Evaluating the ECB's Survey of Professional Forecasters Under Asymmetric Loss and Higher Moments

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Outline

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- Motivation: Asymmetric loss and higher moments
- Methods:
  - Testing asymmetry and optimality simultaneously
    Elliott, Komunjer and Timmermann (2005, 2008) [EKT]
  - Taylor approximation of the loss function
  - Linex and Linex-Linex loss functions
- Data: The ECB's Survey of Professional Forecasters
- Results
- Conclusion

Motivation (I)

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- Asymmetric loss:
  - There is no reason for economic loss induced by forecast errors to be symmetric (Granger, 1969)
  - Mean squared error loss is difficult to justify (Granger and Newbold, 1986)
  - Producing biased forecasts can be rational (EKT, 2008)
  - Loss functions need to be more flexible:
    - piecewise linear loss (Lin-Lin)
    - piecewise quadratic loss (Quad-Quad)
    - Linex loss (Varian, 1975)

Motivation (II)

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- Higher moments:
  - Financial decision making: asymmetric preferences and non-normal asset returns
  - Jondeau and Rockinger (2006): "...under large departure from normality [...] three-moment or four-moment optimization strategies may provide a good approximation of the expected utility."
  - Approaches to introduce higher moments:
    - Taylor series approximation (Jondeau and Rockinger, 2006)
    - Gram-Charlier distribution (Christodoulakis, 2005)

Motivation (III)

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- Research questions:
  - Are higher moments relevant for macroeconomic forecasts?
  - How many moments should be used?
  - How should the moments of forecast errors be measured?
  - Which loss function is best suited to the analysis?
  - What can we learn about forecasters (policymakers) preferences?

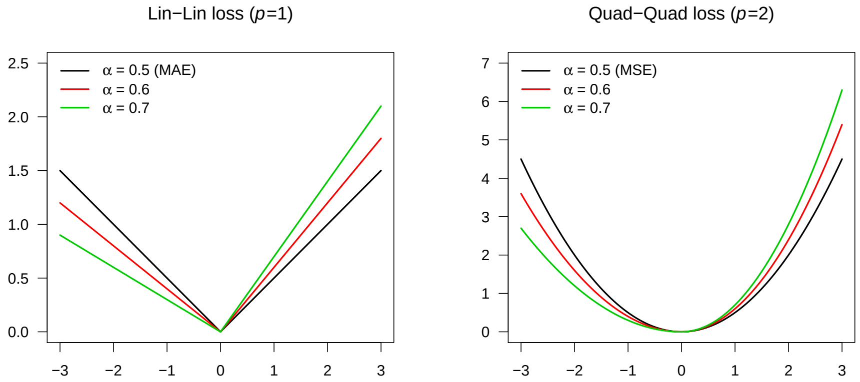
Methods (I)

- EKT propose a flexible family of loss functions:

$$L(e_{t+1}; \alpha, p) = [\alpha + (1 - 2\alpha)I(e_{t+1} < 0)] \cdot |e_{t+1}|^p$$

  - $L(.)$ is symmetric for $\alpha = 0.5$ and turns into Lin-Lin ($p = 1$) and Quad-Quad ($p = 2$) loss
  - Solve the first order condition $\mathrm{E}(L'(e_{t+1}; \alpha, p) \mid \Omega_t) = 0$, where Ω_t is the information set at time t and $L'(.)$ the derivative of the loss function
  - Simultaneously back out loss parameters α and p and test the rationality of the forecasts by testing the orthogonality condition $E([\alpha - I(e_{t+1} < 0)] \cdot |e_{t+1}|^{p-1} \cdot \mathbf{w}_t) = \mathbf{0}$, with $\mathbf{w}_t \in \Omega_t$.

Methods (II)



Lin−Lin loss (p=1)
α = 0.5 (MAE)
α = 0.6
α = 0.7
0.0
0.5
1.0
1.5
2.0
2.5
−3
−2
−1
0
1
2
3
Quad−Quad loss (p=2)
α = 0.5 (MSE)
α = 0.6
α = 0.7
0
1
2
3
4
5
6
7
−3
−2
−1
0
1
2
3

Methods (III)

