

Recent Developments in Experimental Macroeconomics

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The views expressed here are ours, and they do not necessarily reflect the views of the Bank of Canada

Experimental economics

- Application of experimental methods to study economic questions
 - Similar to controlled scientific experiments...
 - ... but people are used as reactants
- Studies human decision-making in a controlled experiment
 - Can be replicated many times, each replication is a “session”
 - Session: 5-10 individuals make decisions in “economic computer game”
- Early experiments focused on individual and group behaviour, how to design contracts, incentive structures and market platforms
 - Thurstone (1931): preferences and “indifference curves”
 - Flood (1958): Prisoner’s Dilemma and cooperative outcomes
 - Smith (1962): experiments of market exchange

Experimental economics

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 - Can be replicated many times, each replication is a “session”
 - Session: 5-10 individuals make decisions in “economic computer game”
- Experimental macroeconomics evaluates modern macro models
 - bank runs, currency attacks, asset bubbles, episodes at the zero lower bound, moral hazard in the banking sector, importance of non-fundamental variables (sunspots), implications of different public policies

Advantages of experimental method

1. Useful for studying factors that cannot be observed or measured
 - Inflation expectations
2. Can “experiment” with policies in a controlled manner
 - Need not fear unintended/unobserved consequences of “bad” policies
 - Can easily link experimental outcomes to experiment parameters (fundamentals versus sunspots)
3. An experiment can be run many times to produce more data
 - Cannot “rerun” an economy to produce multiple versions of macro data
 - So experimental evidence can supplement aggregate data

Challenges for experimental approach

1. Making the experiment look like reality: “external validity”
 - Decisions may be affected by amount and complexity of information
 - Individuals may not exert the same effort as they do in everyday life
2. Sample sizes are small, usually < 10 participants
 - May not be enough to study economy-wide phenomena
 - Group should be large enough to limit the impact of individual effects
 - Challenge in finding representative pool of participants
3. Simplicity forces researchers to interpret results with caution
 - Experiment on switching from inflation- to price-level targeting

Experimental studies of expectations

- Expectations affect the conduct of monetary policy, and vice versa
 - Bank of Canada speeches: Boivin (2011), Carney (2012)
- Experiments find support for non-rational expectations, Duffy (2008)
 - Backward-looking component, Pfajfar-Žakelj (2012)
 - Adaptive learning, Arifovic et al. (2013)
 - Use of heuristic forecasting rules, Hommes (2011)
- Expectations and monetary policy
 - Sluggish expectations increase inflation persistence, Adam (2007)
 - More aggressive monetary policy under IT, Assenza et al. (2012)
 - Policy rule design and expectations, Pfajfar-Žakelj (2012, 2013)

Application of experimental economics

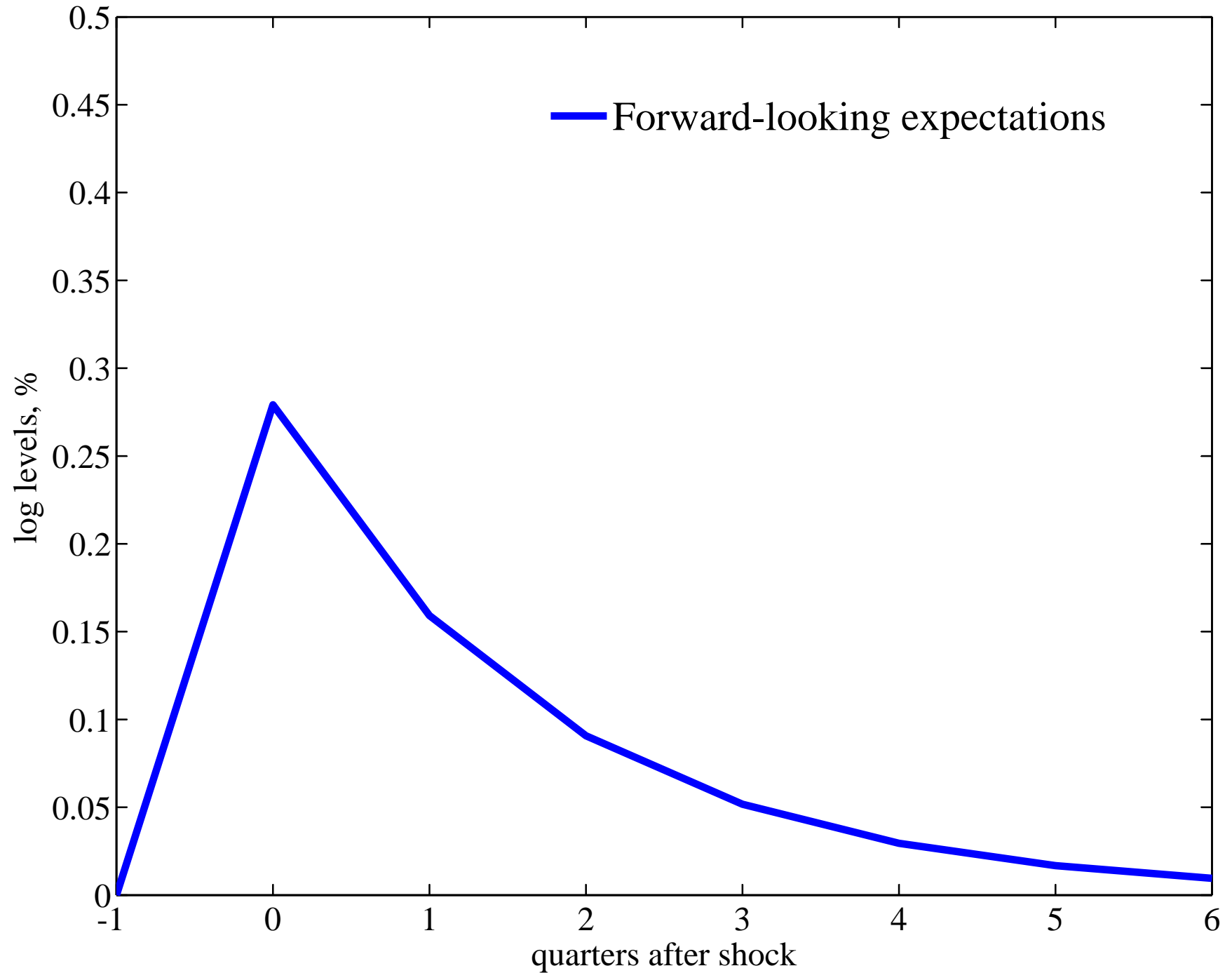
Kryvtsov and Petersen (2015):

- Some evidence on how individuals form expectations
- Implications for monetary policy: measuring expectations channel

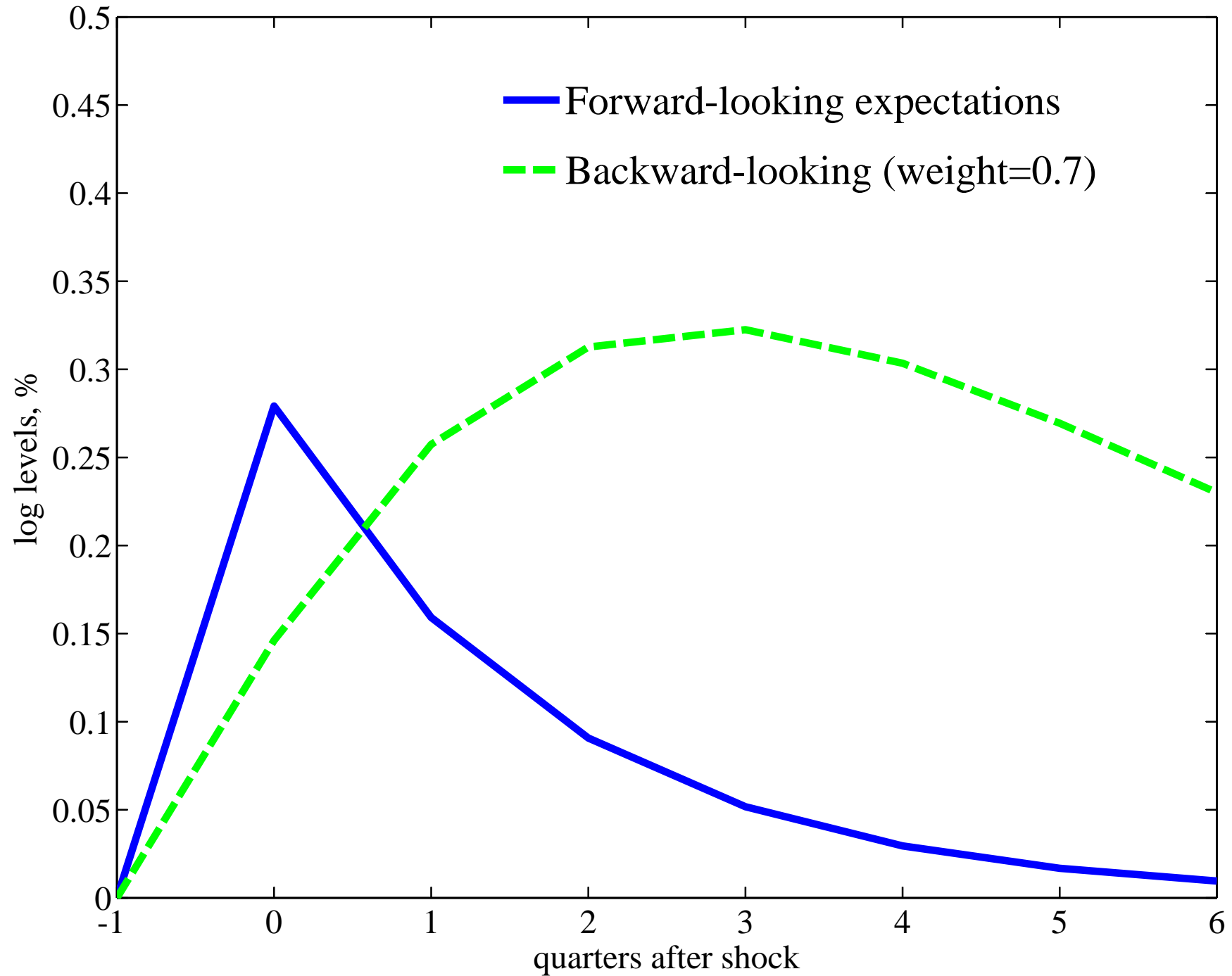
A better understanding of expectations can help answer:

