Inflation expectation formation. Laboratory experiment in high and low inflation environment

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Motivation

Inflation expectations are one of the main determinants of inflation:

Theory: New Keynesian Phillips curve

Empirical studies: Galí, Gertler and López-Salido (2001), Taylor (2000)

Policy: efforts of central banks in measuring inflation expectations

But inflation expectations are unobservable!

Survey or experiment?

Methods

Analyze survey data	Conduct an experiment
+Panel data are available for many countries	**+Control the information set that subjects have**
+Data for long periods of time	+Control the incentives
-No incentive to truthfully report the expectations	**+Control the shocks that hit the experimental economy**
-Decision in real life situations may be based on different expectations than stated in the survey	-Small sample => internal validity issues
-Many shocks may hit the economy at the same time, so it is hard to disentangle the effects of various shocks	-External validity issues (artificial setting, etc.)
-Data on expectations from many developing countries is either not available or not reliable	

Main idea

Research questions:

- How are individual inflation expectations formed and adapted?
- How are aggregate expectations formed?

Hypotheses:

- The majority of people do not switch between forecasting rules. Instead, they use adaptive learning model ($\pi\downarrow t\uparrow e = \pi\downarrow t-1\uparrow e + \lambda(\pi\downarrow t-1 - \pi\downarrow t-1\uparrow e)$) and change updating parameter in response to chan in the environment.
- Reaction to changes in macroeconomic parameters will be bigger in high inflation environment because underprediction inflation in unstable environment is more costly than overpredicting it.

Method: learning-to-forecast experiment with 2 treatments: high inflation environment (tested on students from Belarus) and low inflation environment (researched on UVA students)

Literature

ypothesis 1:

glewski and Wachtel (1981) adaptive expectations are the best fit to the survey data, heterogeneity in adapti
rameter;

fajfar and Santoro (2010) – adaptive learning fits the data to the right of the median in the Michigan survey da

etersen (2014) - adaptive expectations are the best fit to the data.

ypothesis 2:

alati et al. (2009) after the Great Recession sensitivity of expectations to macroeconomic information increas

fajfar and Santoro (2010) agents update information more often when inflation is high and volatile;

fajfar and Zakelj (2016) higher updating coefficients in treatments with higher inflation variability.

ontribution:

effects of environment on individual and aggregate expectation formation

the new rule of change in the parameter of the adaptive learning model (asymmetric costs of underpredicting
flation => higher updating parameter in uncertain environment)

