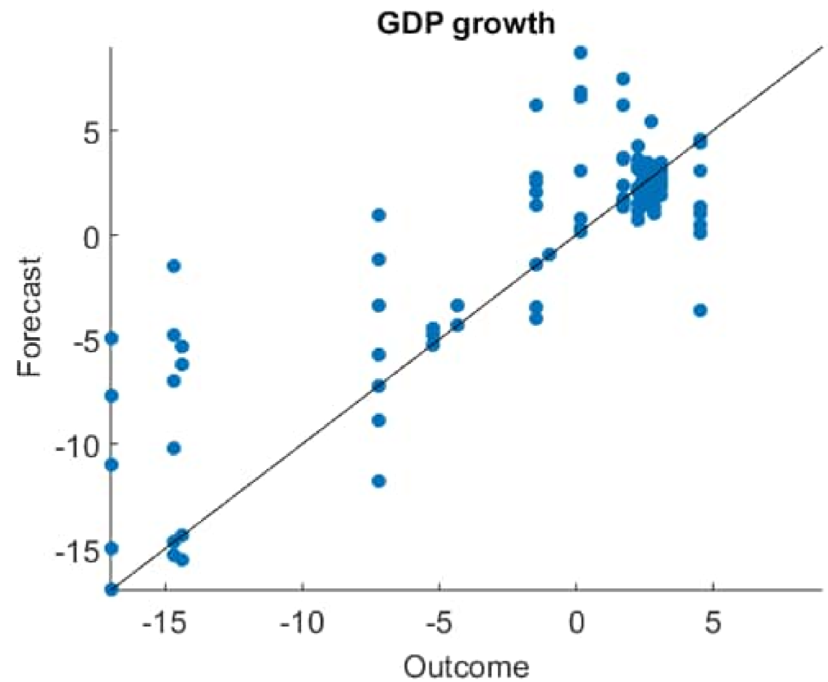
$$SRMSE = \frac{RMSE}{\sigma_{y_t}},$$

σ_{y_t} - the standard deviation of the actual data.



Graphical inspection of the forecasts





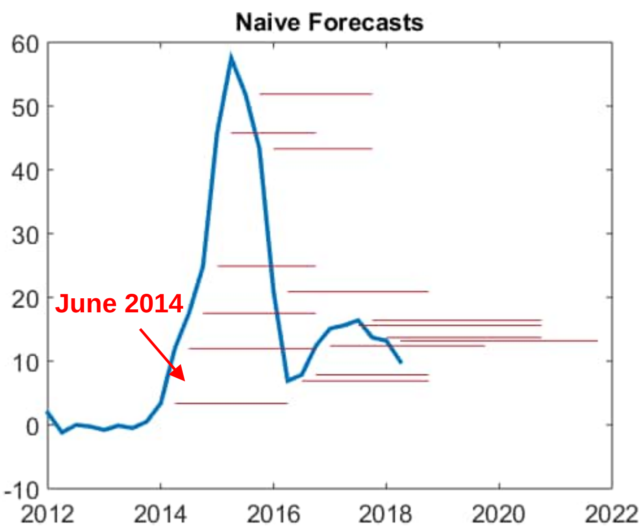
Part 2

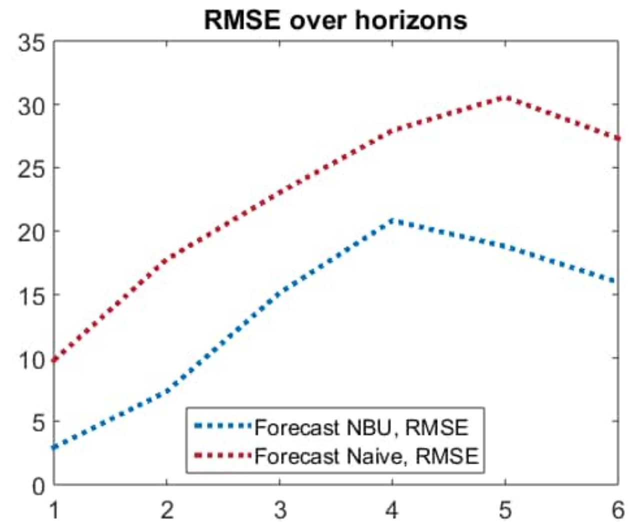
(Comparing Forecasts of the NBU and AR Models)

Comparing forecasts: NBU and NAÏVE
(forecast period: June 2014 – July 2018)