1. What should be the interest rate response under inflation targeting?

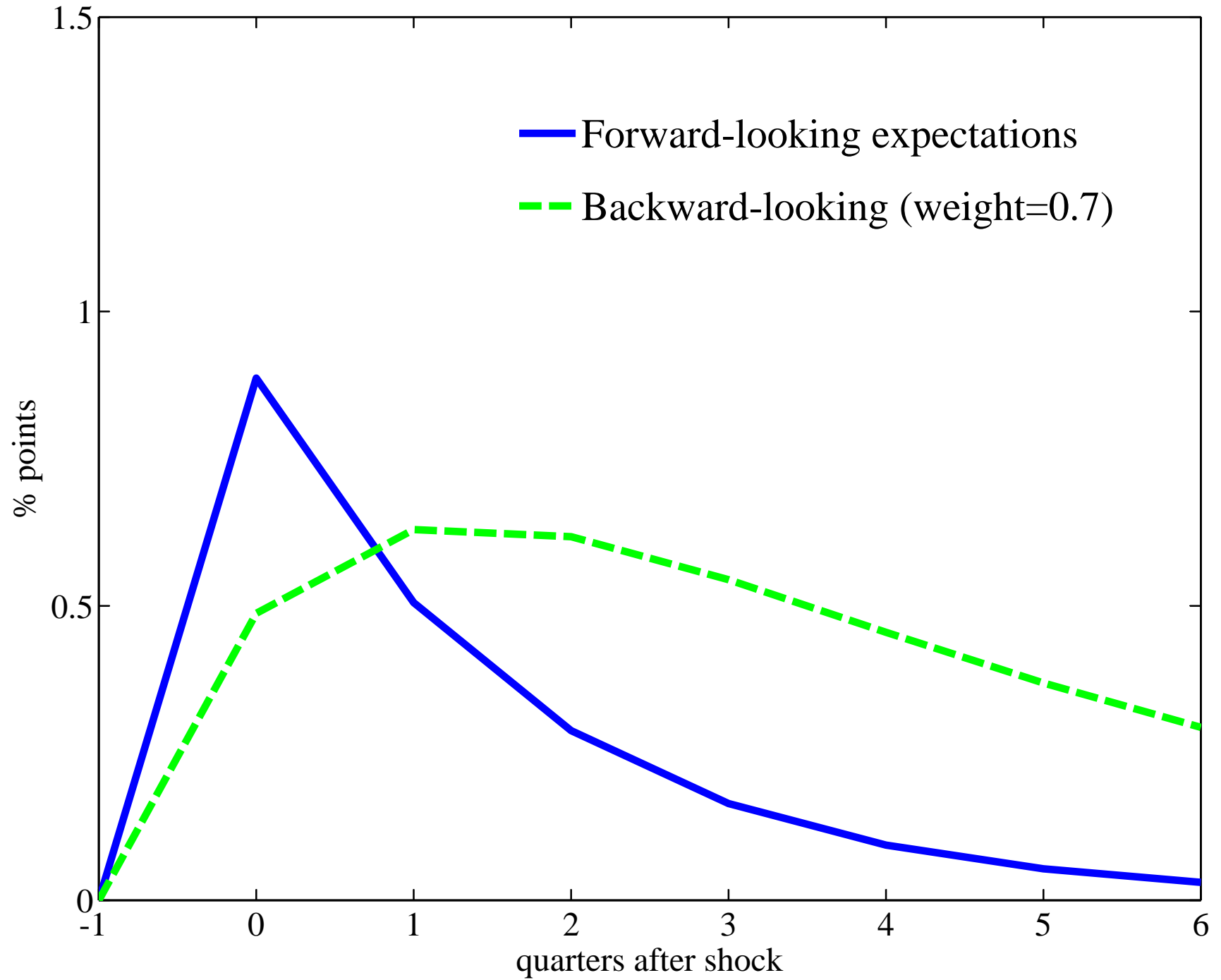
Inflation response to unexpected increase in demand



Inflation response to unexpected increase in demand



Nominal interest rate response



A better understanding of expectations can help answer:

1. What should be the interest rate response under inflation targeting?
 - **Expectations may have substantial influence on the response**
 - Under backward-looking expectations, policy has smaller impact
 - “Expectations channel” is the main mechanism

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2. Is inflation targeting the best monetary policy framework?

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 - “Expectations channel” is the main mechanism
2. Is inflation targeting the best monetary policy framework?
 - Price-level targeting: **expectations may calibrate the benefits of PLT**
Amano-Mendes-Murchison (2011)
Kryvtsov-Shukayev-Ueberfeldt (2012)
 - Nominal GDP targeting? Work in progress.

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Goal today:

- Use **experimental approach** to measure importance of expectations for monetary policy

Experimental design

Consists of

- Laboratory and Participants
- Data-generating model
- Procedures
- Interface
- Robustness of results to changes in experiment

Experimental design

- “Learning-to-forecast” setup :
 - Model for inflation, output gap and monetary policy
 - Expectations are provided by participants in each period
 - “Self-referential” setup: participants’ expectations affect outcomes

Standard New Keynesian Business Cycle Model

System for $\{x_t, \pi_t, i_t\}_{t=0}^{\infty}$:

Aggregate demand : $x_t = E_t^* x_{t+1} - \sigma^{-1} (i_t - E_t^* \pi_{t+1} - r_t^n)$

Aggregate supply : $\pi_t = kx_t + \beta E_t^* \pi_{t+1}$

Monetary policy : $i_t = \varphi_{\pi} E_{t-1}^* \pi_t + \varphi_x E_{t-1}^* x_t$

$x_t = Y_t - Y_t^n$ - output gap

π_t - inflation

i_t - nominal interest rate

r_t^n - exogenous disturbance to natural rate of interest

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Monetary policy :
$$i_t = \varphi_{\pi} E_{t-1}^* \pi_t + \varphi_x E_{t-1}^* x_t$$

$E_t^* \pi_{t+1}, E_t^* x_{t+1}$ - aggregate expected values of π_t, x_t conditional on information available through period t

- Theory: $E_t^* \pi_{t+1}, E_t^* x_{t+1}$ are functions of the state history
- Experiments: subjects provide $E_t^* \pi_{t+1}, E_t^* x_{t+1}$ directly
- Assume individuals have identical information sets and form expectations identically

Experiments

- Each session: 9 participants, 120 minutes total
- Non-technical instructions (30 minutes)
- Game is a sequence of rounds of play, or “periods” (90 minutes)
- One period represents a quarter
- Each period: 1 min to review information and enter forecasts
- Let participants learn the game in periods 1 to 45, then reset
- Participants rewarded for forecast accuracy, can earn \$18 to \$45

Forecast Screen

Subject: Subject-1
Period: 7
Time Remaining: 30
Total Points: 1.16

Current Period

Interest Rate: 500
Shock: 420
Shock Forecast: 336

Forecast

[History](#)

[Instructions](#)

Next Period

Please input your forecasts.

Inflation:

Output:

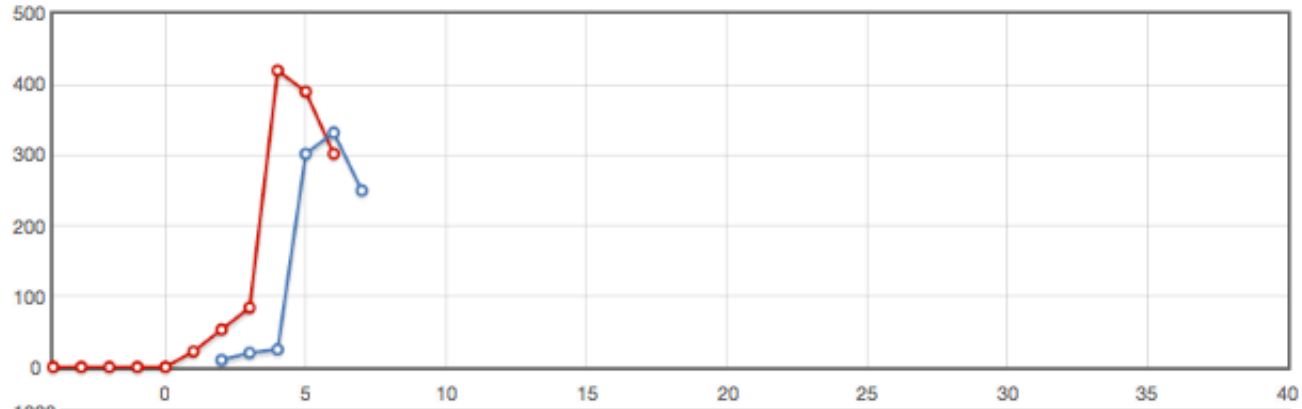
History Screen

Subject: Subject-1
Period: 7
Time Remaining: 15
Total Points: 1.16

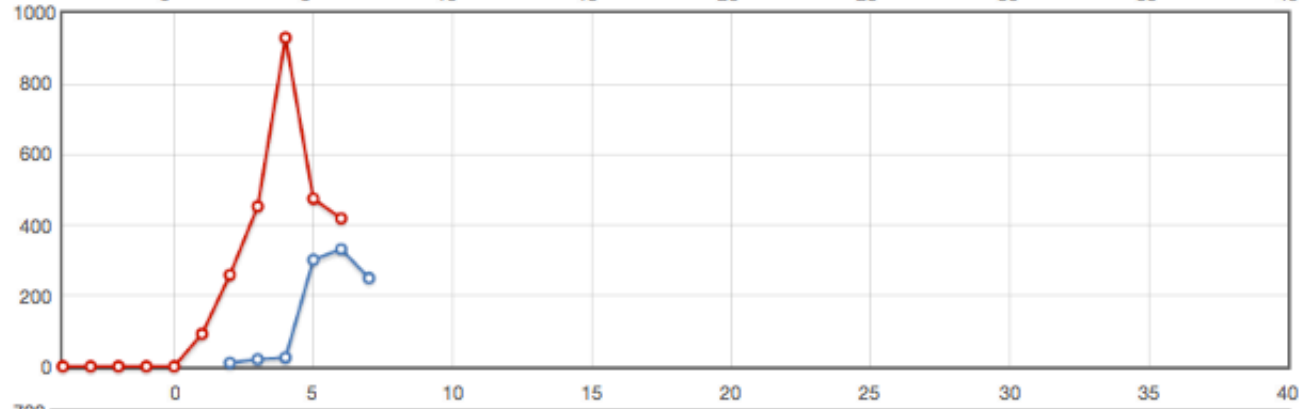
Forecast

History

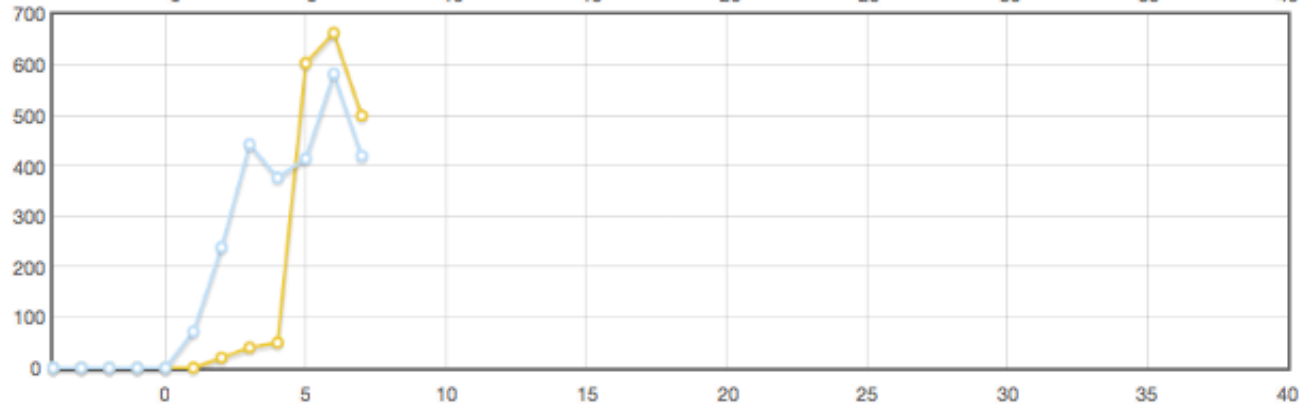
Instructions



Inflation
Inflation Forecast



Output
Output Forecast

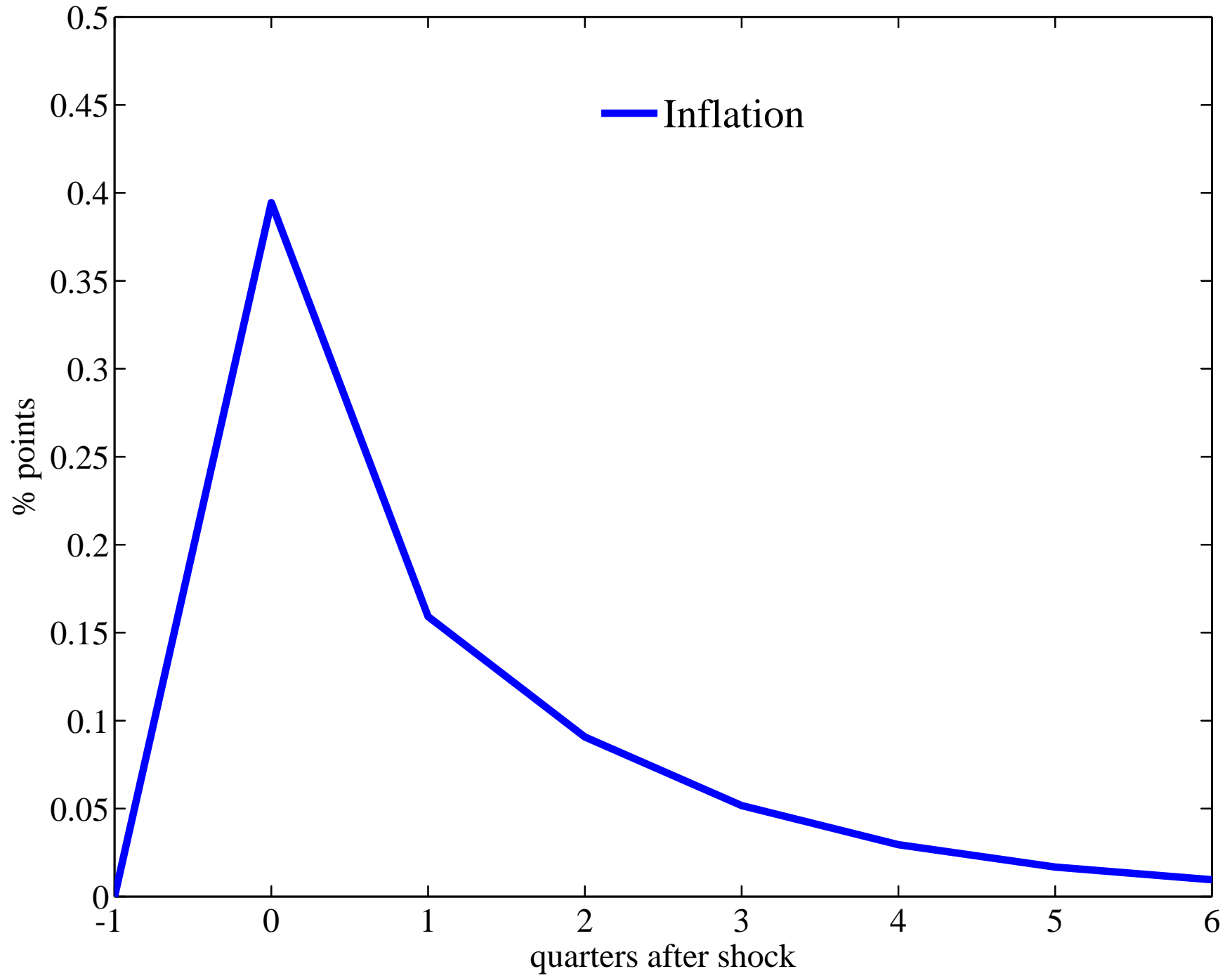


Interest Rate
Shock

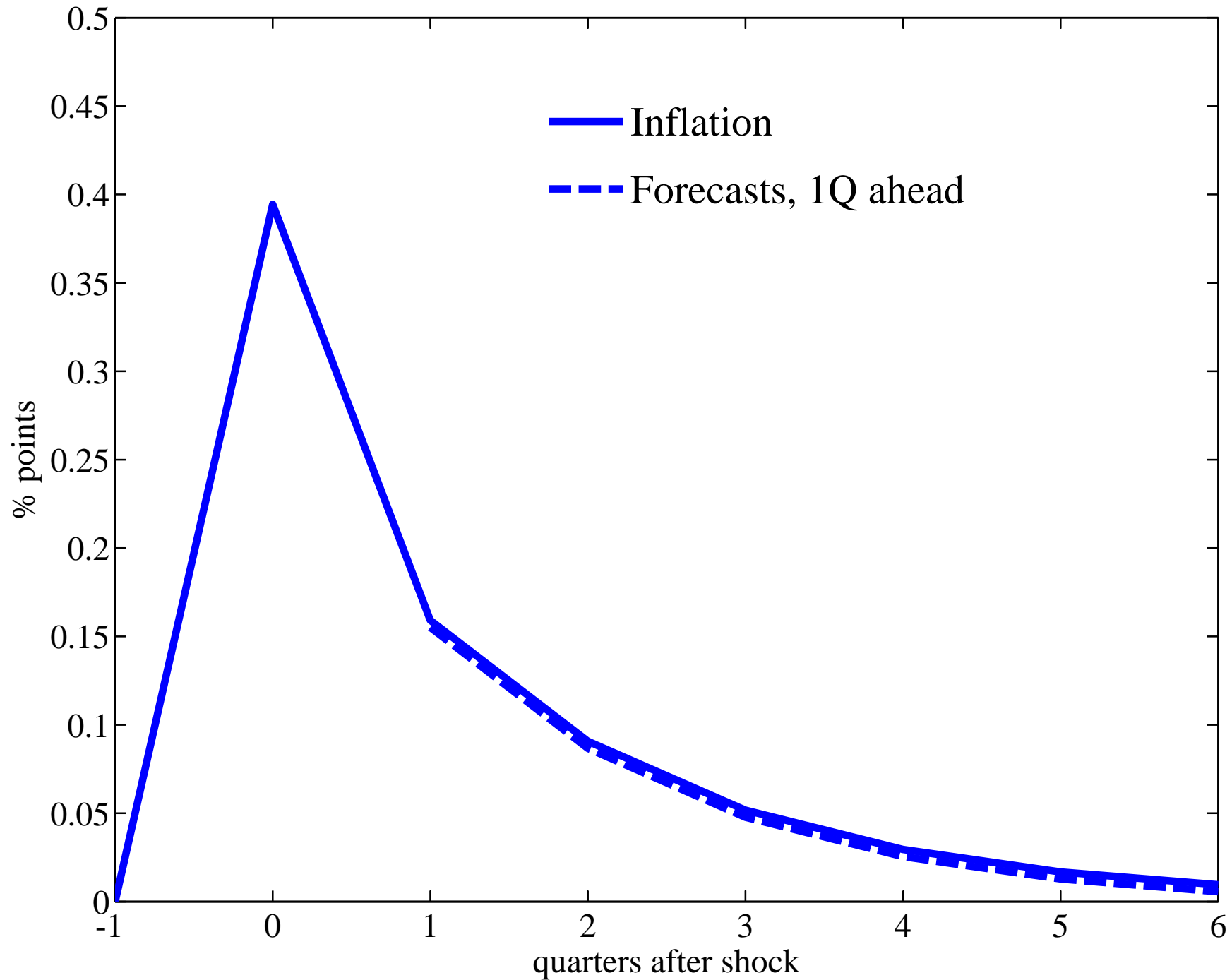
How individuals form expectations?