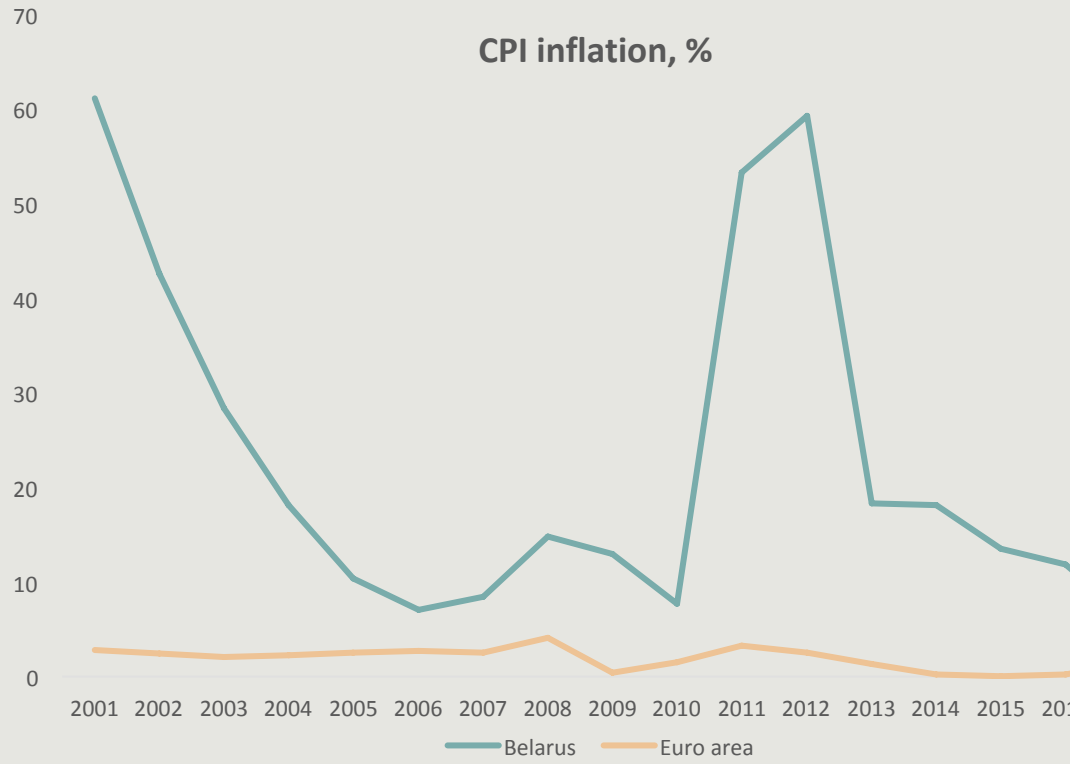
Low and high inflation environments

larus: high inflation throughout the whole history

rsistent expectations of high inflation currency valuation, high inflation

therlands: low and stable inflation

low inflation expectations



Experimental design

- Groups of **5**, each representing a separate experimental economy, constant group composition.
- Task: **forecast inflation** in the next period based on information up to previous period:

> "During the next period, what do you expect inflation to be (negative value means decrease in prices, positive value refers to increase in prices and 0 denotes no change in prices)?"

- In period *t* - forecast inflation in period t+1 based on:
  - ✓ Subject's previous forecasts;
  - ✓ Data on inflation, GDP growth and interest rate up to period t-1; in period 1 subjects are given an interval of possible values of inflation forecast [-5;15].
- Subjects' forecasts **have a feedback** on the experimental economy.

Experimental timeline

Period 1

bjects forecast inflation
period 2 without any
ues of inflation, GDP
wth and interest rate
ssible values [-5;15])

Inflation, GDP growth and interest rate data for period 1 are generated using forecasts

Period 2

Subjects forecast inflation in period 3 based the values of inflation, GDP growth, interest rate from period 1.

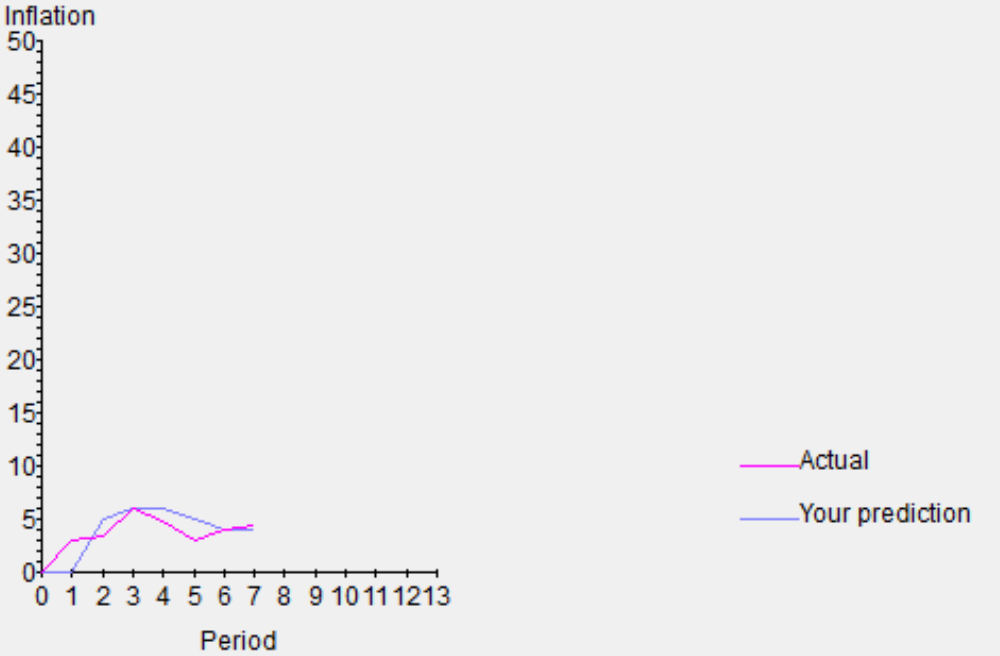
Inflation, GDP growth and interest rate data for period 2 are generated using forecasts

30 periods

Period

8 of 10

Remaining time [sec]: 60



During the next period, what do you expect inflation to be (negative value means decrease in prices, positive value refers to increase in prices and 0 denotes no change in prices)?