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- Introducing higher moments to a loss function by using a Taylor series expansion around $E_t(e_{t+1}) = e^\star_{t+1}$

$$
\begin{aligned}
E_t\left[L\left(e_{t+1}\right)\right] \approx\; & L(e^\star_{t+1}) + L^{(1)}(e^\star_{t+1})E_t\left[e_{t+1} - e^\star_{t+1}\right] + \frac{1}{2}L^{(2)}(e^\star_{t+1})E_t\left[\left(e_{t+1} - e^\star_{t+1}\right)^2\right] \\
& + \frac{1}{3!}L^{(3)}(e^\star_{t+1})E_t\left[\left(e_{t+1} - e^\star_{t+1}\right)^3\right] + \frac{1}{4!}L^{(4)}(e^\star_{t+1})E_t\left[\left(e_{t+1} - e^\star_{t+1}\right)^4\right]
\end{aligned}
$$

- Substituting the moments with σ^2_{t+1}, s^3_{t+1} and k^4_{t+1}, the loss function can be approximated by

$$
E_t\left[L\left(e_{t+1}\right)\right] \approx L(e^\star_{t+1}) + \frac{1}{2}L^{(2)}(e^\star_{t+1})\sigma^2_{t+1} + \frac{1}{6}L^{(3)}(e^\star_{t+1})s^3_{t+1} + \frac{1}{24}L^{(4)}(e^\star_{t+1})k^4_{t+1}.
$$

Methods (IV)

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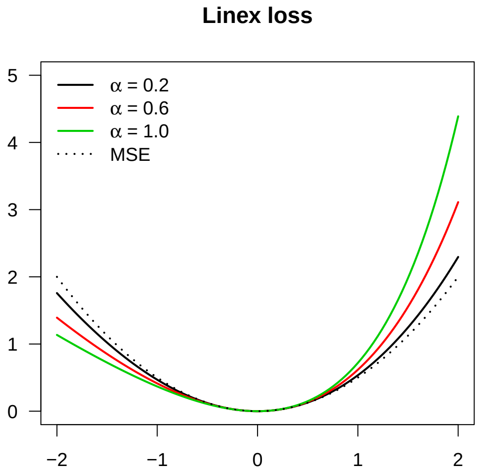
- Linex loss function:
  - Proposed by Varian (1975) and used by Zellner (1986), Christophersen and Diebold (1997), Batchelor and Peel (1998) and more recently Clatworthy, Peel and Pope (2012) among others.
  - For $\alpha \to 0$ Linex converges to squared loss

$$L(e_{t+1}) = \frac{1}{\alpha^2}\left(\exp\left(\alpha e_{t+1}\right) - \alpha e_{t+1} - 1\right), \alpha \in \mathbb{R} \setminus \{0\}$$

- 4th order Taylor approximation and differentiation leads to the following FOC

$$E\left[\frac{1}{\alpha}\left(\exp(\alpha e_{t+1})\left(1 + \frac{\sigma_{t+1}^2}{2}\alpha^2 + \frac{s_{t+1}^3}{6}\alpha^3 + \frac{k_{t+1}^4}{24}\alpha^4\right) - 1\right) \cdot \mathbf{w}_t\right] = \mathbf{0}$$

Methods (V)



Methods (VI)

- Linex-Linex loss function:
  - $L(e_{t+1})$ has a symmetric special case for $\alpha = 0.5$
  - α can be interpreted analogous to the EKT approach

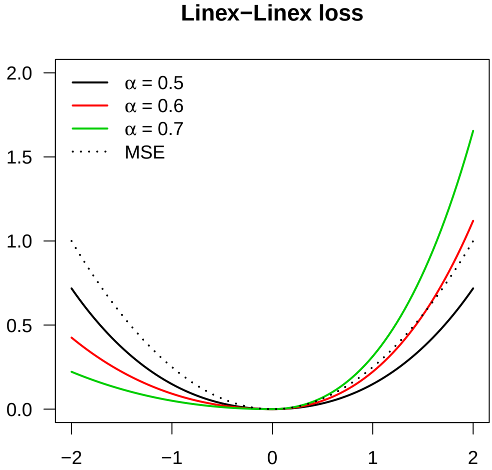
$$L(e_{t+1}) = \exp\left([\alpha - I(e_{t+1} < 0)] \cdot e_{t+1}\right) - [\alpha - I(e_{t+1} < 0)] \cdot e_{t+1} - 1$$

- 2nd order Taylor approximation and differentiation leads to the following FOC

$$E\left[[\alpha - I] \cdot \left(\exp([\alpha - I] \cdot e_{t+1})\left(1 + \frac{\sigma_{t+1}^2}{2}[\alpha - I]^2\right) - 1\right) \cdot \mathbf{w}_t\right] = \mathbf{0}$$