- How well participants forecast inflation?
 - Forward- vs Backward-looking expectations (model illustration)
 - Experiment allows to pin down the size of backward-looking component

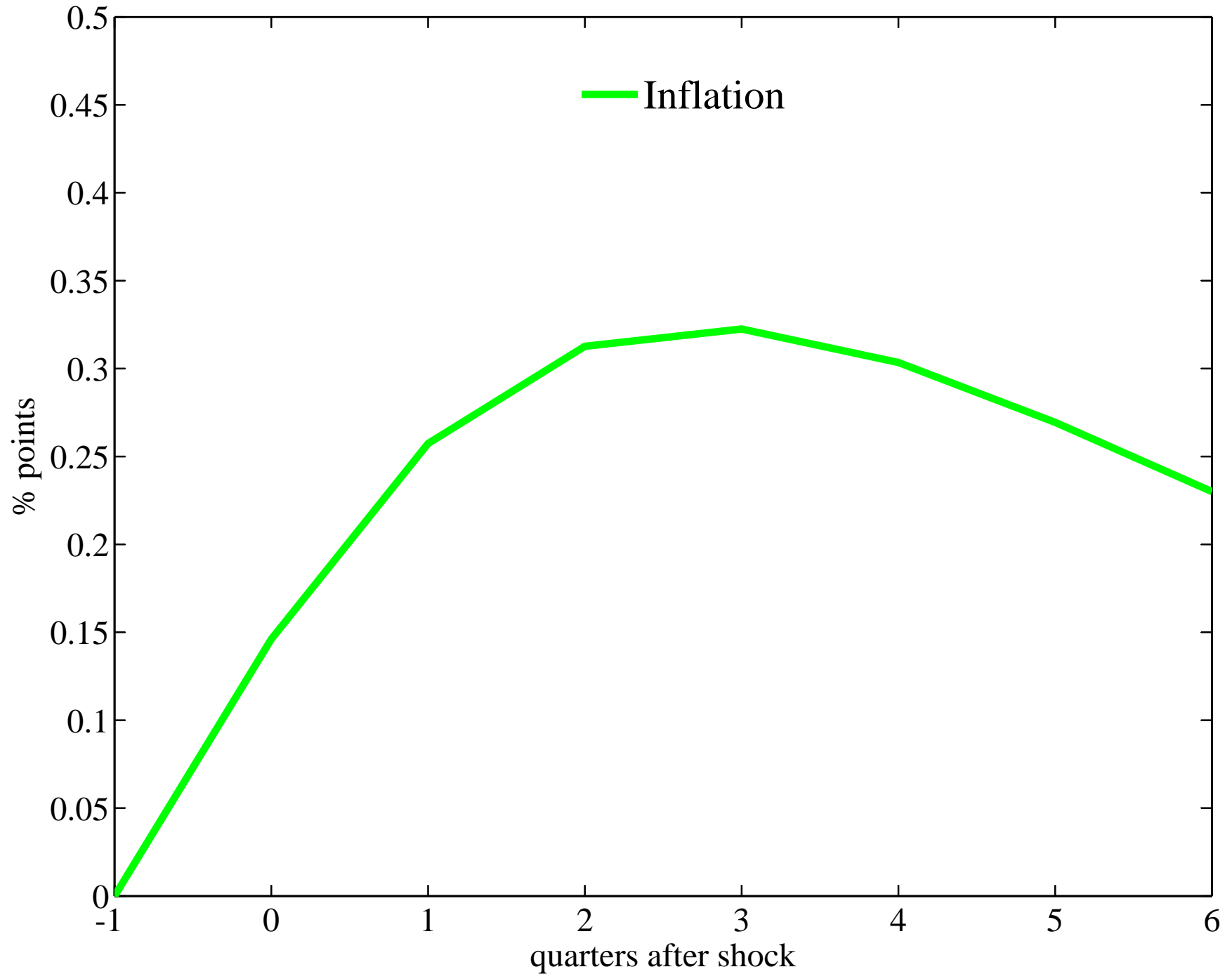
Model forecasts, Forward-looking expectations



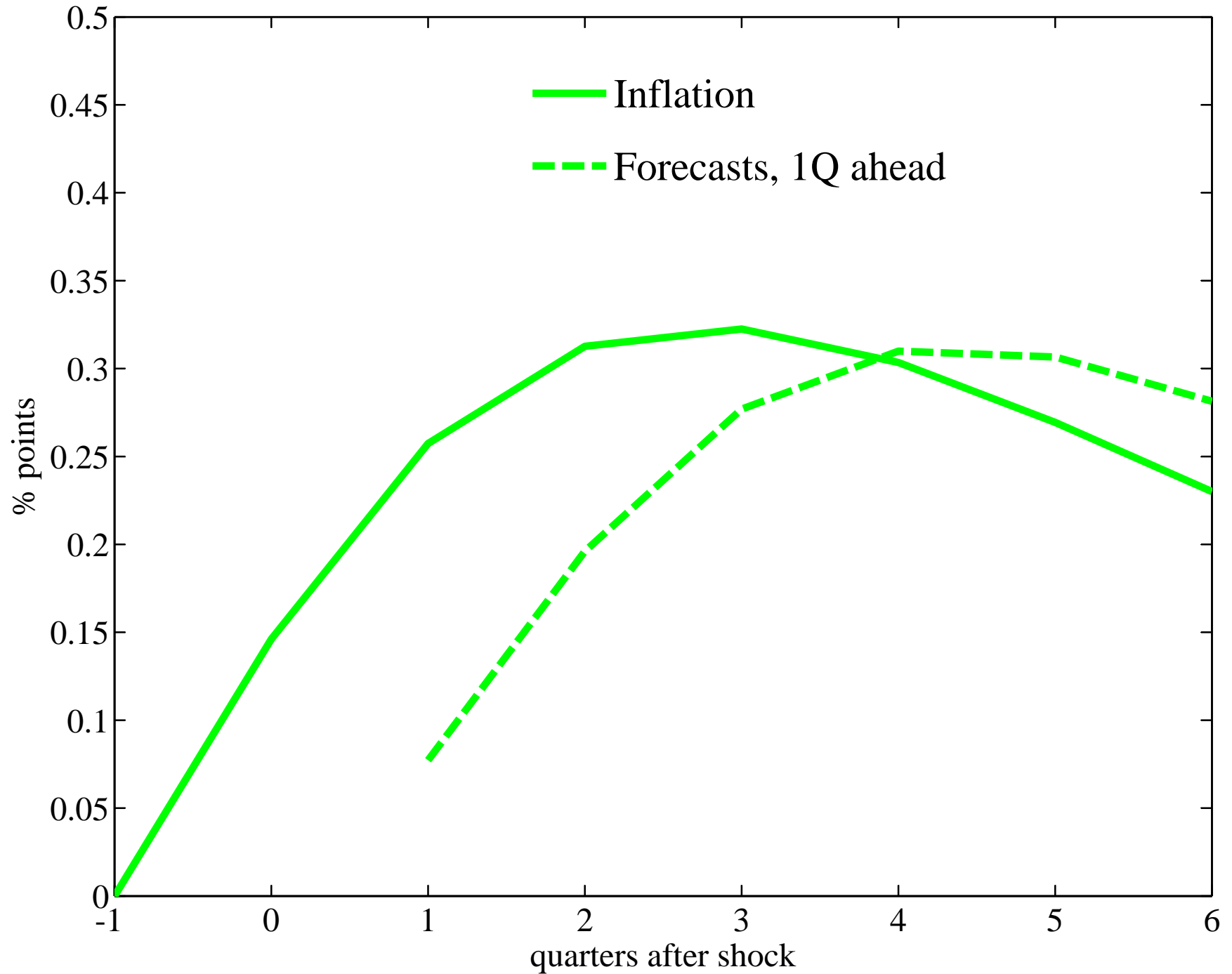
Model forecasts, Forward-looking expectations



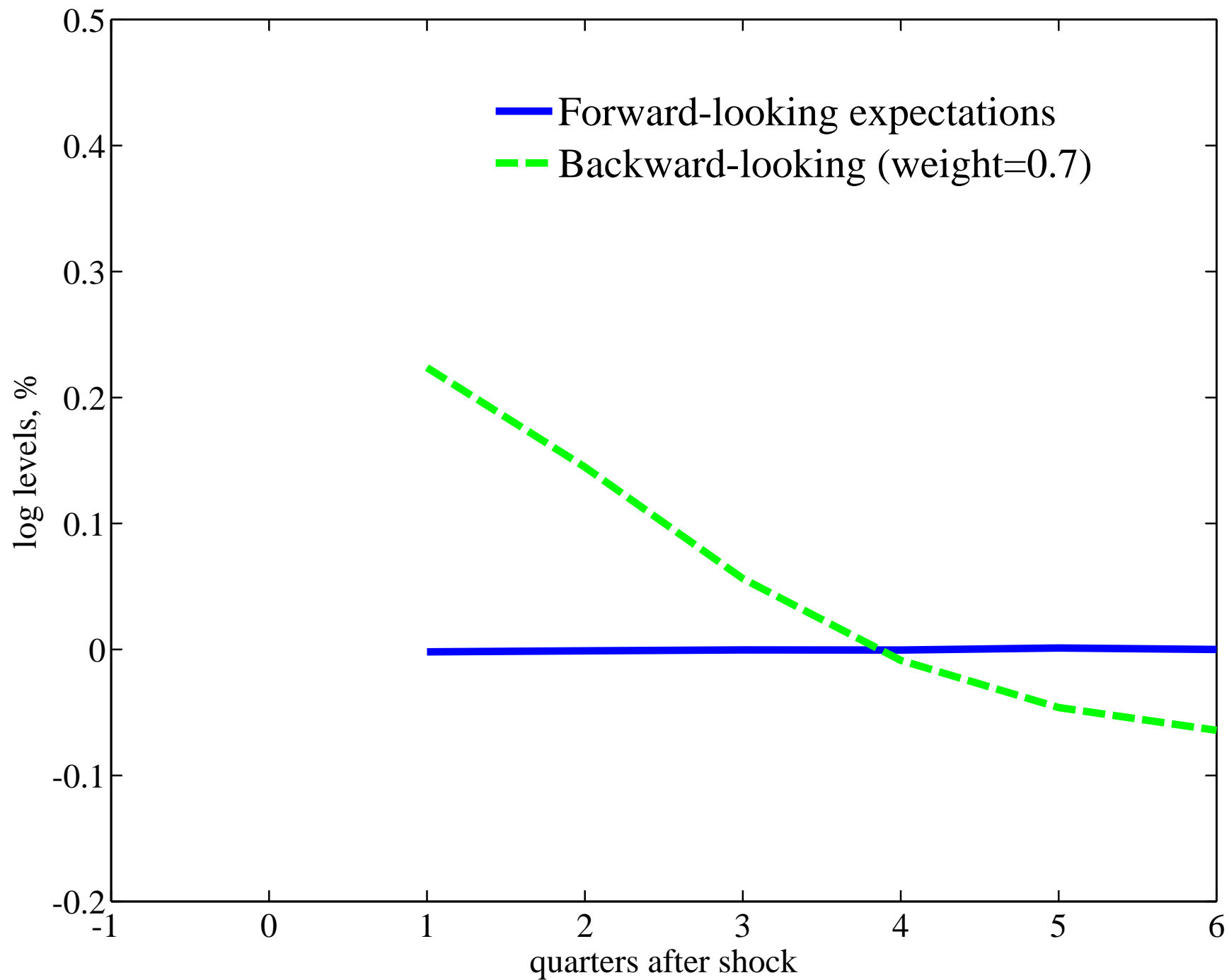
Model forecasts, Backward-looking expectations