OK

Period	GDP growth	Inflation	Interest rate	Inflation forecasts	Your profit	Accumulated profit
1	2.7	3.4	6.0	0.00	0.00	0.0
2	4.0	6.1	7.5	5.00	0.00	0.0
3	4.5	5.0	7.5	6.00	29.09	29.1
4	3.9	3.0	6.0	6.00	5.06	34.1
5	3.0	4.0	4.5	5.00	30.27	64.4
6	4.6	4.5	4.5	4.00	48.53	112.9
7	4.0	5.6	6.0	4.00	19.21	132.1

The model

The experimental economy is described by the following model:

$$y_t = E_t^{*} y_{t+1} - 0.164 (i_t - E_t^{*} \pi_{t+1}) + \varepsilon_t$$

$$\pi_t = 0.3 y_t + 0.7 E_t^{*} \pi_{t+1} + u_t$$

$$i_t = 1.5 (E_t^{*} \pi_{t+1} - \pi) + \pi$$

$$\varepsilon_t = 0.6 \varepsilon_{t-1} + \varepsilon_t$$

$$u_t = 0.6 u_{t-1} + u_t$$

y_t - GDP gap, π_t - inflation, i_t - interest rate, $E_t^{*} y_{t+1}$ - expected output gap (assumed to be eq
o previous value of the output gap $\Rightarrow E_t^{*} y_{t+1} = y_{t-1}$), $E_t^{*} \pi_{t+1}$ - expected inflation, π - inf
arget (3%), ε_t - mean-zero demand shock, u_t - mean-zero supply shock. Shocks are assumed to be fir
rder autoregressive processes with coefficient equal to 0.6.

n period 15 each experimental economy is hit by a supply shock of magnitude 5.

Questionnaire

- general questions (sex, age, country, monthly expenditures, faculty)
- strategy used when forecasting inflation;
- whether they changed strategy during the experiment;
- was central bank successful in stabilizing inflation;
- questions to assess general optimism/pessimism about country's economic situation and personal economic situation.

Payoff

- Payment in cash based on the forecasting accuracy.
- Payoff in each period is found with the following formula (Adam, 2007):

$$points_t = \max\{100/1 + error_t - 20, 0\}$$

- Forecasting accuracy: $error_t = |\pi_t - \pi_t^f|$

Payoff for selected values of forecast error

fe_t^k	0	0.5	1	1.5	2	2.5	3	3.5	≥ 4
$points_t^k$	80	46.7	30	20	13.3	8.6	5	2.2	0

- Payoffs in each period were accumulated: $payoff = \sum_{t=31}^{30} points_t$.
- 2 trial periods, so only in the last 28 rounds subjects could earn money
- Exchange rate – 80 points/euro, 65 points/ruble plus 7 euro (5 rubles) participation fee.

Additional information

Sample: 2 groups of 10 people, first - students from the University of Amsterdam second - students from the Belarusian State University.

Sessions: 2 (in Amsterdam and in Belarus), on average 40 minutes.

Instructions: for students from UVA in English, for students from BSU in Russian.

Average payoff: 10 rubles, 14 euro.

Software: Z-TREE.

Data analysis

1. Test experimental data for matching the rational expectations hypothesis:

✓ unbiasedness: $\pi\downarrow t = \alpha + \beta\pi\downarrow t\uparrow e + \varepsilon\downarrow t$, if $\alpha = 0, \beta = 1 \Rightarrow$ unbiased

✓ efficiency:

- strong form: $\pi\downarrow t - \pi\downarrow t\uparrow e = \alpha + \beta\pi\downarrow t-1 + \gamma y\downarrow t-1 + \delta i\downarrow t-1 + u\downarrow t$,
- weak form: $\pi\downarrow t - \pi\downarrow t\uparrow e = \alpha + \beta\pi\downarrow t-1 + u\downarrow t$?