- 4th order Taylor involves s_{t+1}^3 and k_{t+1}^4

Methods (VII)



Data (I)

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- The ECB's Survey of Professional Forecasters (SPF)
  - Quarterly survey of the private sector's expectations regarding euro area macroeconomic developments
    - First survey round took place in 1999:Q1
    - Unbalanced panel currently with approx. 75 active participants
  - Key variables are GDP growth, HICP inflation and unemployment rate
    - Forecasters are asked for their point estimates and a probability assessment of the key variables
    - Point estimates of oil prices, interest rates and exchange rates are also provided by the forecasters
    - Latest reference data for target variables is provided
    - Horizons vary slightly for these variables

Data (II)

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- We use the one-year-ahead year-on-year point and probability forecasts
- Individual forecasters are included in the analysis if they have provided at least 40 forecasts for a certain variable
  - 23 (GDP and UPR) and 24 (HICP) forecasters meet that requirement

	SPF forecast horizons (year-on-year)		
Survey	GDP growth	HICP inflation	Unemployment rate
2013:Q1	2013:Q3	Dec 2013	Nov 2013
2013:Q2	2013:Q4	Mar 2014	Feb 2014
2013:Q3	2014:Q1	Jun 2014	May 2014
2013:Q4	2014:Q2	Oct 2014	Sep 2014

- Evidence for bias in the SPF forecasts in literature, see Bowles et al. (2010), Andrade and Bihan (2013) and Pierdzioch et al. (2013)

Data (III)

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- Realization data and data used for the instruments are taken from the Real Time Database (RTD) provided by the ECB's Statistical Data Warehouse (Giannone et al., 2012)
  - Since the RTD begins in 2001:Q1, the data used for the analysis is shortened accordingly
- Accounting for a possible influence of data revisions, all analysis are carried out using first vintages (real-time) and current vintages (revised) as realization data
- Instrumental variables are all real-time data, as this reflects the forecaster's information set
- Instruments are:
  - lagged forecast errors (weak efficiency)
  - lagged GDP growth, HICP inflation and unemployment rate
  - second lags, squares and interactions of the above

Data (IV)

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- Moments of forecast errors cannot be observed directly
- Calculate sample moments by exploiting the probability forecasts of the individual forecasters
- Aspects to consider:
  - Weights of discrete intervals $\rightarrow$ mean of each interval
  - Open intervals at extreme ends $\rightarrow$ treat as if closed
  - Expected value to center moments $\rightarrow$ use point forecasts

Results - GDP forecasts under Linex loss

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Forecaster	$\hat{\alpha}$ **estimates**				$H_0 : \alpha \leq 0$				$H_0 : J = 0$			
	-	σ^2	s^3	k^4	-	σ^2	s^3	k^4	-	σ^2	s^3	k^4
						Real-time						
average	1.516	0.987	0.971	0.909	73	71	72	72	43	43	42	42
id 4	3.587	1.470	1.450	1.344	100	100	100	100	20	53	60	60
id 5	1.983	0.992	0.859	0.782	81	81	75	75	27	53	47	40
id 15	1.425	0.936	0.881	0.852	88	88	88	88	53	60	60	60
id 16	0.942	0.257	0.240	0.231	63	56	50	50	67	60	60	60
id 20	1.274	0.910	0.895	0.882	50	50	56	56	53	27	27	27
id 22	1.519	0.927	0.874	0.836	56	69	75	75	47	20	20	20
id 23	0.815	0.410	0.430	0.379	31	50	56	50	60	53	53	53
						Revised						
average	0.687	0.453	0.437	0.424	53	49	48	48	47	43	41	43
id 4	1.590	0.716	0.710	0.696	81	75	75	75	33	47	47	47
id 5	1.054	0.369	0.310	0.295	69	38	38	38	47	40	40	40
id 15	0.862	0.624	0.591	0.560	63	81	75	75	67	73	73	73
id 16	0.452	0.008	0.011	0.008	50	31	31	31	53	80	80	80
id 20	0.688	0.527	0.533	0.530	38	44	44	44	27	27	27	27
id 22	0.337	0.252	0.188	0.187	50	50	44	44	27	20	13	13
id 23	0.559	0.061	0.064	0.062	50	38	38	38	67	53	53	53