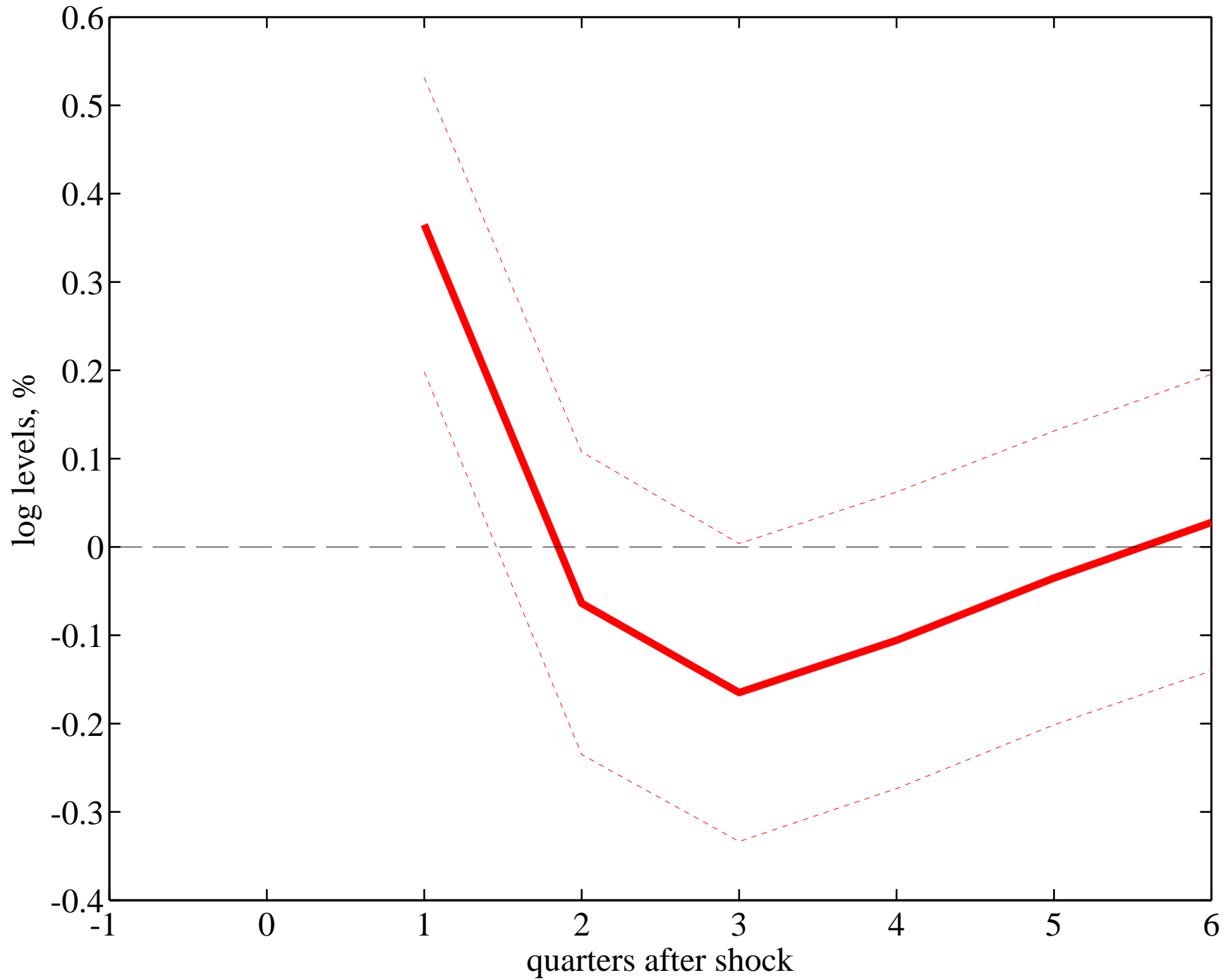
Model forecasts, Backward-looking expectations



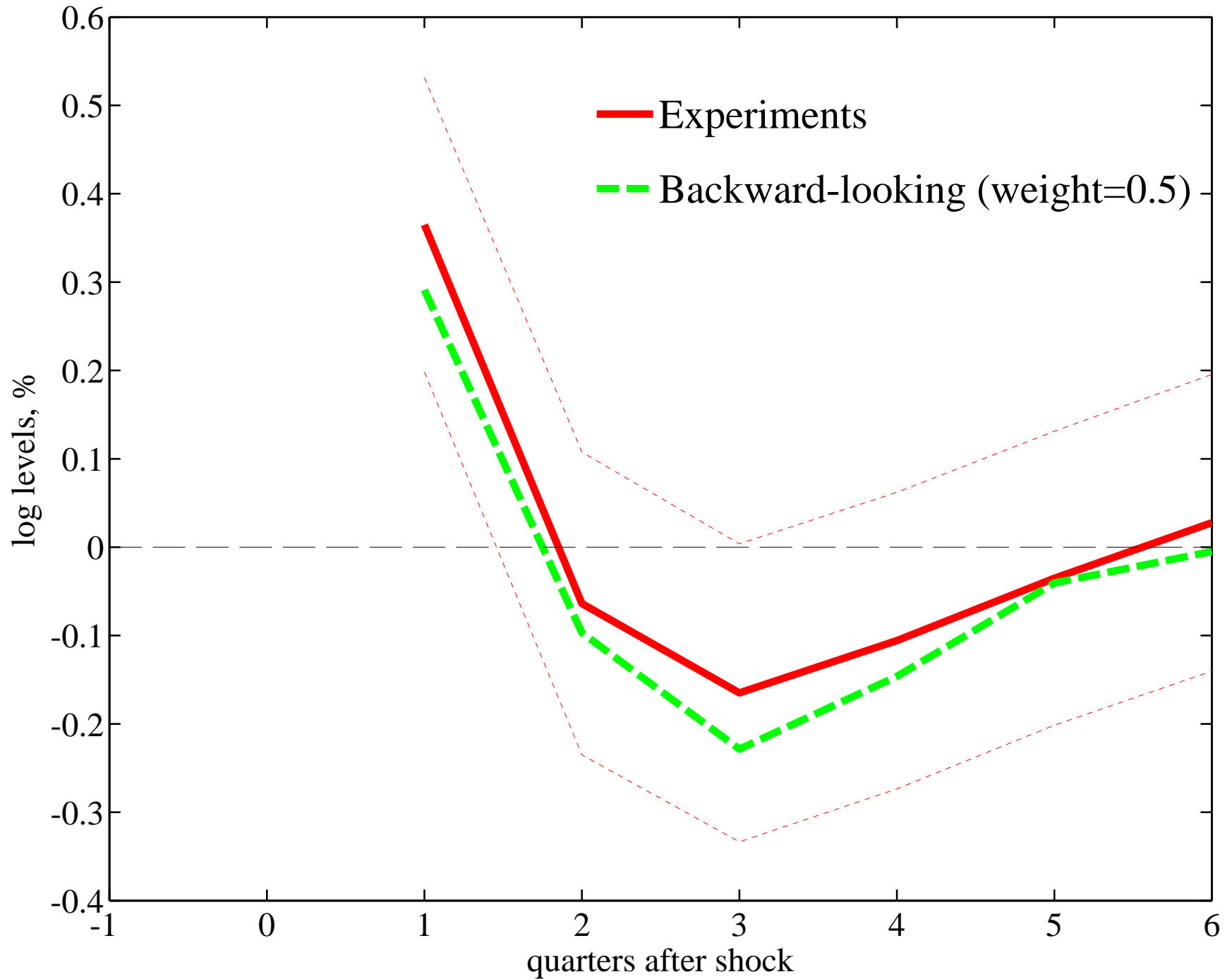
Inflation forecast errors, Model



Inflation forecast errors, Experiment



Inflation forecast errors, Experiment



How individuals form expectations?

- How well participants forecast inflation?
 - Forward- vs Backward-looking expectations (model illustration)
 - Experiment allows to pin down the size of backward-looking component
- Backward-looking component of inflation expectations:
 - Experiment: 0.5

Measuring expectations

- How well participants forecast inflation?
 - Forward- vs Backward-looking expectations (model illustration)
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 - ToTEM (DSGE model at the Bank of Canada): 0.1