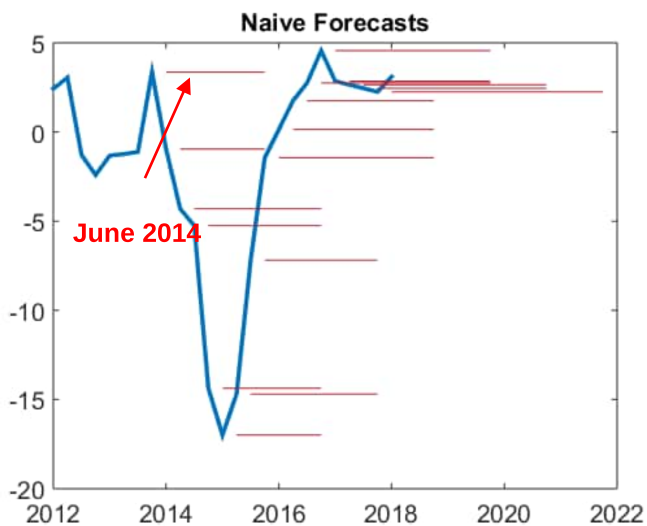
Naïve model: $y_t = y_{t-1}$

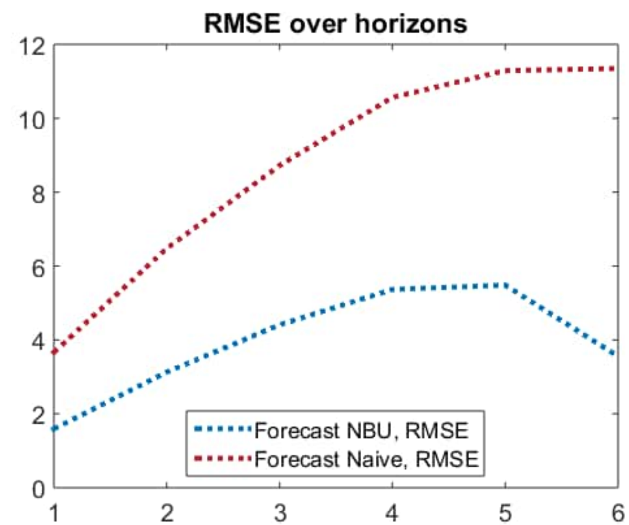
Inflation





Real GDP

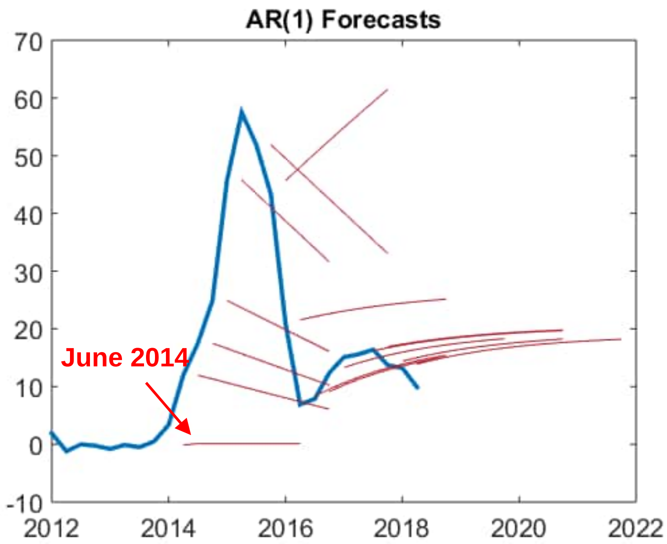


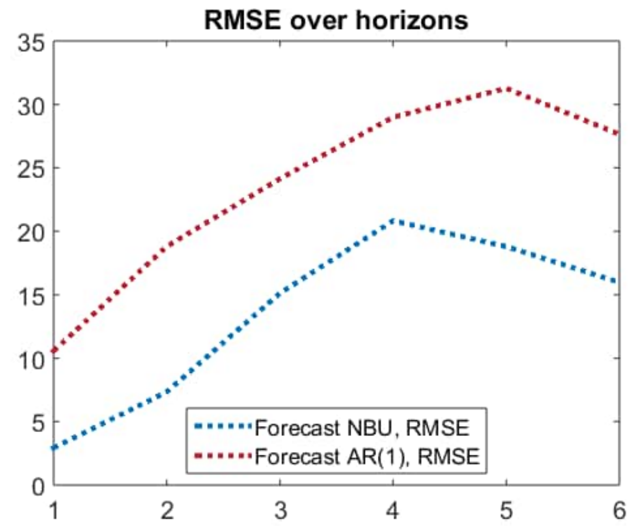


Comparing forecasts: NBU and AR(1)
(forecast period: June 2014 – July 2018)

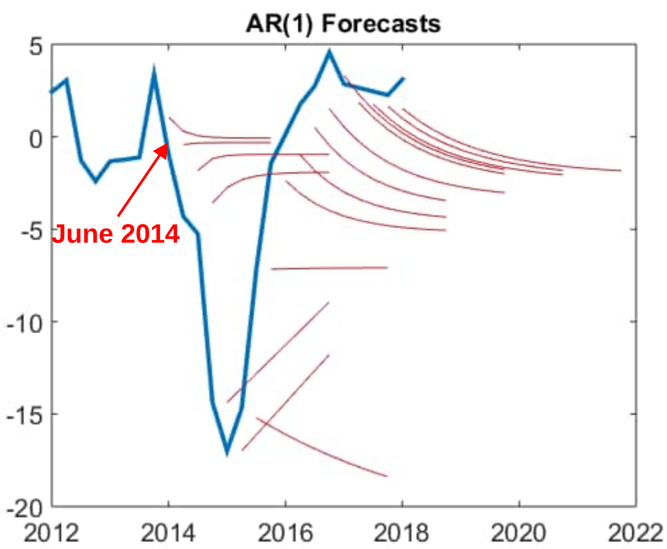
AR(1) model: $y_t = \alpha_0 + \alpha_1 y_{t-1} + \varepsilon_{it,h}$

