How accurate are survey-based measures of macroeconomic uncertainty?

Alexander Glas and Matthias Hartmann

Freier Fachvortrag
Berufungsverfahren W2-Professur in Volkswirtschaftslehre

ESB Business School, Hochschule Reutlingen

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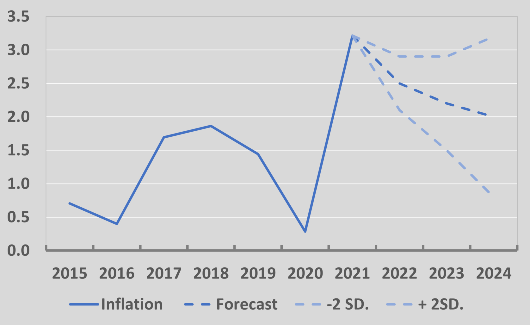
Macroeconomic uncertainty



- **Forecasting applications:** Point forecasts without uncertainty bands are incomplete (Dawid, 1984; Gneiting and Raftery, 2007).
- **Monetary policy applications:** Heightened inflation uncertainty may be related to de-anchoring of inflation expectations (Kumar et al., 2015).

This study

- **Aim:** Measurement of average uncertainty, from a panel of survey-based histogram forecasts.

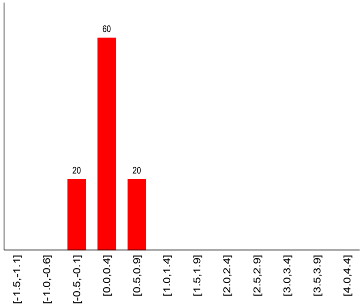
- **Starting point (Kenny et al., 2014):**
  Variances of histogram forecasts $\ll$ mean squared forecast errors.

- **Research questions:**
  Why do ex-ante uncertainty and ex-post uncertainty differ?
  Can we correct for this?

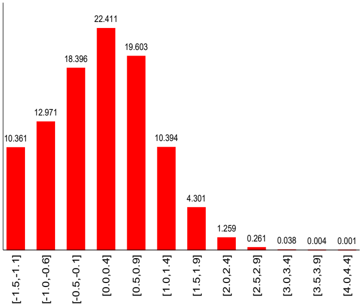
- **Novel findings and contribution:**
  - A subgroup of forecasters reports strongly rounded numbers.
  - Histogram forecasts of this group are very narrow.
  - Discarding these observations helps to re-align average ex-ante uncertainty and ex-post uncertainty.

Example histogram forecasts for HICP inflation, 1Q ahead

Forecaster #102



Forecaster #95



Both histogram forecasts were reported as part of the ECB's *Survey of Professional Forecasters* in 2016Q4.

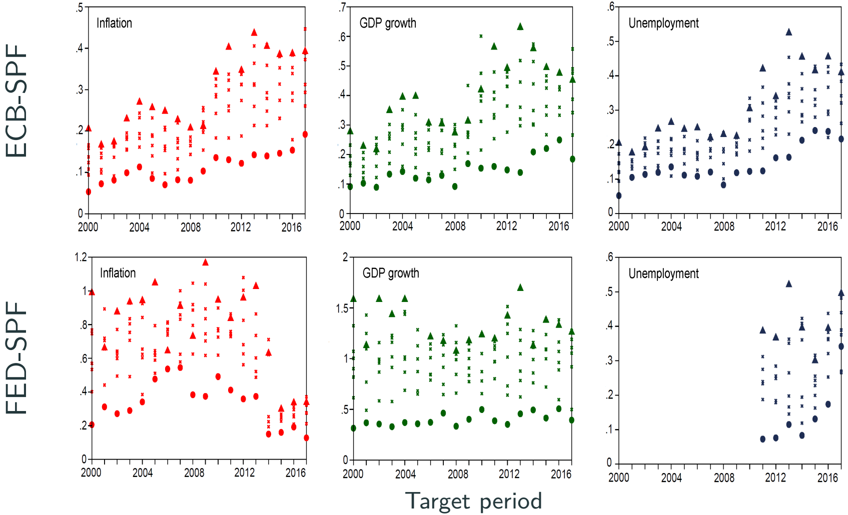
Survey of Professional Forecasters (SPF)

- Data set comprises forecasts from ECB-SPF and FED-SPF.
- Quarterly fixed-event histogram forecasts for inflation, real GDP growth and unemployment rates in the euro area and the U.S.
- Common sample: 1999Q1-2017Q4 (target years: 2000-2017).
- Unemployment rate in FED-SPF available since 2009Q2.

	Forecast horizon h	
	Current year	Next year
Q1	4	8
Q2	3	7
Q3	2	6
Q4	1	5

- Sequence of h-step-ahead histogram forecasts for target year $t = 1, \dots, T$ with forecast horizon $h \in \{8, 7, \dots, 1\}$.

Consensus ex-ante uncertainty



Notes: Graphs depict the cross-sectional averages over the variances derived from the individual histograms, i.e. $\sigma^2_{i,t,h}$, at forecast horizons $h \in \{8, 7, \ldots, 1\}$. Triangles "△" depict the 8-step-ahead variance forecasts and bullets "•" the 1-step-ahead variance forecast. The sample period is 1999Q1-2017Q4.

