How do Inflation Expectations form?
Evidence from a High-Frequency Survey

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Motivation for our Survey

- Correctly measuring and understanding inflation expectations crucial given their impact on the actual inflation process (Bernanke, 2007).

  – However, given their subjective nature, inflation expectations are hard to obtain.

- Survey allows *direct measurement* based on *actual economic development.*

  – Potential disadvantages: Lack of motivation, sensitivity to phrasing, law of motion unknown.

- Survey on inflation expectations especially interesting during crisis.

  – Important research question: have long-term inflations remained anchored?

- Existing surveys tend to have *low frequency* and *non-salient rewards*, so improvement possible.

  – Our survey also has three well-defined *participant subgroups*, allowing us to study *cross-group expectations heterogeneity*.

Related Literature

- In recent years, a series of papers has departed from the *Rational Expectation Hypothesis (REH)* and the assumption of a known and constant central bank policy objective.

Three strands of literature:

- *Learning:* Assumes agents do not have full information about the economy or central bank objectives. Instead, they make statistical inferences about unknown economic parameters (e.g. Orphanides and Williams, 2005).

- *Behavioral:* Assumes agents use rules-of-thumb ("heuristics") to make inflation forecasts (e.g. Brazier et al. 2008).

- *Game-Theoretical:* Monetary policy as an information game in which agents form expectations based on all (public and private) available information, which will be noisy (Demertzis and Viegi, 2008).

Survey Characteristics

- Weekly frequency, duration 1 year (June 2009 – June 2010).

- Three participant subgroups of roughly equal size: Students, Academics, DNB staff.
  - 42 students, 37 academics and 50 DNB staff (129 total).
  - All students and academics were Netherlands-based, most from Amsterdam.

- Three questions: short-term, medium-term and long-term inflation expectations.
  - *"What inflation in consumer prices of the Euro Area do you expect over the whole calendar year T?"*
  - T = 2010 (short term), 2011 (medium term) and 2019 (long term).

- Survey done by email, participants provided with *relevant economic information*.

- Questions rewarded separately: 1st question's reward *accuracy-based*, 2nd and 3rd questions' rewards *participation-based* ("show-up fee").
  - 1st question's reward will be calculated by a Linear Scoring Rule.
  - Payout of full rewards beginning 2011 (waiting until 2012, 2020 impractical).

Participants' Information

- Inflation expectations for horizon *h* of participant *i* at week *t*:

$$\pi_{h,i}^e(t) = f_{h,i}(\Pi_i^e(t), \Pi_c^e(t), \Pi(t), I(t), \ldots), \text{ with}$$

$\Pi_i^e(t)$ = Set of previous predictions of participant *i* (h = 2010, 2011, 2019),

$\Pi_c^e(t)$ = Set of available Consensus forecasts at week *t* (h = 2010, 2011, 5-10 ahead),

$\Pi(t)$ = Set of previous inflation data at week *t*,

$I(t)$ = Set of macro-economic indicators available at week *t*.

- – Assumes consistent use of predictions rules (to be checked).
- – Consensus forecasts only available to DNB staff.
- – Of course, information gathering not restricted (*common minimal knowledge*).
- – Most participants did not submit expectations in all weeks, so analysis considers *aggregate expectations functions* (means or medians).

- In addition, some macro-economic analysis was available through the Euro Area inflation section of JP Morgan's *Global Data Watch*.

Survey Means and Medians
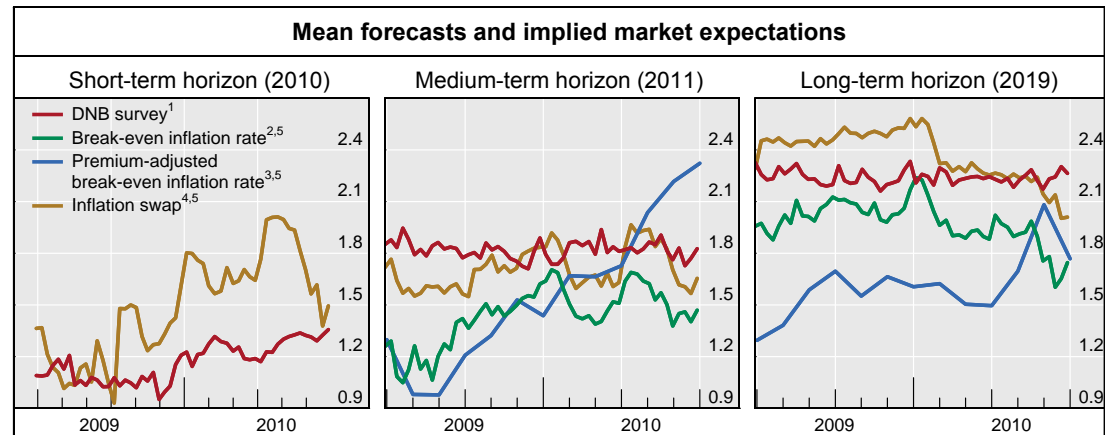
- Increase from 2010 to 2011 to 2019 horizon indicates participants expected crisis to end (though only on long term).