Results - GDP forecasts under Linex-Linex loss

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Forecaster	$\hat{\alpha}$ **estimates**				$H_0: \alpha \leq 0.5$				$H_0: J = 0$			
	-	σ^2	s^3	k^4	-	σ^2	s^3	k^4	-	σ^2	s^3	k^4
Real-time												
average	0.713	0.700	0.698	0.697	89	86	86	86	21	20	20	19
id 4	0.784	0.741	0.740	0.739	100	100	100	100	33	27	27	27
id 5	0.749	0.676	0.664	0.662	100	88	88	88	20	20	7	7
id 15	0.716	0.676	0.674	0.673	88	75	75	75	40	40	40	40
id 16	0.614	0.608	0.603	0.602	56	56	56	56	27	40	27	27
id 20	0.743	0.711	0.710	0.710	100	100	100	100	7	7	7	7
id 22	0.699	0.690	0.681	0.680	81	94	94	94	13	7	7	7
id 23	0.639	0.611	0.611	0.610	69	69	69	69	27	27	27	27
Revised												
average	0.635	0.625	0.626	0.625	62	58	59	59	11	11	12	13
id 4	0.694	0.660	0.660	0.659	100	88	88	88	13	0	0	0
id 5	0.716	0.612	0.610	0.610	100	69	69	69	0	13	20	20
id 15	0.661	0.629	0.628	0.628	75	69	69	69	27	13	13	13
id 16	0.582	0.569	0.574	0.574	44	31	38	44	7	27	40	40
id 20	0.657	0.645	0.645	0.644	69	75	75	75	0	7	7	7
id 22	0.618	0.579	0.577	0.577	50	31	31	31	0	0	0	0
id 23	0.561	0.559	0.576	0.576	38	38	44	44	7	0	7	7

Conclusion

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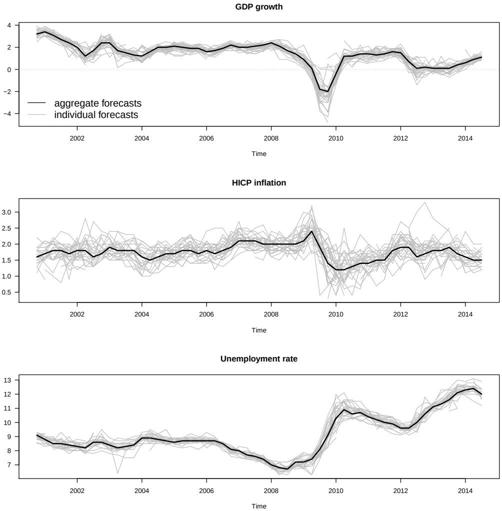
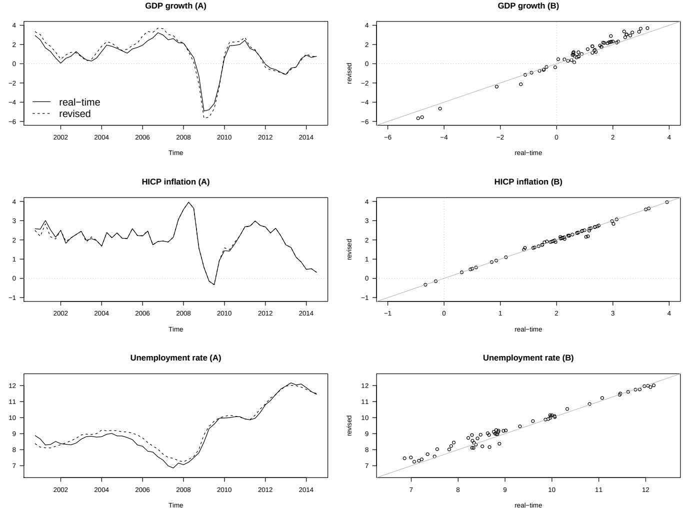
- Asymmetry:
  - GDP growth: Higher weights on positive forecast errors (underestimation)
  - HICP inflation: Opposite holds for inflation forecasts
  - Unemployment rate: Less evidence of asymmetry. Direction varies over forecasters
  - Data revisions affect results for GDP and unemployment
- Higher moments:
  - Including the second moment reduces the degree of asymmetry
  - Higher moments have a minor impact on the asymmetry parameter
- Loss function: Results are similar for both loss functions
  - Direction of asymmetry is the same for both loss functions
  - Adding higher moments has a greater influence under Linex loss
  - Rationality is rejected less often under Linex-Linex loss