2. Fit the data to

- linear prediction rule: $\pi\downarrow j,t+1\uparrow e = c + \sum i=0\uparrow 2 \alpha\downarrow i \ \pi\downarrow j,t-i\uparrow e + \sum i=1\uparrow 3 \beta\downarrow i \pi\downarrow t-i + \sum i=1\uparrow 3 \gamma\downarrow t-i + \mu\downarrow t$
- trend extrapolation rule: $\pi\downarrow j,t+1\uparrow e = \beta\downarrow 0 + \beta\downarrow 1 \pi\downarrow t-2 + \beta\downarrow 2 (\pi\downarrow t-2 - \pi\downarrow t-3) + \mu\downarrow t$
- adaptive learning rule: $\pi\downarrow t\uparrow e = \pi\downarrow t-1\uparrow e + \lambda(\pi\downarrow t-1 - \pi\downarrow t-1\uparrow e)$

3. Compare coefficients for different individuals and between groups, conduct statistical test to find out whether these coefficients are significantly different;

4. If $\alpha\downarrow i\uparrow BSU, \beta\downarrow i\uparrow BSU, \gamma\downarrow i\uparrow BSU > \alpha\downarrow i\uparrow UVA, \beta\downarrow i\uparrow UVA, \gamma\downarrow i\uparrow UVA \Rightarrow$ evidence supporting the 2nd hypothesis