- Positive trend at 2010 horizon, but not at 2011 / 2019 horizons (consistent with anchoring).

- Survey means, medians close to SPF / Consensus at 2010 horizon, but above them at 2011 / 2019 horizon.

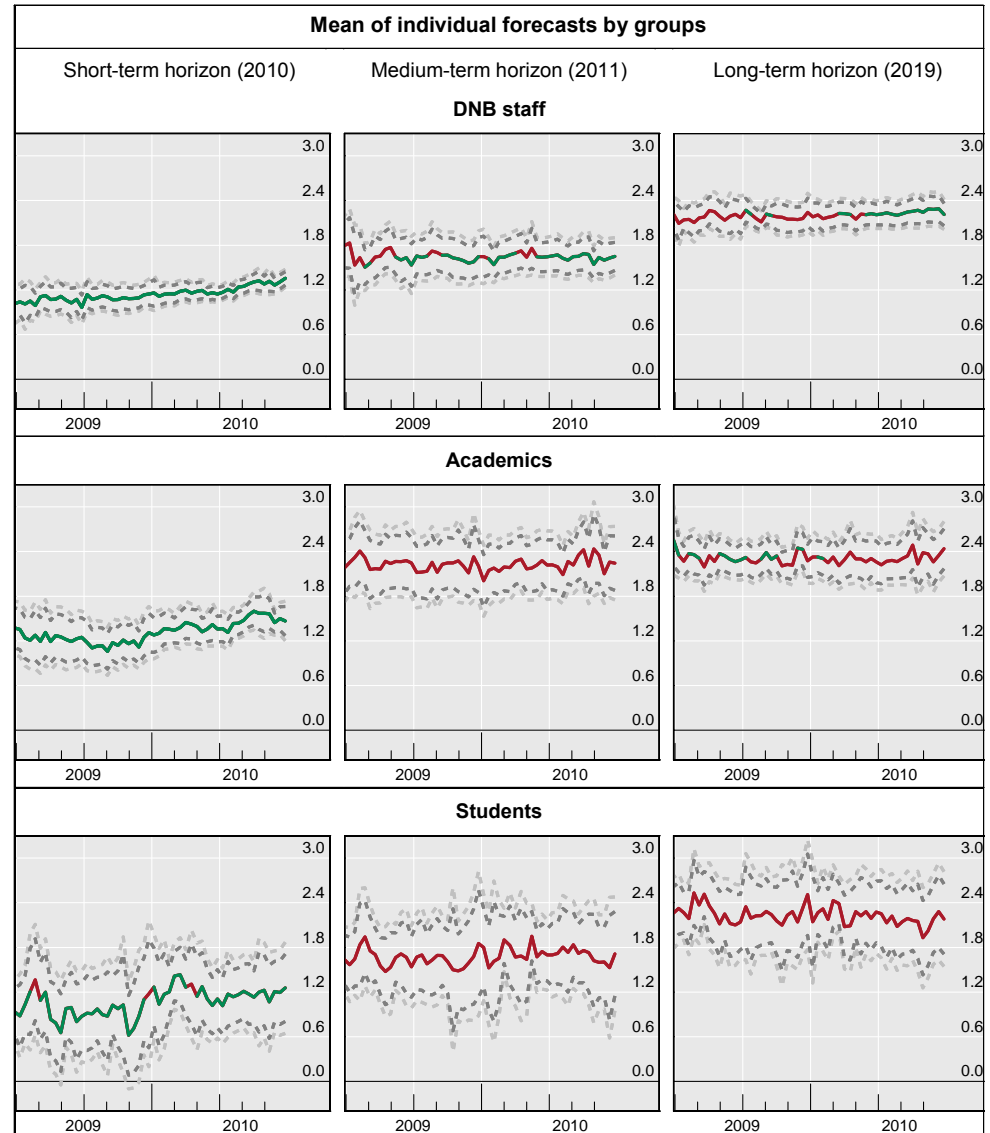- Means > medians at 2011 / 2019 horizons, implying skewed distributions.
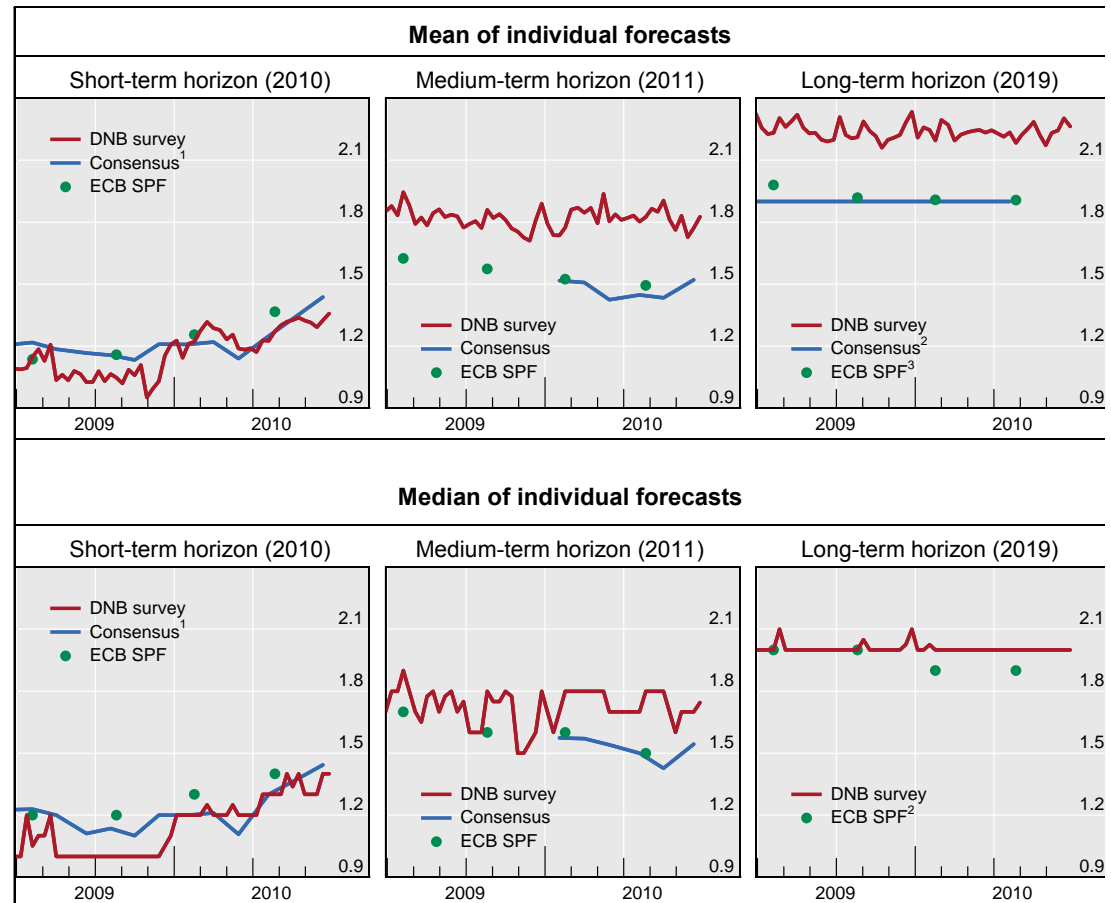
Comparison with Market-derived Expectations

- Aside from surveys, inflation expectations can be derived from market-traded assets such as bonds, inflation swaps.

- Difficulties: isolating expected inflation component, moving horizons (instead of fixed horizons in survey).

- However, survey means are close to expectations derived from swaps (at 2011 / 2019 horizons, first months of 2010 horizon), reasonably close to non-adjusted BE rates.

Mean forecasts and implied market expectations

Short-term horizon (2010) | Medium-term horizon (2011) | Long-term horizon (2019)

- DNB survey[1]
- Break-even inflation rate[2,5]
- Premium-adjusted break-even inflation rate[3,5]
- Inflation swap[4,5]

Group Means and Disagreement

- Looking across groups, signs of *homogeneity* (trend at 2010 horizon, fluctuations around constant at 2011, 2019 horizon), and *heterogeneity* (Academics higher at 2011 horizon, less agreement among Students).