Backup (I)


GDP growth
aggregate forecasts
individual forecasts
Time
HICP inflation
Time
Unemployment rate
Time

Backup (II)


GDP growth (A)
real−time
revised
Time
GDP growth (B)
revised
real−time
HICP inflation (A)
Time
HICP inflation (B)
revised
real−time
Unemployment rate (A)
Time
Unemployment rate (B)
revised
real−time

Backup (III) - HICP forecasts under Linex loss

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Forecaster	$\hat{\alpha}$ estimates				$H_0: \alpha \geq 0$				$H_0: J = 0$			
	-	σ^2	s^3	k^4	-	σ^2	s^3	k^4	-	σ^2	s^3	k^4
Real-time												
average	-1.161	-1.040	-1.060	-1.029	62	66	67	67	56	45	44	41
id 4	-1.338	-1.702	-1.823	-1.647	69	94	94	94	67	27	7	20
id 5	-1.294	-1.690	-1.791	-1.651	75	100	100	100	47	20	13	27
id 15	-1.181	-1.044	-1.077	-1.061	69	75	75	75	53	60	60	60
id 16	-0.857	-0.670	-0.653	-0.645	56	56	56	56	67	47	53	40
id 20	-1.615	-1.589	-1.834	-1.520	63	63	63	63	53	27	27	20
id 22	-1.398	-1.035	-1.233	-1.114	81	75	75	75	80	67	60	60
id 23	-0.910	-0.760	-0.709	-0.746	63	69	69	69	67	60	60	60
Revised												
average	-1.151	-1.045	-1.069	-1.038	61	66	66	67	56	44	43	40
id 4	-1.313	-1.709	-1.825	-1.655	69	94	94	94	67	20	7	20
id 5	-1.254	-1.677	-1.777	-1.641	75	100	100	100	47	20	20	27
id 15	-1.166	-1.039	-1.063	-1.046	69	75	75	75	53	60	60	60
id 16	-0.848	-0.675	-0.656	-0.648	63	56	56	56	67	47	53	40
id 20	-1.594	-1.574	-1.820	-1.506	56	63	63	63	53	27	27	20
id 22	-1.384	-1.069	-1.267	-1.180	81	75	75	75	80	67	53	60
id 23	-0.894	-0.776	-0.720	-0.769	56	56	56	69	67	60	60	60

Backup (IV) - HICP forecasts under Linex-Linex

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Forecaster	$\hat{\alpha}$ estimates				$H_0:\ \alpha \geq 0.5$				$H_0:\ J=0$			
	-	σ^2	s^3	k^4	-	σ^2	s^3	k^4	-	σ^2	s^3	k^4
Real-time												
average	0.300	0.310	0.310	0.311	71	73	72	72	1	2	2	2
id 4	0.261	0.271	0.271	0.272	81	100	100	100	0	0	0	0
id 5	0.274	0.255	0.253	0.254	81	100	100	100	0	0	0	0
id 15	0.275	0.296	0.297	0.298	81	69	69	69	0	7	7	7
id 16	0.299	0.339	0.341	0.344	63	63	56	56	0	0	0	0
id 20	0.263	0.262	0.262	0.263	69	69	69	69	0	0	0	0
id 22	0.227	0.260	0.257	0.258	81	88	88	88	0	0	0	0
id 23	0.281	0.313	0.312	0.313	75	63	63	63	0	0	7	7
Revised												
average	0.304	0.312	0.312	0.313	70	72	72	72	1	1	1	1
id 4	0.264	0.271	0.270	0.271	81	100	100	100	0	0	0	0
id 5	0.277	0.254	0.252	0.253	81	100	100	100	0	0	0	0
id 15	0.282	0.299	0.300	0.300	75	69	69	69	0	0	0	0
id 16	0.301	0.340	0.342	0.345	63	56	56	56	0	0	0	0
id 20	0.265	0.264	0.263	0.264	69	69	69	69	0	0	0	0
id 22	0.228	0.261	0.258	0.259	81	94	94	94	0	0	0	0
id 23	0.288	0.316	0.315	0.316	63	63	63	63	0	0	7	7