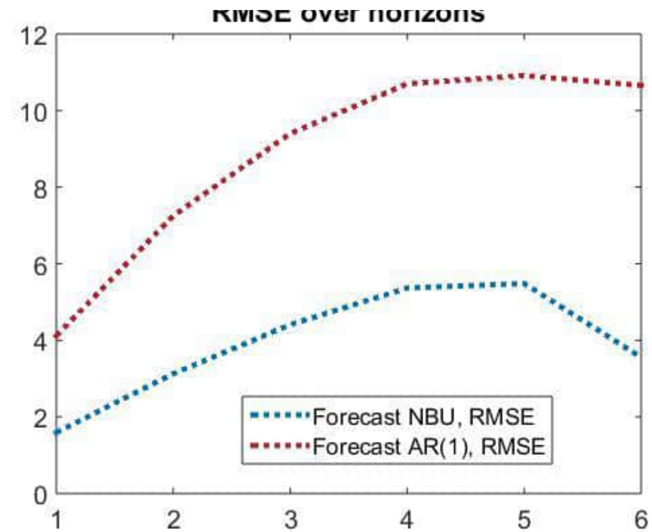
Inflation





Real GDP

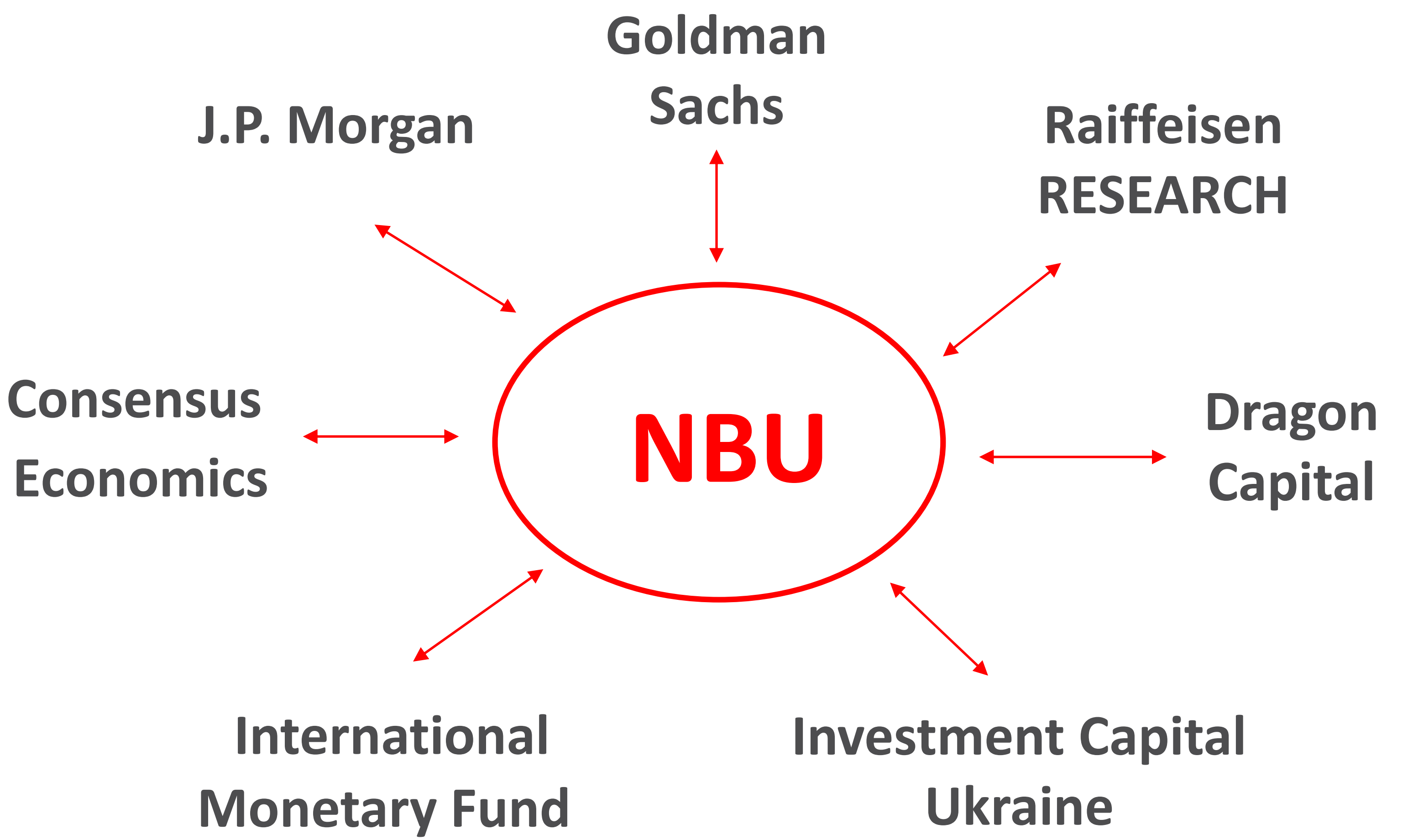




Part 3

(Comparing Forecasts of NBU and different institutions)

Financial institutions



How to compare forecasts of individual organizations that were made at different points in time?

The easiest option is to compare the **mean *absolute forecast errors*** of different organizations :

$$\frac{1}{N}\sum_{t=1}^{N}\left(|y_t - \hat{y}_{it,h}|\right)$$

The annual change of a variable is a function of the quarterly changes during the last four quarters:

$$\frac{Y_{T,1} - Y_{T-1,1}}{Y_{T-1,1}} = \frac{Y_{T,1}}{Y_{T-1,1}} - 1 = \frac{Y_{T,1}}{Y_{T-1,4}} * \frac{Y_{T-1,4}}{Y_{T-1,3}} * \frac{Y_{T-1,3}}{Y_{T-1,2}} * \frac{Y_{T-1,2}}{Y_{T-1,1}} - 1 \qquad (1)$$

The previous equation can be expressed as:

$$1 + g_{T,1}^{4} = (1 + g_{T,1}^{1}) * (1 + g_{T-1,4}^{1}) * (1 + g_{T-1,3}^{1}) * (1 + g_{T-1,2}^{1})$$

$g_{T,1}^{4}$ and $g_{T,1}^{1}$ are the annual and quarterly change for quarter ***q*** of year ***T***

The Relative Importance of Each Quarter

The yearly average growth for year *T:*

$$\Delta_4 y_T = \frac{1}{4}\,[(1+g^1_{T,1})*(1+g^1_{T-1,4})*(1+g^1_{T-1,3})*(1+g^1_{T-1,2})+ \\ (1+g^1_{T,2})*(1+g^1_{T,1})*(1+g^1_{T-1,4})*(1+g^1_{T-1,3})+ \\ (1+g^1_{T,3})*(1+g^1_{T,2})*(1+g^1_{T,1})*(1+g^1_{T-1,4})+ \\ (1+g^1_{T,4})*(1+g^1_{T1,3})*(1+g^1_{T,2})*(1+g^1_{T,1})]-1 \qquad (2)$$

The equation which describes the annual growth rate of year *T* is a function of all quarterly growth rates of the previous year, *T – 1*, until the last quarter of the forecast year, T.