- For *average disagreement*, Students > Academics > DNB staff at all horizons.

- Also, medium- > long- > short-term horizon (consistent with expectations anchoring).

- Looking at 3rd column, only Students are anchored according to *t* tests ("*imprecisely right*").

Mean of individual forecasts by groups

| Short-term horizon (2010) | Medium-term horizon (2011) | Long-term horizon (2019) |

Anchoring: Impact Analysis (1)

- More verification of expectations anchoring necessary, since *t* tests mostly invalid due to skewness (Jarque-Bera tests mostly rejected).

- We begin by estimating *impact of relevant macro-economic variables* on expectation means at each horizon. We use a simple linear regression in first differences (monthly changes).

- Table shows impact of variables in *common information sets*, i.e. Eurostat's flash estimate, JP Morgan's inflation estimate. Anchoring implies that coefficient at 2019 horizon is insignificant.

- Results are consistent with anchoring: some significance at 2010 and 2011 horizons, but not at 2019 horizon.

Impact of News on Inflation Means

(a) Flash inflation number

Specification: $\bar{\pi}_t^h - \bar{\pi}_{t-4}^h = c + \alpha_1\left(\pi_t^f - \pi_{t-4}^f\right) + \varepsilon_t.$

Horizon (h)	c	$\pi_t^f - \pi_{t-4}^f$	R^2
2010	0.001	0.12**	0.19
2011	-0.014	0.05*	0.02
2019	-0.002	-0.01	0.00

(b) JP Morgan's inflation estimate

Specification: $\bar{\pi}_t^h - \bar{\pi}_{t-4}^h = c + \alpha_1\left(\pi_t^{JPM} - \pi_{t-4}^{JPM}\right) + \varepsilon_t.$

Horizon (h)	c	$\pi_t^{JPM} - \pi_{t-4}^{JPM}$	R^2
2010	0.004	0.07	0.00
2011	-0.017	0.05*	0.01
2019	-0.001	0.06	0.02

* / **: Significant at 5% / 1% level.

Anchoring: Impact Analysis (2)

- Since the *fiscal "periphery crisis"* in the Euro Area reached a high point during the survey (Greek fiscal deficit was revised to over 12% GDP in October 2009; EU / IMF aid package was approved in May 2010), associated macro-economic variables may have influenced inflation expectations.

- Table shows impact of *Credit Default Swap prices* based on 10-year government bonds of the Euro Area (weighted average) and Greece.

- Both impacted positively on short- and medium-term inflation expectations. Moreover, Greek CDS prices have significantly influenced long-term expectations, though to a lesser extent than short- and medium-term expectations.

Impact of News on Inflation Means			
(c) CDS prices Euro Area			
Specification: $\bar{\pi}_t^h - \bar{\pi}_{t-4}^h = c + \alpha_1(CDS_t^{EA} - CDS_{t-4}^{EA}) + \varepsilon_t.$			
Horizon (h)	c	$CDS_t^{EA} - CDS_{t-4}^{EA}$	R^2
2010	0.01	0.07**	0.18
2011	-0.02	0.05**	0.11
2019	0.001	-0.002	0.00
(d) CDS prices Greece			
Specification: $\bar{\pi}_t^h - \bar{\pi}_{t-4}^h = c + \alpha_1(CDS_t^{GR} - CDS_{t-4}^{GR}) + \varepsilon_t.$			
Horizon (h)	c	$CDS_t^{GR} - CDS_{t-4}^{GR}$	R^2
2010	0.00	0.08**	0.20
2011	-0.02	0.06**	0.14
2019	-0.004	0.022*	0.01
* / **: Significant at 5% / 1% level.			

Anchoring: Persistence of Expectations Shocks

- A more general way of testing for anchoring is by estimating *persistance of macro-economic shocks across expectations horizons*. If long-term expectations are anchored, shocks influencing short- and medium-term expectations do not carry over to long-term expectations. We test whether long-term expectation means are influenced by shorter-term means for each participant subgroup.

- Estimations indicate that long-term expectations of Academics and DNB staff are not significantly influenced by shorter-term expectations. However, long-term expectations of Students are positively influenced by their short-term expectations, violating anchoring.