Measuring expectations

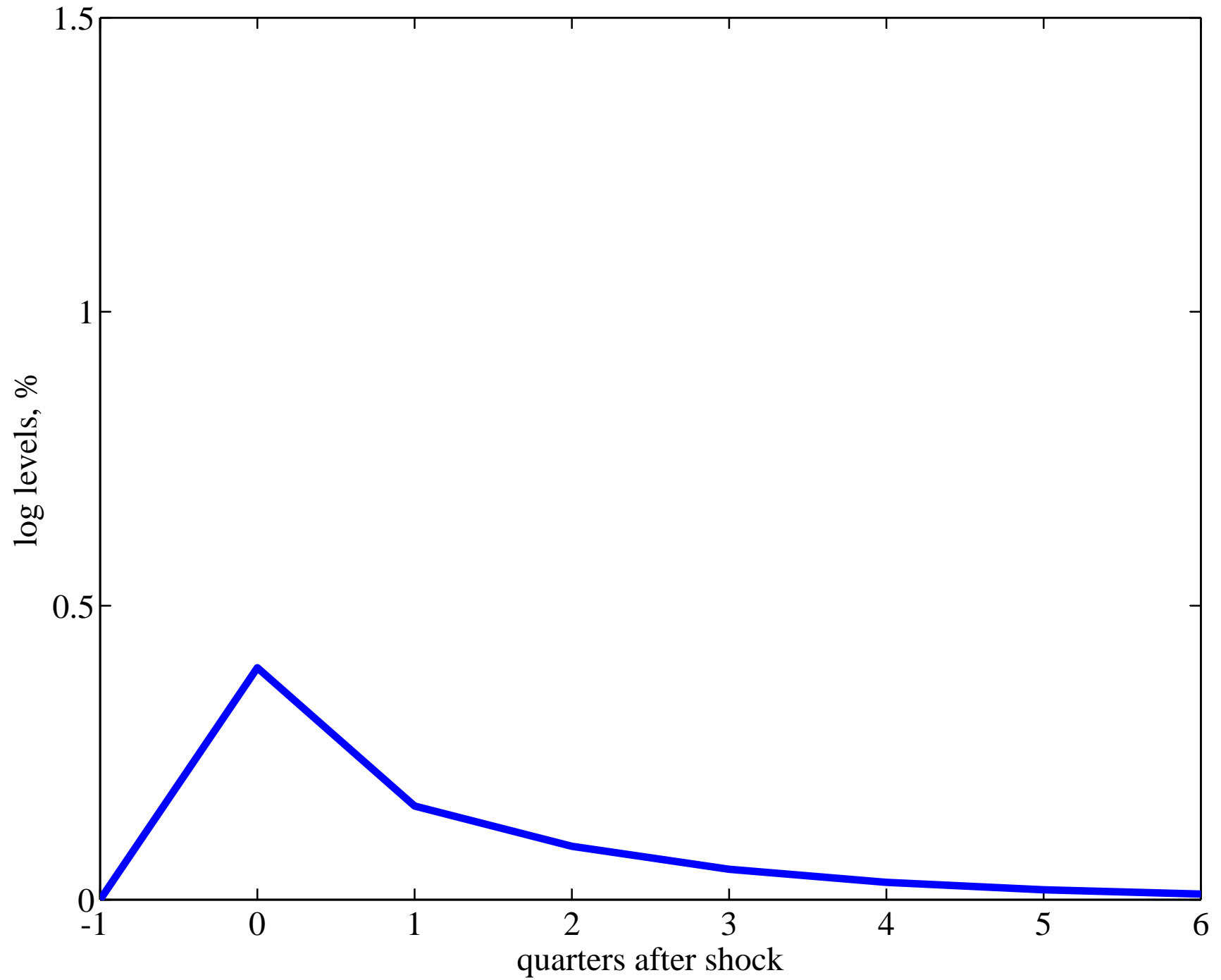
- How well participants forecast inflation?
 - Forward- vs Backward-looking expectations (model illustration)
 - Experiment allows to pin down the size of backward-looking component
- Backward-looking component of inflation expectations:
 - Experiment: 0.5
 - ToTEM (DSGE model at the Bank of Canada): 0.1
- To the extent the experiments capture reality, the backward-looking component in expectations may be more important
- Monetary policy may have smaller influence on expectations

Implications for monetary policy

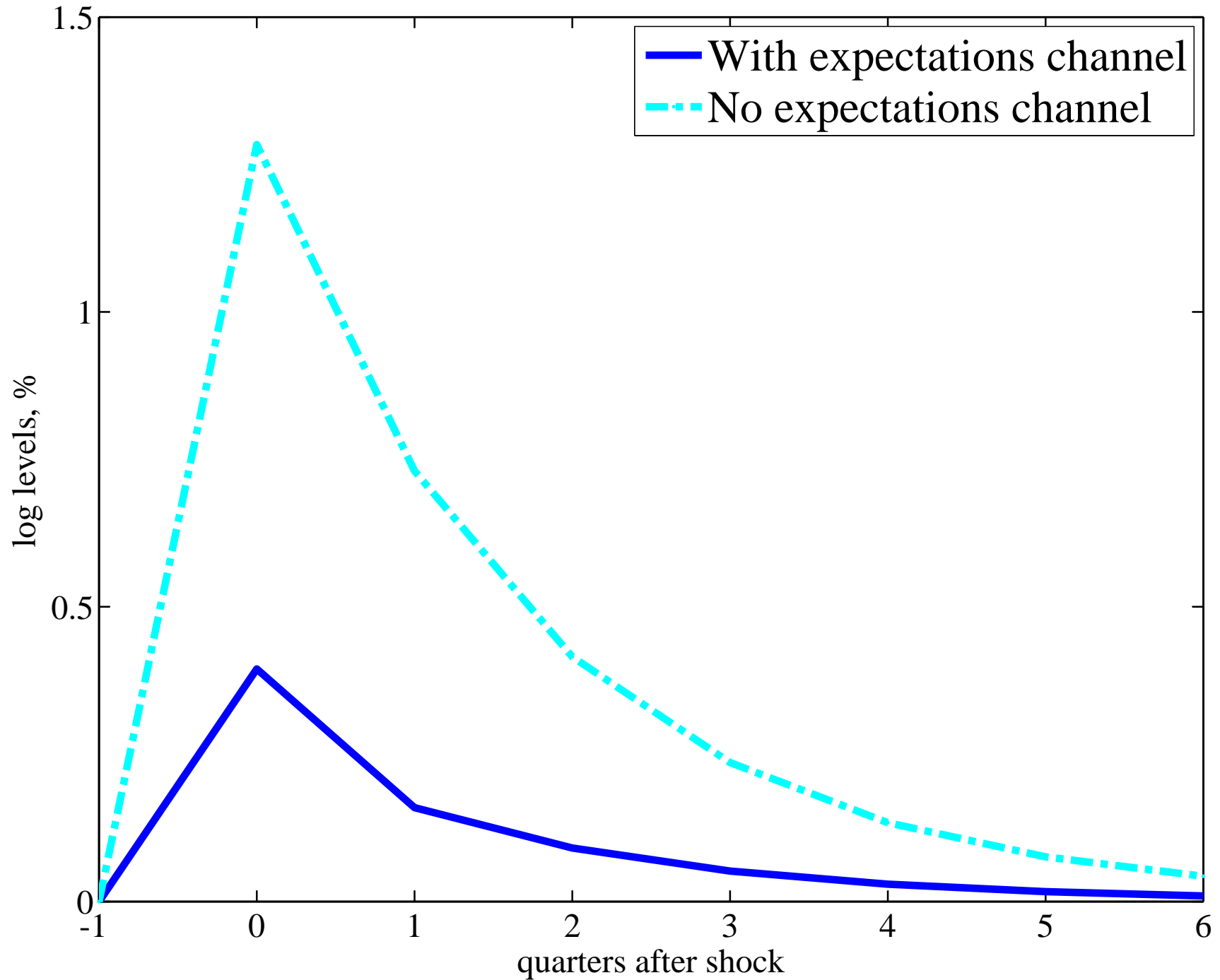
Measure degree to which expectations help monetary policy stabilize **equilibrium responses** of inflation and output gap to shock

- Construct **counterfactual responses** that occur in the absence of future responses of nominal interest rates
- Document how much counterfactual responses are reduced in equilibrium with countercyclical nominal interest rate responses
- Compare expectations channel in the model and in the experiments

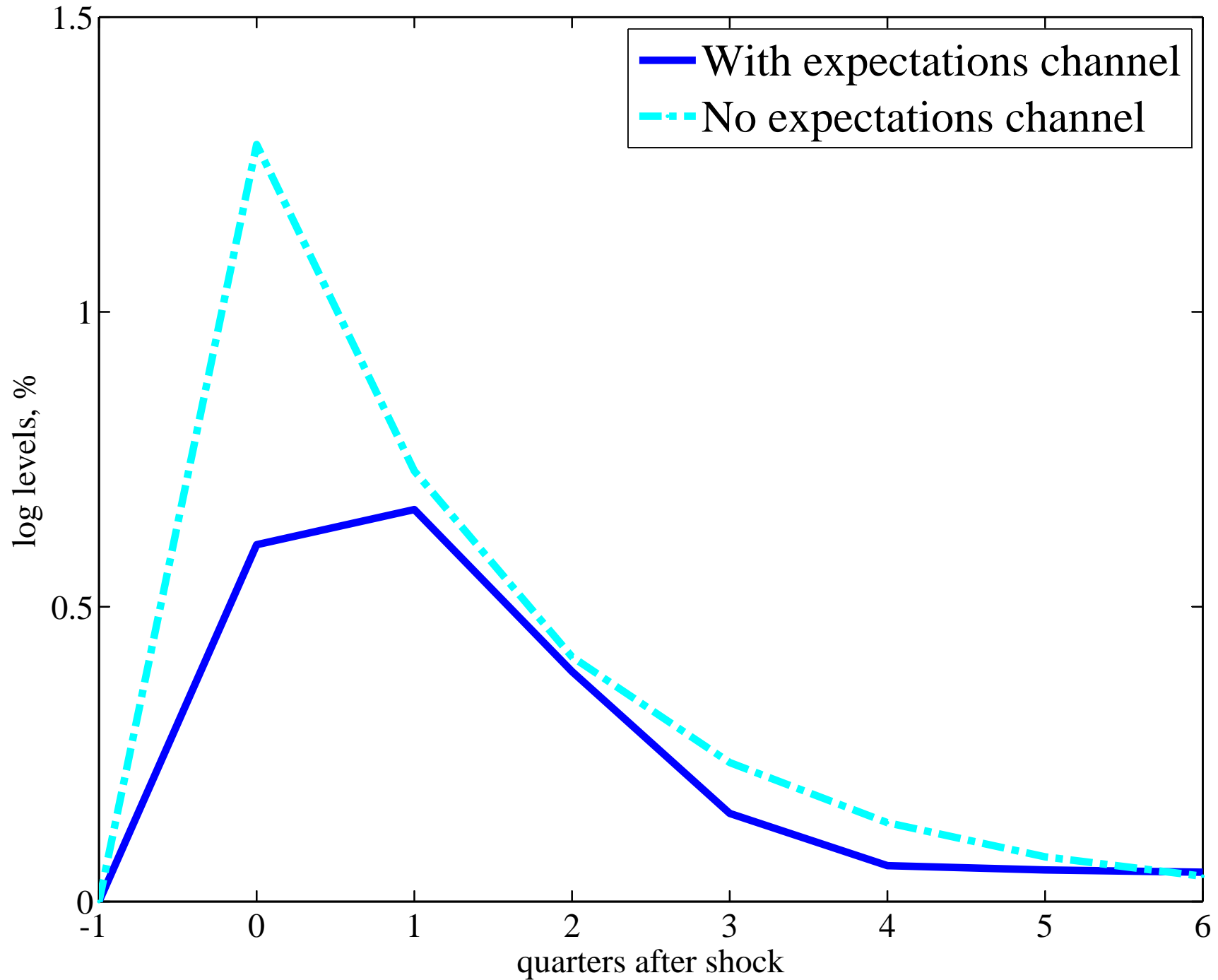
Stabilization of inflation via expectations, Rational Expectations



Stabilization of inflation via expectations, Rational Expectations



Stabilization of inflation via expectations, Adaptive(1) Expectations



How strong is the expectations channel?