Table 1: The relative importance of each quarter in annual average calculations

	Year: T-1				Year: T			
Quarter	1	2	3	4	1	2	3	4
Weight	0/16	1/16	2/16	3/16	4/16	3/16	2/16	1/16
Accumulated weight	0/16	1/16	3/16	6/16	10/16	13/16	15/16	16/16

Note: The table shows the weights of each quarter in the yearly calculation, together with the proportion of the full year value (accumulated) known at each point in time.

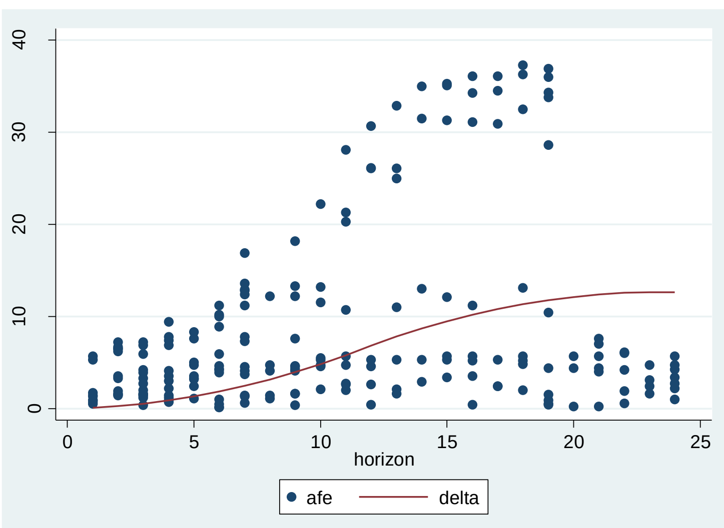
Model to adjust for information differences

The model is based on the assumption that the (absolute) forecast errors can be divided into different components:

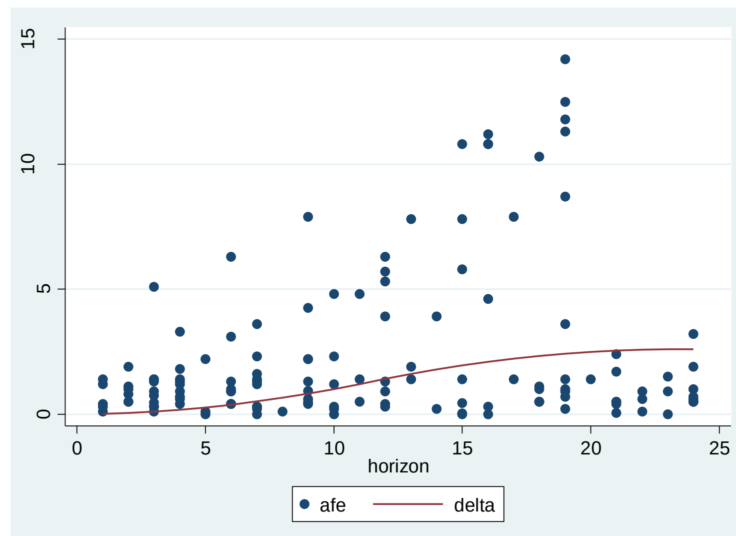
$$\boldsymbol{\varepsilon_{it,h} = \delta M_{it,h} + \mu_i + \lambda_t + \varepsilon_{it,h}}$$

- a component that is due to the amount of information available at the time of publication ($\boldsymbol{M_{it,h} = 1 - W_{it,h}}$; $\boldsymbol{\delta}$ – the marginal effect on the absolute forecast error)
- a component that reflects the general forecasting ability of the i-th forecaster ($\boldsymbol{\mu_i}$);
- a component that refers to different years can be more or less difficult to predict ($\boldsymbol{\lambda_t}$).

(a) CPI inflation



(b) real GDP growth



A more flexible specification & Estimation Result

$$\varepsilon_{it,h} = \delta_t M_{it,h} + \mu_i + \lambda_t + \varepsilon_{it,h}$$

Table A

		CPI(1)			CPI(2)		
		Coef.	SE	p-val	Coef.	SE	p-val
	Timing (δ)	12.64***	1.53	0.00			
Timing*year (δt)	2014				46.53***	7.37	0.00
	2015				39.13***	1.48	0.00
	2016				2.7***	0.80	0.00
	2017				1.61**	0.61	0.01
Year effects (λt)	2015	6.8***	1.55	0.00	-1.4	1.14	0.22
	2016	-10.75***	1.32	0.00	-1.44	0.96	0.13
	2017	-7.85***	1.05	0.00	0.82	0.95	0.39
Individual effects (μ.i)	NBU	5.19***	1.41	0.00	1.78*	1.00	0.07
	FocusEconom	6.32***	0.93	0.00	2.92***	0.92	0.00
	DragonCapital	6.28***	1.44	0.00	2.8**	0.92	0.01
	JPMorgan	7.05***	1.15	0.00	3.59***	1.03	0.00
	ICU	8.07***	1.32	0.00	3.83***	1.14	0.00
	Raiffeisen	6.37***	1.55	0.00	3.82**	1.01	0.01
Adj. R-squared		0.77			0.95		
RMSE		6.42			3.00		

		GDP(1)			GDP(2)		
		Coef.	SE	p-val	Coef.	SE	p-val
	Timing (δ)	2.6***	0.53	0.00			
Timing*year (δt)	2014				3.11***	0.51	0.00
	2015				10.56***	1.03	0.00
	2016				0.43	0.33	0.21
	2017				-0.29	0.26	0.27
Year effects (λt)	2015	3.42***	0.57	0.00	-0.45	0.64	0.48
	2016	-1.56***	0.38	0.00	-0.24	0.31	0.45
	2017	-1.81***	0.37	0.00	-0.27	0.30	0.38
Individual effects (μ.i)	NBU	0.92	0.49	0.64	0.96***	0.33	0.00
	GoldmanSachs	1.62***	0.51	0.00	1.82***	0.41	0.00
	DragonCapital	1.14**	0.45	0.01	0.93**	0.36	0.01
	JPMorgan	0.51	0.41	0.23	0.42	0.35	0.25
	ICU	1.03**	0.41	0.01	0.85**	0.32	0.01
	Raiffeisen	1.2**	0.51	0.02	1.06***	0.38	0.00
	IMF	0.75	0.62	0.23	0.91**	0.36	0.01
Adj. R-squared		0.74			0.90		
RMSE		2.01			1.25		