Impact of 2010 and 2011 Group Inflation Expectation Means on 2019 Expectations Means								
Specification: $\bar{\pi}_t^{g,2019} = c + \alpha_1\bar{\pi}_t^{g,2010} + \alpha_2\bar{\pi}_t^{g,2011} + \alpha_3\bar{\pi}_{t-1}^{g,2019} + \varepsilon_t.$								
Estimated coefficients:					Diagnostics (*p* values):			
Group (*g*)	*c*	$\bar{\pi}_t^{g,2010}$	$\bar{\pi}_t^{g,2011}$	$\bar{\pi}_{t-1}^{g,2019}$	R^2	B-G	White	Ramsey
ACA	1.81**	0.04	0.21	—	0.08	0.70	0.80	0.008**
STU	1.41**	0.28**	0.02	0.20	0.45	0.44	0.09	0.72
DNB	1.16**	-0.06	0.31	0.27*	0.16	0.98	0.03*	0.97
* / **: Significant at 5% / 1% level.								

Cross-Group Heterogeneity: Correlations (1)

- Having three well-defined participant subgroups allows us to investigate expectations heterogeneity between them.

- We start by estimating correlations between group inflation expectation means at different horizons.

- At the 2010 horizon, cross-group correlations are all highly positive and significant. This is not surprising, given the positive trend all groups' expectations share at the 2010 horizon.

- Using *detrended expectation means*, the cross-group correlations decrease, though their ordering is preserved. The correlation between DNB staff and Students is no longer significant.

Correlation between Group Inflation Expectation Means		
(a) 2010 horizon		
Specification: $\bar{\pi}_t^{g_1,2010} = c + \alpha_1 \bar{\pi}_t^{g_2,2010} + \varepsilon_t.$		

g_2 \ g_1	ACA	STU	DNB
ACA	1	0.56**	0.78**
STU	0.56**	1	0.48**
DNB	0.78**	0.48**	1

(b) 2010 horizon (detrended variables)		
Specification: $\bar{\pi}^{*}{}_t^{g_1,2010} = c + \alpha_1 \bar{\pi}^{*}{}_t^{g_2,2010} + \varepsilon_t.$		

g_2 \ g_1	ACA	STU	DNB
ACA	1	0.34*	0.40**
STU	0.34*	1	0.13
DNB	0.40**	0.13	1

* / **: Significant at 5% / 1% level.

Cross-Group Heterogeneity: Correlations (2)

- At the 2011 and 2019 horizons, most cross-group correlations become negative, and all are insignificant at the 5% level.

- According to *contemporaneous correlations* between group expectation means, there is considerable homogeneity at the 2010 horizon, which disappears at the medium- and long-term horizons.

Correlation between Group Inflation Expectation Means		
(c) 2011 horizon		
Specification: $\bar{\pi}_t^{g_1,2011} = c + \alpha_1 \bar{\pi}_t^{g_2,2011} + \varepsilon_t.$		
g_2 \ g_1 — ACA	STU	DNB
ACA 1	-0.01	-0.08
STU -0.01	1	-0.04
DNB -0.08	-0.04	1
(d) 2019 horizon		
Specification: $\bar{\pi}_t^{g_1,2019} = c + \alpha_1 \bar{\pi}_t^{g_2,2019} + \varepsilon_t.$		
g_2 \ g_1 — ACA	STU	DNB
ACA 1	-0.13	0.04
STU -0.13	1	-0.23
DNB 0.04	-0.23	1
* / **: Significant at 5% / 1% level.		

Cross-Group Heterogeneity: Causality

- Given that expectations homogeneity was found at the 2010 horizon, a next question is whether a *Granger-causality structure* exists between the group expectation means.

- At the 2010 horizon, we find DNB → ACA ↔ STU. This suggests that expectation formation at the 2010 horizon originates at DNB staff, then spreads to Academics and Students.

- At the 2011 horizon, we find DNB → ACA, and at the 2019 horizon DNB → STU ← ACA. This provides evidence for an *originating role of DNB staff expectations* at all horizons.

- While no contemporaneous cross-group correlations were found at the 2011 and 2019 horizons, group expectations are apparently related intertemporally.

Pairwise Granger Causality Tests on Group Inflation Expectation Means
2 lags, Table shows *p* values

(a) 2010 horizon

↗ does not cause →	ACA	STU	DNB
ACA	—	0.085*	0.242
STU	0.062*	—	0.433
DNB	0.026**	0.255	—

(b) 2011 horizon

↗ does not cause →	ACA	STU	DNB
ACA	—	0.212	0.228
STU	0.495	—	0.491
DNB	0.023**	0.476	—

(c) 2019 horizon

↗ does not cause →	ACA	STU	DNB
ACA	—	0.098*	0.693
STU	0.726	—	0.528
DNB	0.532	0.007***	—

* / ** / ***: Significant at 10% / 5% / 1% level.