Benchmark Treatment		Fraction of conditional variance decreased via expectations channel	
		π_t	x_t
<u>Model</u>			
	Rational	0.73	0.65
	Adaptive(1)	0.20	0.32
<u>Experiment</u>			
	median	0.51	0.45
	min	0.25	0.03
	max	0.56	0.56

- Expectations channel helps reduce around **half** of the variance

Alternative treatments

- Two alternative experimental treatments:
 - more-persistent shocks (increase ser.corr. from 0.57 to 0.8)
 - more-aggressive monetary policy (double Taylor rule coeffs)
- Monetary policy provides more stabilization in both treatments:
 - Reducing $\pi_t(x_t)$ variance by 0.95 (0.96) in high-persistence treatment
 - Reducing $\pi_t(x_t)$ variance by 0.72 (0.56) in aggressive-policy treatment
- (Auxilliary) Communication treatment:
 - Subjects observed on their main screens a forecast of future interest for the following nine periods
 - Find that publishing central bank's interest rate forecast impedes stabilization by monetary policy

Conclusions

- Individuals form their expectations...
 - relying mostly on recent data and a qualitative understanding of the workings of the economy
 - paying attention to the behaviour of the nominal interest rate
- Monetary policy provides a substantial degree of macroeconomic stabilization via its effect on expectations
 - Reducing around **half** of the variance of inflation and output gap
- Our work suggests important role of communication as a tool that central banks use to manage expectations

Дякую!

Thank you!

Table 1: Model Predictions under Rational Expectations

		Fraction of conditional variance decreased via expectations channel		std(π_t)	ser.cor.(π_t)	$\frac{\text{std}(x_t)}{\text{std}(\pi_t)}$
		π_t	x_t			
Baseline		0.73	0.65	0.44	0.40	4.4
1	High-persistence	0.97	0.98	1.16	0.71	2.4
2	Steep NKPC	0.89	0.86	0.80	0.39	2.4
3	Lower risk aversion	0.81	0.88	0.66	0.35	5.1
4	Aggressive policy	0.82	0.75	0.31	0.35	5.1
5	No policy lag	0.76	0.73	0.34	0.57	3.4
6	Interest rate smoothing	0.87	0.75	0.27	0.19	6.3

Table 2: Model Predictions under Alternative Expectations

		Fraction of conditional variance decreased via expectations channel		std(π_t)	ser.cor.(π_t)	$\frac{\text{std}(x_t)}{\text{std}(\pi_t)}$
		π_t	x_t			
Baseline		0.73	0.65	0.44	0.40	4.4
1	Sensitive	0.55	0.54	0.70	0.40	3.7
2	Static	0.89	0.74	0.18	0.57	7.7
3	Adaptive(0)	0.55	0.51	0.81	0.14	3.5
4	Adaptive(1)	0.20	0.32	1.00	0.74	2.6
5	Adaptive(2)	-0.14	0.35	0.96	0.87	2.4

Table 3: Experimental evidence, summary statistics

Treatment	Fraction of conditional variance decreased via expectations channel		std(π_t)	ser.cor.(π_t)	std(x_t)/std(π_t)
	π_t	x_t			
<u>Benchmark</u>					
Model (Rational)	0.73	0.65	0.44	0.40	4.4
Model (Adaptive 1)	0.20	0.32	1.00	0.74	2.6
Experiments					
median	0.51	0.45	0.79	0.56	3.8
min	0.25	0.03	0.54	0.49	3.0
max	0.56	0.56	0.92	0.69	4.1
<u>High-persistence</u>					
Model (Rational)	0.97	0.98	1.16	0.71	2.4
Model (Adaptive 1)	0.95	0.98	2.07	0.87	1.6
Experiments					
median	0.95	0.96	3.96	0.81	2.5
min	0.86	0.92	1.80	0.76	2.1
max	0.97	0.98	11.18	0.87	2.6
<u>Aggressive policy</u>					
Model (Rational)	0.82	0.75	0.31	0.35	5.1
Model (Adaptive 1)	0.68	0.51	0.46	0.56	4.1
Experiments					
median	0.72	0.56	0.48	0.28	5.5
min	0.71	0.48	0.40	0.11	4.7
max	0.79	0.59	0.56	0.44	6.0

Note: Statistics for each treatment in the experiments are computed for five sessions of repetition 2.

Table 4: Time-series comparisons, Experiment vs. Model

Statistic	Rational	Sensitive	Static	Adaptive(1)	Adaptive(2)
$\text{std}(X_t^{\text{Model}})/\text{std}(X_t^{\text{Experiment}})$					
$E_t^*(\pi_{t+1})$	0.36	0.72	0.15	1.24	1.03
$E_t^*(x_{t+1})$	0.38	0.76	0.23	0.70	0.72
π_t	0.58	0.93	0.27	1.24	0.87
x_t	0.74	1.01	0.53	0.91	0.81
i_t	0.43	0.86	0.23	1.07	0.88
$\text{corr}(X_t^{\text{Model}}, X_t^{\text{Experiment}})$					
$E_t^*(\pi_{t+1})$	0.55	0.55	-0.46	0.76	0.48
$E_t^*(x_{t+1})$	0.56	0.56	-0.52	0.78	0.52
π_t	0.71	0.69	0.83	0.86	0.63
x_t	0.68	0.66	0.83	0.89	0.75
i_t	0.61	0.61	-0.51	0.83	0.59

Notes: Time series for the experiment correspond to benchmark treatment (repetition 2). Time series for the model correspond to equilibrium outcomes given the same shock history. The entries are medians across five sessions.

Table 5: Individual usage of history screen

Treatment	Clicks per period			Fraction of time per period		
	Median forecaster	Top forecaster	Bottom forecaster	Median forecaster	Top forecaster	Bottom forecaster
Benchmark	2.4	1.9	1.0	0.45	0.45	0.34
High-persistence	2.2	1.9	2.2	0.46	0.56	0.33
Aggressive policy	2.0	1.9	1.4	0.41	0.35	0.25
Communication	1.7	2.4	1.3	0.40	0.46	0.26

Note: Entries are means across periods for sessions in the benchmark treatment (repetition 2).