Note: * signicant at 1%, ** signicant at 5%, * signicant at 10%.**

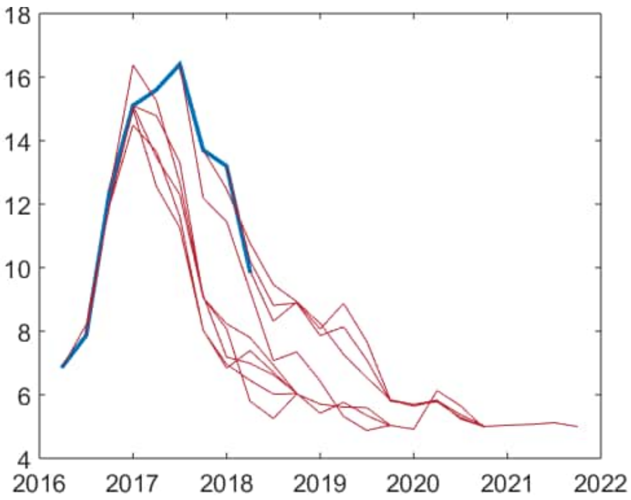
Descriptive statistics for absolute forecast errors, 2014 - 2018

Table B

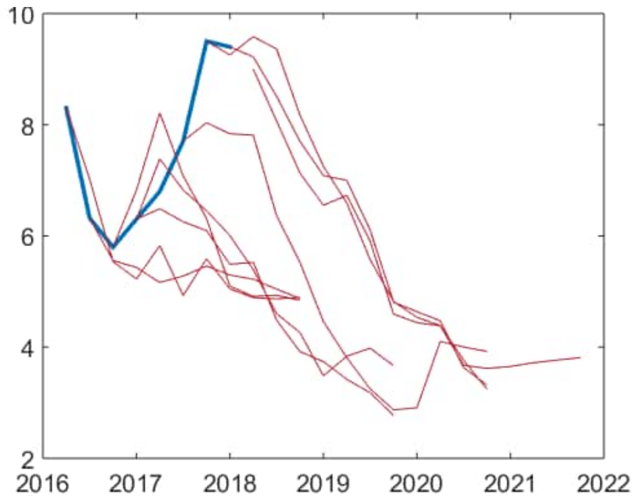
	Number of forecasts	Mean horizon	Mean value (afe)	Standard deviation (afe)	Min(afe)	Max(afe)
Panel (a) CPI						
Dragon Capital	26.00	10.15	7.39	9.66	0.40	37.30
Focus Economics	71.00	10.52	7.86	10.66	0.10	36.30
ICU	18.00	10.83	10.62	10.51	1.40	34.50
JPMorgan	42.00	11.05	10.52	9.73	0.10	32.50
NBU	24.00	12.42	**7.35**	10.31	0.35	36.90
Raiffeisen	17.00	10.47	8.61	9.81	0.90	34.30
Overall	198.00		**8.62**	10.17	0.10	37.30
Panel (b) GDP						
Dragon Capital	18.00	11.61	2.81	3.22	0.00	10.80
Goldman Sachs	20.00	11.65	2.92	3.84	0.00	14.20
ICU	22.00	11.59	1.99	3.14	0.00	11.80
IMF	12.00	10.50	**1.63**	3.10	0.03	10.80
JPMorgan	26.00	10.92	1.79	1.95	0.10	8.70
NBU	24.00	12.42	**2.02**	3.27	0.00	12.50
Raiffeisen	18.00	12.28	2.44	3.29	0.20	11.30
Overall	140.00		**2.22**	3.08	0.00	14.20

Forecasts NBU: Inflation, Real GDP
(forecast period: July 2016 – July 2018)