Prediction Rules by Group and Horizon

- To investigate expectation formation of the three groups at each horizon, we estimated 3x3 prediction rules.

- Regressors include the *latest inflation number*, the *latest Consensus forecast* (DNB staff only), and *CDS prices from the Euro Area and Greece*.

- At the 2010 horizon, the latest inflation number is significant for all groups. Also, Greek CDS prices have a positive impact on the inflation means of Academics and DNB staff.

- At the 2011 and 2019 horizons, the latest inflation number has no significant positive impact, but Greek CDS prices remain significant in several cases.

Inflation Prediction Rules by Group and Horizon												
Specification: $\bar{\pi}_t^{g,h} = c + \alpha_1 \pi_t + \alpha_2 CE_t^h + \alpha_3 CDS_t^{EA} + \alpha_4 CDS_t^{GR} + \alpha_5 \bar{\pi}_{t-1}^{g,h} + \alpha_6 \bar{\pi}_{t-2}^{g,h} + \varepsilon_t.$												
Estimated coefficients:										Diagnostics (*p* values):		
g	**h**	**c**	π_t	CE_t^h	CDS_t^{EA}	CDS_t^{GR}	$\bar{\pi}_{t-1}^{g,h}$	$\bar{\pi}_{t-2}^{g,h}$	**R²**	**B-G**	**White**	**Ramsey**
ACA	2010	0.68**	0.05*	—	—	0.047*	—	0.41**	0.84	0.21	0.63	0.09
STU	2010	0.52**	0.09**	—	—	—	0.48**	—	0.56	0.12	0.07	0.41
DNB	2010	0.87**	0.03*	0.14	—	0.059**	—	—	0.83	0.22	0.25	0.82
ACA	2011	2.17**	-0.05	—	—	0.061*	—	—	0.12	0.26	0.25	0.45
STU	2011	1.19**	0.03	—	—	—	0.49**	-0.21	0.27	0.12	0.97	0.10
DNB	2011	1.18**	—	—	—	—	0.28*	—	0.09	0.13	0.00**	0.57
ACA	2019	2.57**	-0.03	—	—	0.047*	—	-0.13	0.16	0.36	0.08	0.047*
STU	2019	2.25**	-0.05*	—	—	—	—	—	0.10	0.19	0.57	0.15
DNB	2019	2.16**	—	—	—	0.029**	—	—	0.33	0.32	0.19	0.85
* / **: Significant at 5% / 1% level.												

Conclusions & Further Research (1)

- Prediction means and medians of all groups indicate return to normal economic conditions.
  - 2010 predictions influenced by rising monthly inflation numbers, 2011 and 2019 predictions roughly stationary.

- Clear regularities in within-group disagreement:
  DNB < Academics < Students, and 2011 < 2019 < 2010.

- Evidence on anchoring at ECB target of long-term expectations ambiguous.
  - Medians mostly equal to 2%, but means above 2% (significantly for Academics / DNB staff).
  - Greek fiscal crisis has influenced long-term expectations (though no contagion effects via the rest of the Euro Area found).
  - Students' expectations sensitive to shocks even at 2019 horizon.

- Partial homogeneity between group inflation means.
  - Strong correlation between group means at 2010 horizon, but not at 2011, 2019 horizons.
  - Formation of inflation expectations originates at DNB staff at all horizons.

Conclusions & Further Research (2)

To be investigated:

- Analyse prediction accuracy once 2010 inflation number is available.
  - Test in which weeks participants were rational, and whether accuracy increased during the survey.
  - Compare group performances and verify whether expectation of DNB staff (most informed and specialized) were most accurate.

- Include more relevant variables in prediction rules.
  - Impact periphery crisis would be clearer if more countries (e.g. Spain, Italy) are included.
  - Stock market indices, unemployment numbers potentially influential.

- Analyse whether Maximizing / Satisficing attitude of participants influences inflation expectation formation.
  - Participants were given a questionnaire taken from Schwartz et al. (2002), measuring their Maximizing / Satisficing attitude.
  - We plan to regroup participants using a median split, and test for expectations differences.