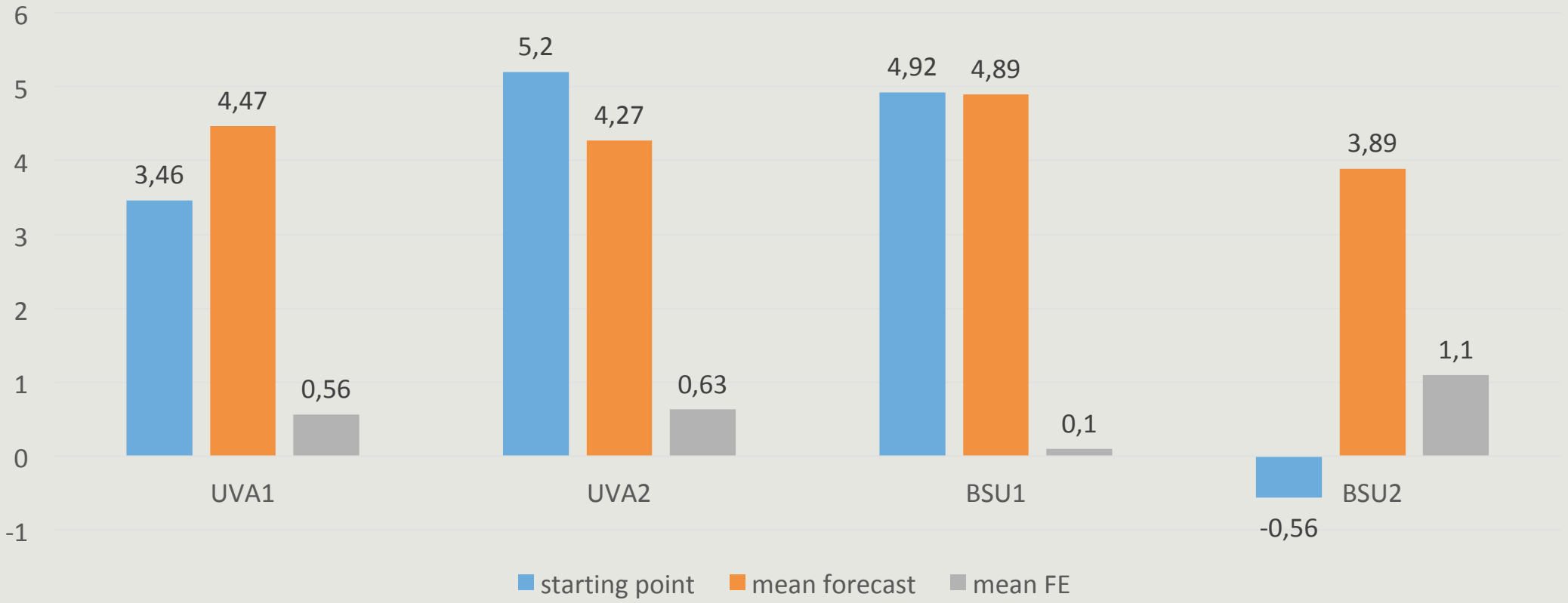
Expected findings

- The majority of the individual data from the experiment was expected to fit adaptive learning rule.
- Agents were expected to be heterogeneous not in terms of forecasting rules but in terms of updating parameter (λ).