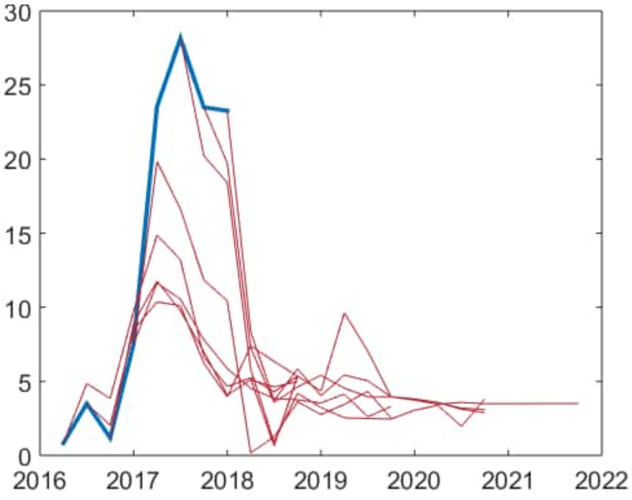
Headline Cpi (%), y-o-y



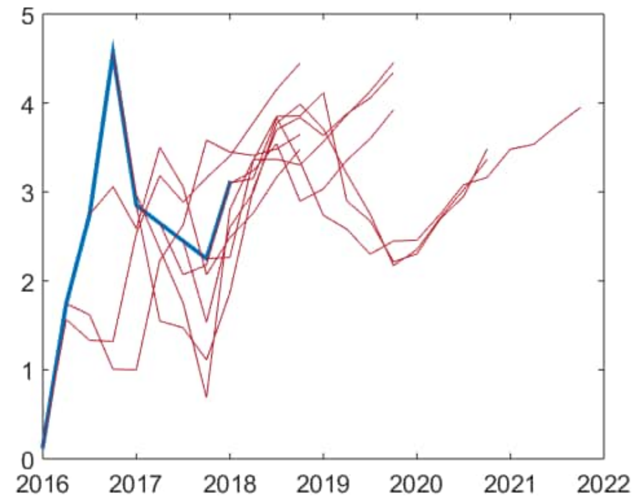
Core Cpi (%), y-o-y



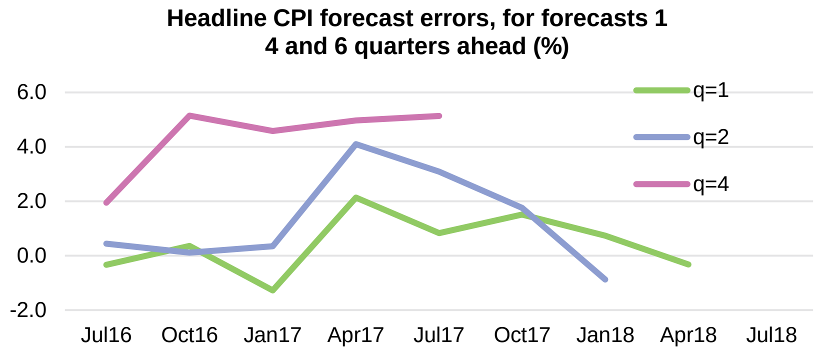
Raw food Cpi (%), y-o-y

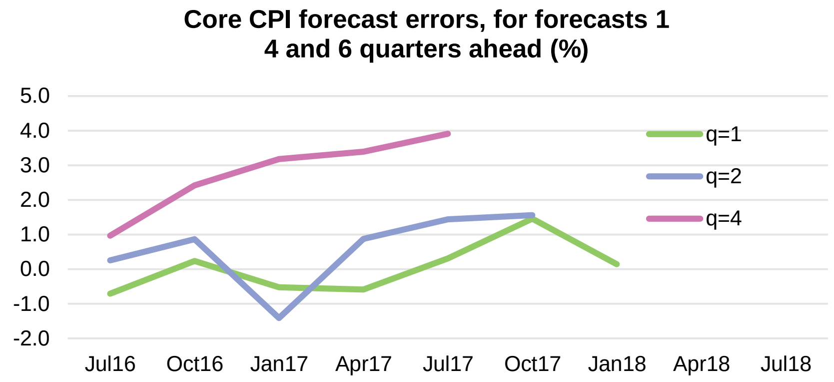


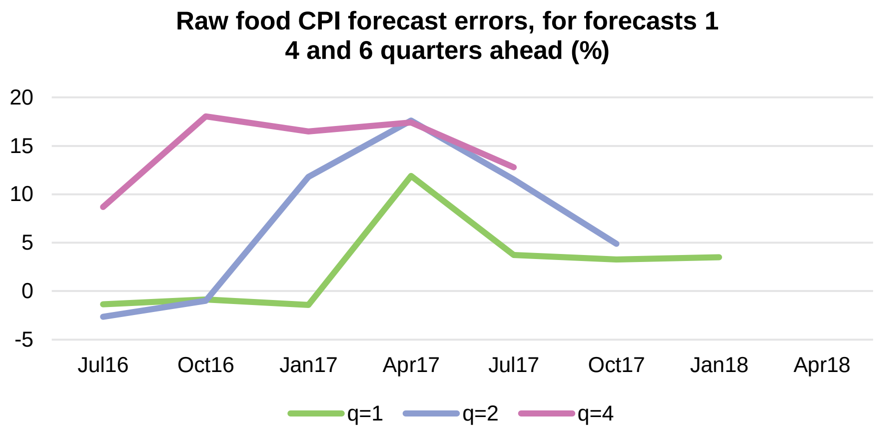
Real GDP (%), y-o-y

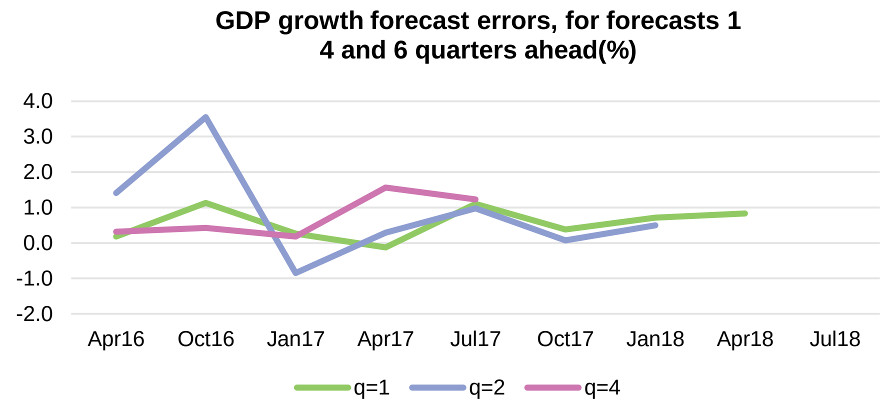


Forecast errors:
(forecast period: July 2016 – July 2018)