Backup (V) - Unemployment forecasts under Linex loss

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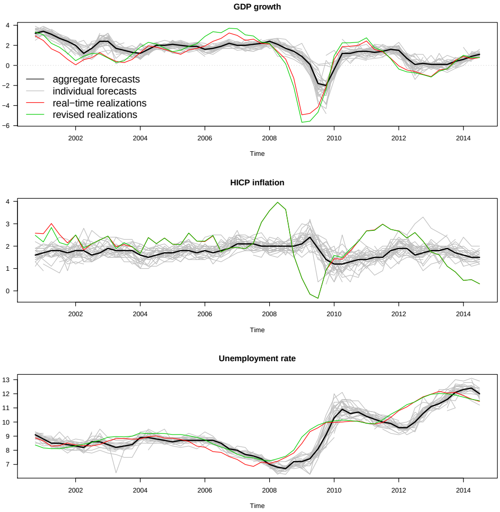
Forecaster	$\hat{\alpha}$ estimates				$H_0: \alpha \geq 0$				$H_0: J = 0$			
	-	σ^2	s^3	k^4	-	σ^2	s^3	k^4	-	σ^2	s^3	k^4
Real-time												
average	-0.756	-0.494	-0.500	-0.488	30	26	25	26	30	26	25	26
id 4	-0.478	0.045	0.062	0.058	19	0	0	0	27	13	13	13
id 5	-1.539	-0.551	-0.573	-0.585	31	0	0	0	53	53	53	53
id 15	-1.309	-0.414	-0.395	-0.399	38	6	6	6	47	33	33	33
id 16	-0.382	-0.098	-0.094	-0.081	19	13	13	13	40	40	40	40
id 20	-0.568	-0.568	-0.561	-0.562	13	25	25	25	40	33	40	33
id 22	0.883	0.555	0.459	0.437	0	0	0	0	40	27	33	33
id 23	-0.586	-0.322	-0.314	-0.314	25	13	13	13	20	27	20	20
Revised												
average	-1.767	-1.159	-1.184	-1.072	65	63	61	65	30	29	30	29
id 4	-1.960	-0.703	-0.681	-0.661	100	44	31	38	40	33	40	40
id 5	-2.915	-1.726	-1.773	-1.621	69	44	50	50	40	40	40	40
id 15	-2.567	-0.982	-0.878	-0.851	75	69	81	88	27	13	13	13
id 16	-1.109	-0.424	-0.379	-0.369	56	56	63	63	20	40	40	47
id 20	-1.252	-1.099	-1.049	-1.052	31	44	38	50	33	27	33	27
id 22	0.176	0.090	0.075	0.074	6	6	6	6	20	20	20	20
id 23	-1.095	-0.679	-0.665	-0.652	38	38	31	38	27	13	13	13

Backup (VI) - Unemployment forecasts under Linex-Linex loss

Forecaster	$\hat{\alpha}$ **estimates**				$H_0 : \alpha \geq 0.5$				$H_0 : J = 0$			
	-	σ^2	s^3	k^4	-	σ^2	s^3	k^4	-	σ^2	s^3	k^4
Real-time												
average	0.410	0.410	0.408	0.408	42	40	41	40	21	17	17	16
id 4	0.434	0.482	0.480	0.479	31	6	6	6	27	13	13	13
id 5	0.287	0.379	0.379	0.380	75	31	31	31	20	20	20	20
id 15	0.343	0.408	0.415	0.417	56	25	25	19	40	33	40	40
id 16	0.446	0.441	0.449	0.448	31	31	31	31	33	40	40	40
id 20	0.418	0.405	0.405	0.405	38	44	44	44	13	27	27	27
id 22	0.656	0.639	0.635	0.631	0	0	0	0	0	0	0	0
id 23	0.394	0.432	0.429	0.429	38	6	6	6	27	7	0	0
Revised												
average	0.313	0.322	0.320	0.321	79	81	81	81	20	18	18	18
id 4	0.314	0.374	0.376	0.376	94	81	88	88	27	20	20	20
id 5	0.232	0.242	0.242	0.242	88	81	81	81	13	33	33	33
id 15	0.260	0.330	0.331	0.331	100	100	94	94	27	20	20	20
id 16	0.360	0.371	0.381	0.383	75	63	63	63	33	27	27	27
id 20	0.350	0.334	0.334	0.334	44	69	69	69	33	27	27	27
id 22	0.527	0.550	0.547	0.546	0	0	0	0	20	7	7	7
id 23	0.331	0.362	0.36	0.361	69	75	81	81	7	7	7	7

Backup (VII)



GDP growth
aggregate forecasts
individual forecasts
real−time realizations
revised realizations
Time
HICP inflation
Time
Unemployment rate
Time

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