Figure 1: Inflation responses to 113 bps r_t^n impulse

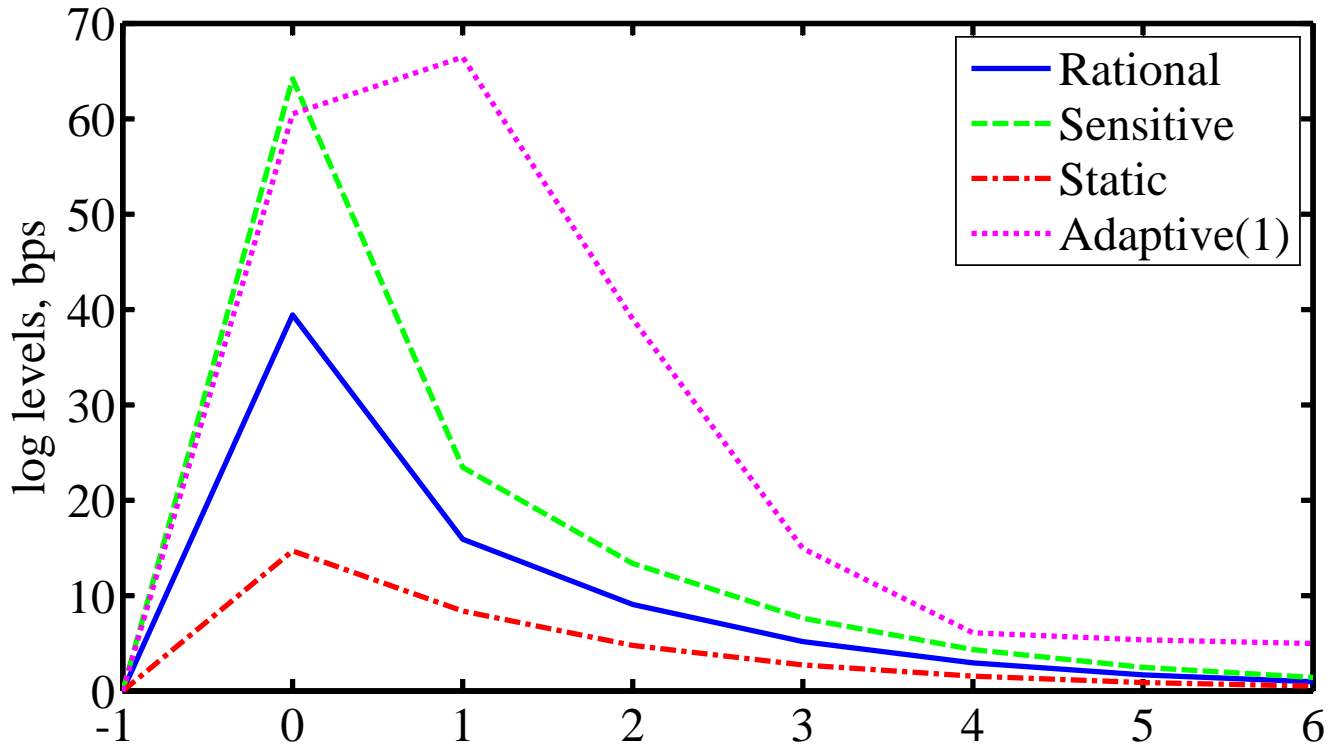


Figure 2: Stabilization of inflation via expectations

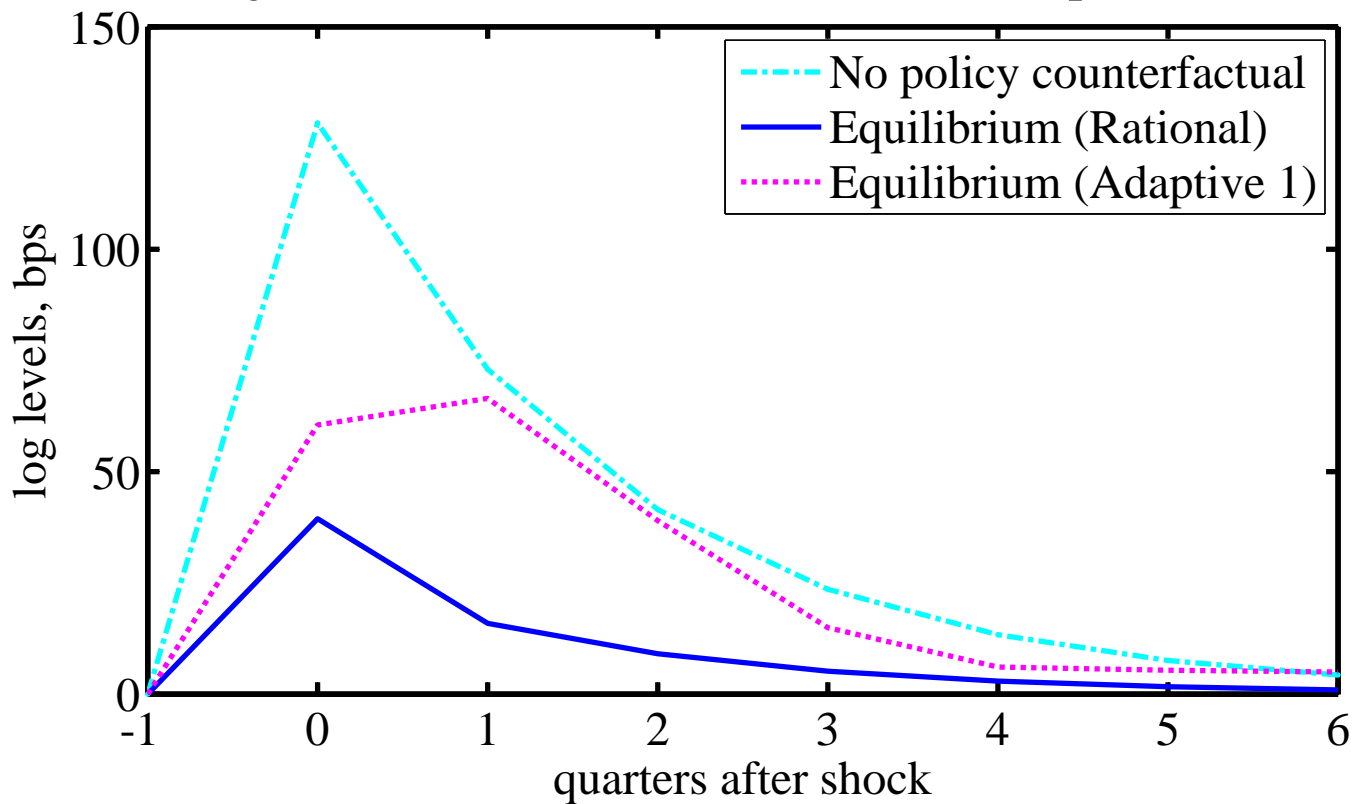
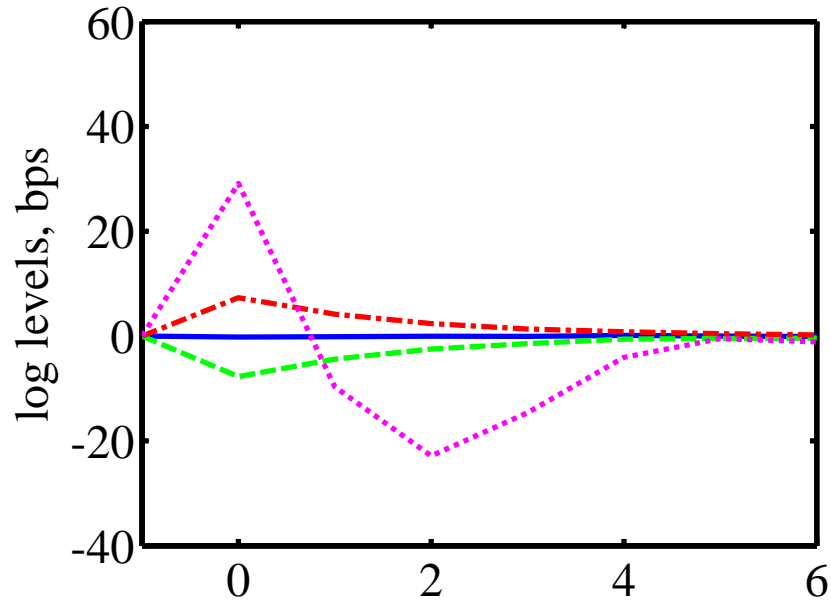
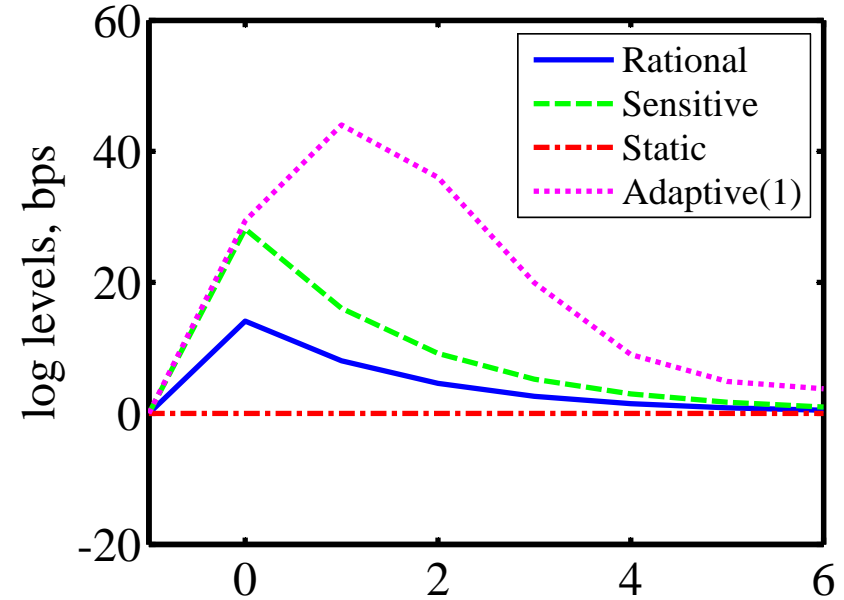


Figure 3: Responses of inflation forecasts and errors, Model vs. Experiment

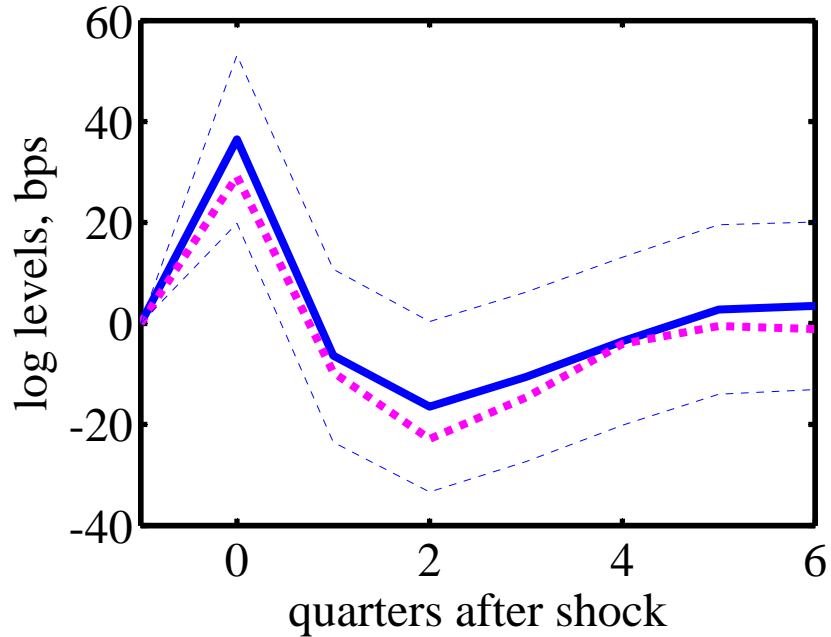
A. Ex ante forecast errors, Model



B. Forecasts, Model



C. Ex ante forecast errors, Experiment



D. Forecasts, Experiment

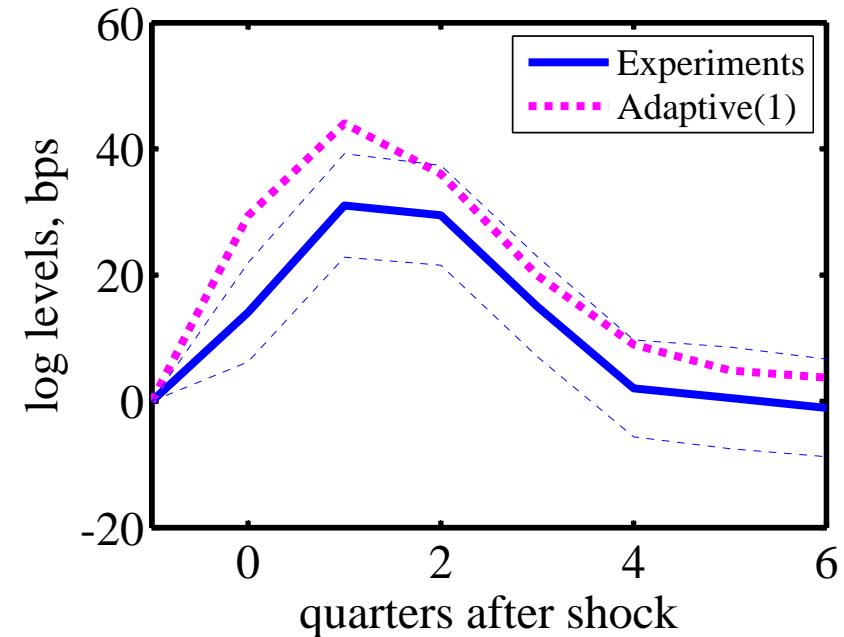


Figure 4: Inflation forecasts in experiment