- People from high-inflation environment were expected to adapt to changes in inflation faster than people who are used to low-inflation.

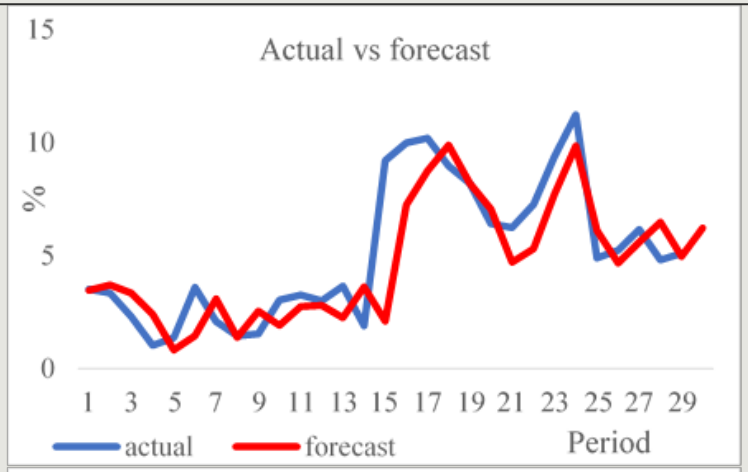
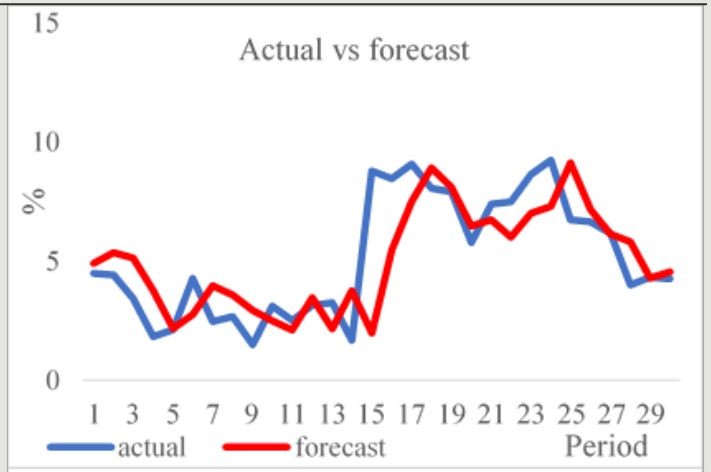
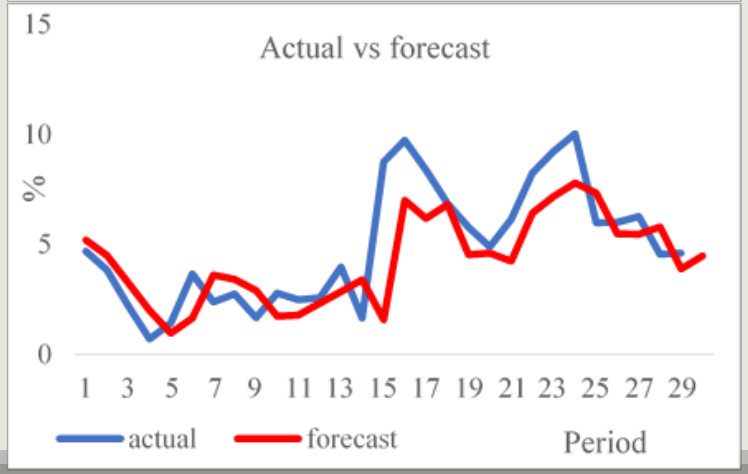
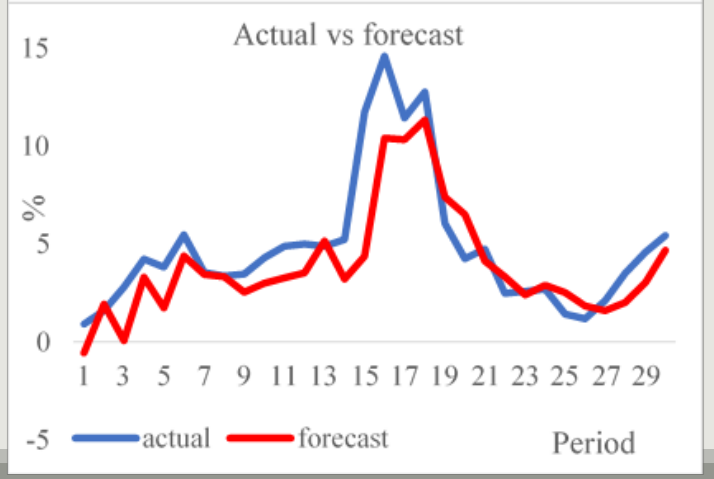
Descriptive statistics