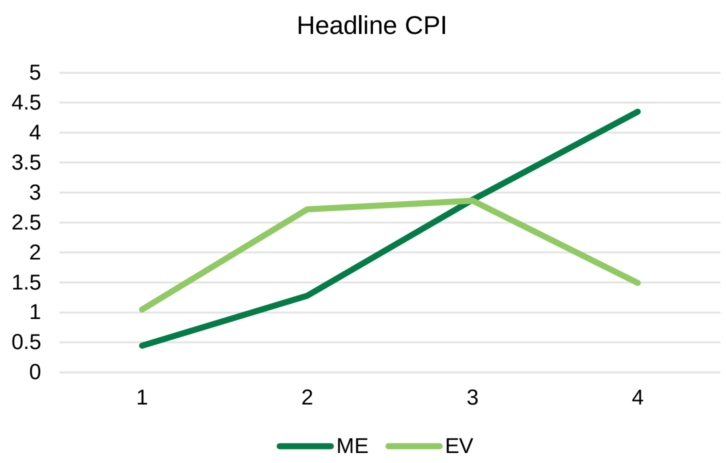


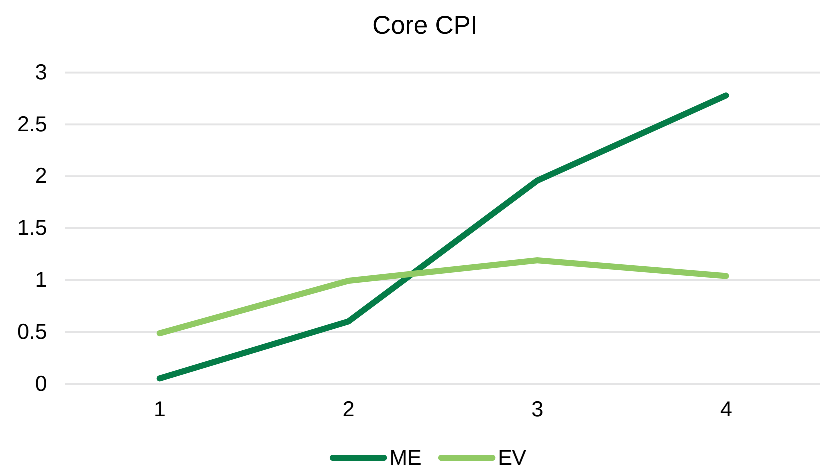


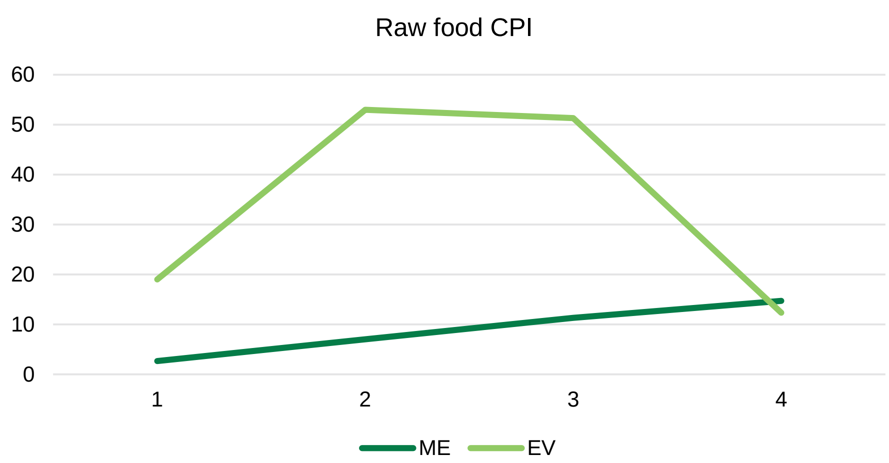


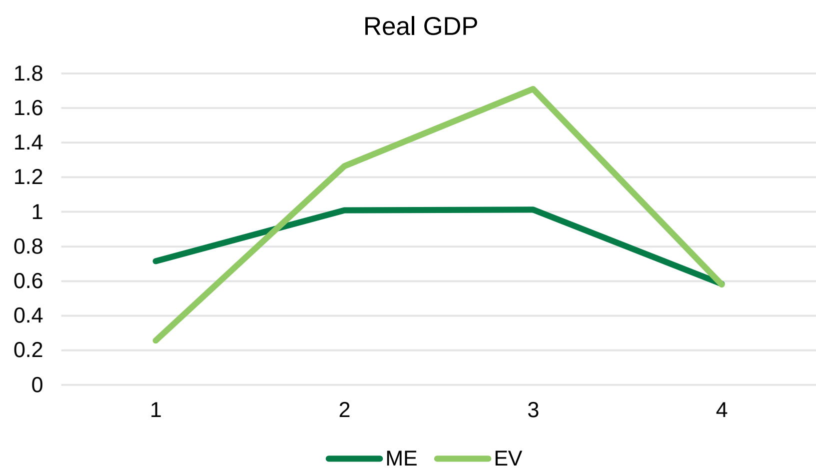


Estimation of forecast quality: Unbiasedness and Precision



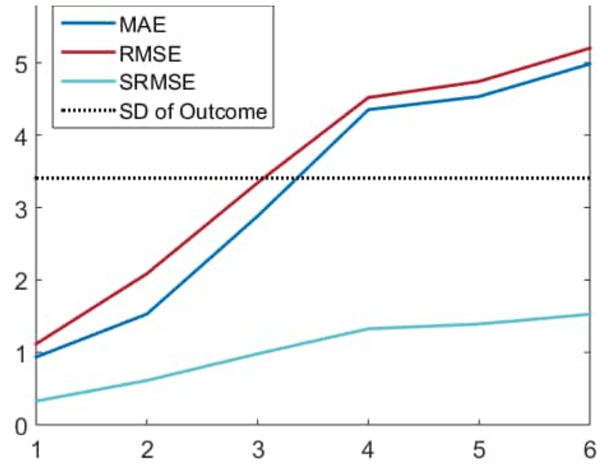




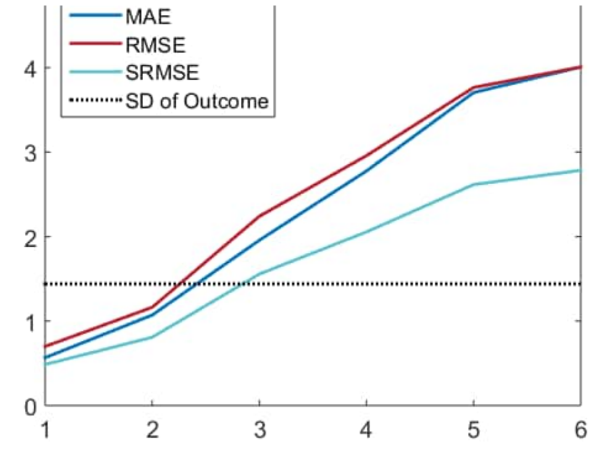


Measures of Accuracy

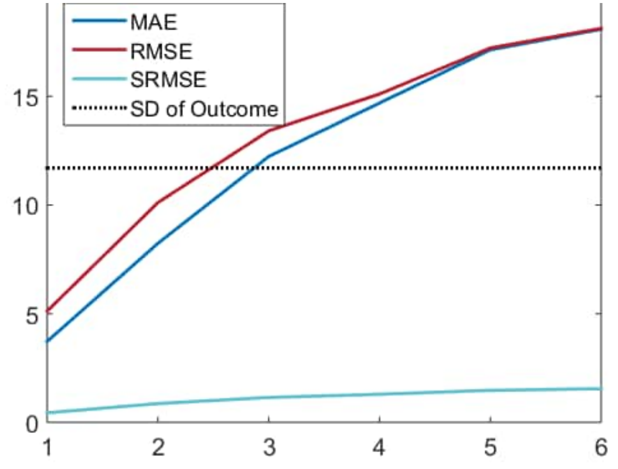
Headline Cpi (%), y-o-y



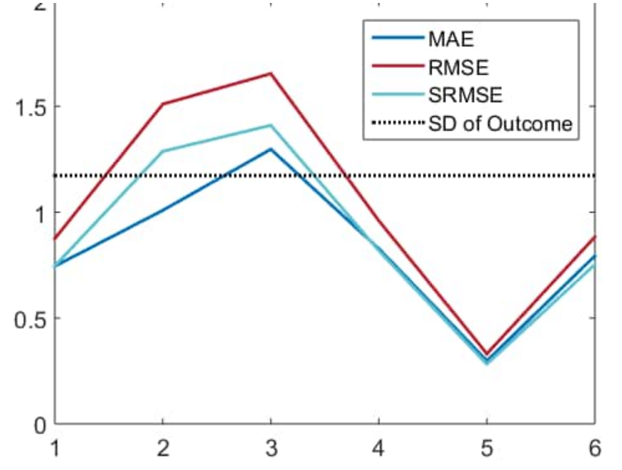
Core Cpi (%), y-o-y



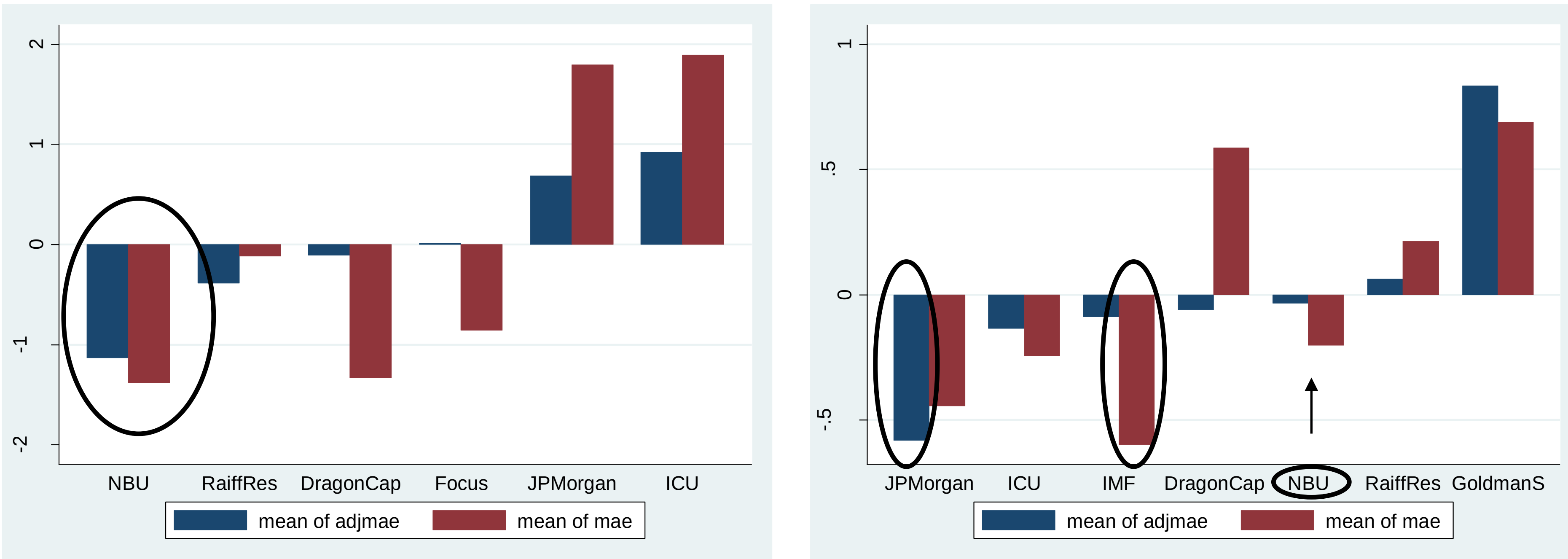
Raw food Cpi (%), y-o-y



Real GDP (%), y-o-y



Ranking Results: Estimated relative forecast ability
(forecast period: June 2014 – July 2018)



(a) CPI inflation

(b) real GDP growth

$$\text{Mean of mae} = \mu_i - \sum_{i=1}^{N} \mu_i$$

$$\text{Mean of adjmae} = \mu_i^* - \sum_{i=1}^{N} \mu_i^*$$

μ_i, μ_i^* – average absolute and adjusted error of forecast of the i-th organization

Conclusions

- The forecasts are systematically too low for Inflation and too high for Real GDP.
- The GDP forecasts are more accurate than the inflation forecasts.
- The forecasts of the NBU are much more accurate than the forecasts of autoregressive models.
- Compared to forecasts of different institutions, the NBU is the best predictor of inflation, and the quality of the GDP forecast is above average.

Thank You

for

attention!