Characteristics	BSU	UVA
age	19.8	21.5
Female/male	8/2	6/4
Education	Bachelors of Corporate Finance	Bachelors and Masters: 9 Economics and Business and 1 Political Science
Country	Belarus	2 Netherlands, Albania, USA, Ukraine, Germany, Latvia, Pakistan, Cuba, Sweden
Participation in experiments in the past	No	?

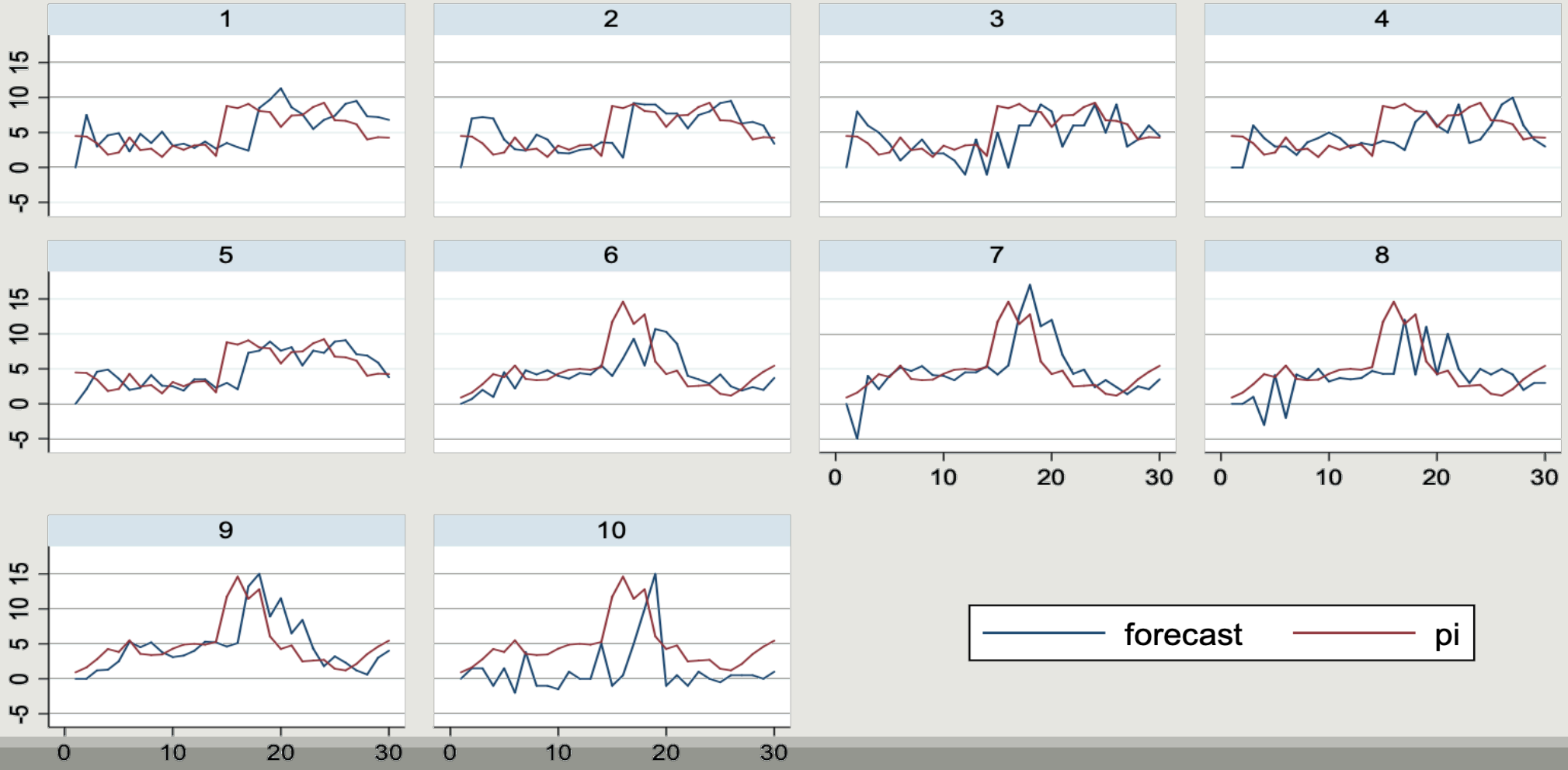
Group results



Group results. 2

Group	UVA	Belarus
1		
2		

Individual results. BSU



Individual results. UVA

Testing aggregate expectations

- Rational expectations hypothesis
- Trend extrapolation rule: $\pi_{j,t+1}^{e} = \beta_0 + \beta_1 \pi_{t-2} + \beta_2 (\pi_{t-2} - \pi_{t-3}) + \mu_t$
- Adaptive expectations: $\pi_t^{e} = \beta_0 + \beta_1 \pi_{t-1}^{e} + \beta_2 fe_{t-2} + \varepsilon_t$
- General linear rule: $\pi_{j,t+1}^{e} = \beta_0 + \beta_1 \pi_{t-1} + \beta_2 y_{t-1} + \beta_3 i_{t-1} + \mu_t$

Testing individual expectations

- Rational expectations hypothesis ✗
- Trend extrapolation rule: $\pi_{j,t+1}^{e} = \beta_0 + \beta_1 \pi_{t-2} + \beta_2 (\pi_{t-2} - \pi_{t-3}) + \mu_t$ +
- Adaptive expectations: $\pi_t^{e} = \beta_0 + \beta_1 \pi_{t-1}^{e} + \beta_2 \pi_{t-2} + \varepsilon_t$ +
- General linear rule: $\pi_{j,t+1}^{e} = \beta_0 + \beta_1 \pi_{t-1} + \beta_2 y_{t-1} + \beta_3 i_{t-1} + \mu_t$ ✗
- **After the shock updating parameter increased in BSU treatment but not at the UVA treatment.**

Hypothesis

Hypothesis 2

Conclusions

1. **Hypothesis 1:**

✓ Adaptive expectations fitted the experimental data better than trend extrapolation and general linear forecasting rule ✚

✓ When divided into 2 subsamples, adaptive expectations fitted the data only after the shock ▬

2. **Hypothesis 2:**

✓ The updating parameter increased after the shock for both Belarus groups but not for the UVA treatment ✚

Weak points

- small sample (10 people in each session);
- confounding effect of possible previous forecasting experiments of UVA participants;
- different cultural backgrounds of the UVA sample (half of the participants were from countries with relatively unstable inflation);
- limited understanding of such concepts as inflation, GDP growth and interest rate
- sample of only master students (=> younger, with lower income and the share of females higher than on average in the population of Belarus and the Netherlands)

Further research

- larger sample from a balanced demographically subject pool
- ask subjects to forecast changes in price level, not inflation
- research the differences inflation perception in high- and low-inflation environment
- research difference in expectation formation between people who have lived in a low-inflation country for a long time but were brought up in high-inflation environment and people who have always lived in a high-inflation country
- research how the choice of forecasting rules depends on the macroeconomic environment

Thank you for attention