Integer-based categorization

- Probabilistic survey forecasts often tend to contain numbers that are multiples of five or ten (Engelberg et al., 2009; Clements, 2011; Boero et al., 2015).
- Consider a histogram forecast by forecaster $i = 1, \dots, N$, consisting of probabilities, $p_{i,k}$, for outcome intervals ('bins') $k = 1, \dots, K$.
- Check whether $p_{i,k}$ is a multiple of five:

$$\tilde{D}^{\mathrm{m5}}_{i,k} = \begin{cases} 1 & \text{if } 5 \cdot \left\lfloor \frac{p_{i,k}}{5} \right\rfloor = p_{i,k} \text{ and} \\ 0 & \text{else.} \end{cases}$$

- Classify i as a rounder according to the following rule:

$$\tilde{D}^{\mathrm{m5}}_{i} = \begin{cases} 1 & \text{if } \mathrm{mode}(\tilde{D}^{\mathrm{m5}}_{i,1}, \dots, \tilde{D}^{\mathrm{m5}}_{i,K}) = 1 \text{ and} \\ 0 & \text{else.} \end{cases}$$

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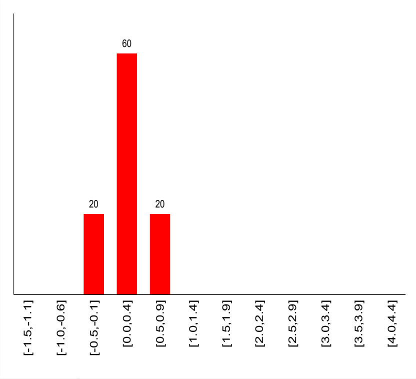

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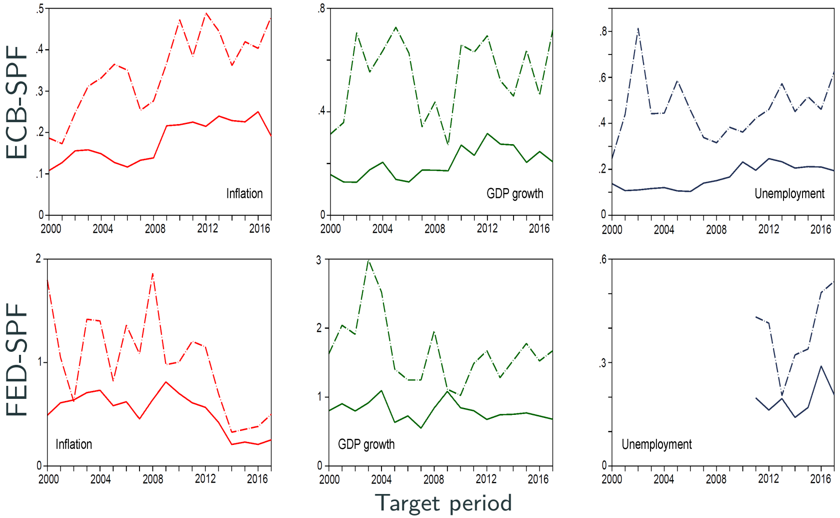
Average ex-ante uncertainty for $h = 4$



Dashed lines: uncertainty from non-rounded forecasts,
solid lines: uncertainty from rounded forecasts.

Horizon-specific variance misalignment

- Individuals' ex-ante uncertainty at horizon h is computed as:

$$\overline{\sigma^2_{i,h}} = \frac{1}{T_{i,h}} \sum_{t=1}^{T_{i,h}} \sigma^2_{i,t,h}.$$

- Ex-post uncertainty is defined as the mean squared error:

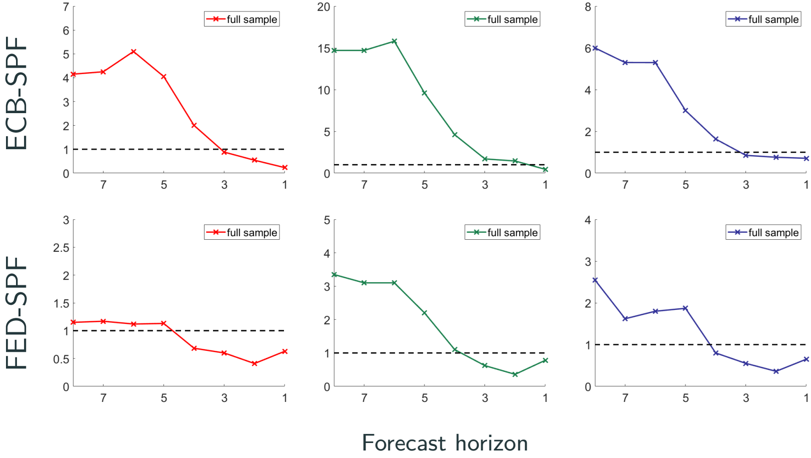
$$\mathrm{MSE}_{i,h} = \frac{1}{T_{i,h}} \sum_{t=1}^{T_{i,h}} e^2_{i,t,h},$$

where $e_{i,t,h} = x_t - \mu_{i,t,h}$ denotes forecast errors.

- Average misalignment ratio (Clements, 2014):

$$m_h = \frac{1}{N_h} \sum_{i=1}^{N_h} \frac{\mathrm{MSE}_{i,h}}{\overline{\sigma^2_{i,h}}}.$$

Variance misalignment



Notes: For each forecast horizon, the plots display the average misalignment ratios m_h for the ECB- (first row) and FED-SPF (second row). The sample period is 1999Q1-2017Q4, except for the unemployment rate forecasts from the FED-SPF, which are available since 2010Q1 for our purposes.

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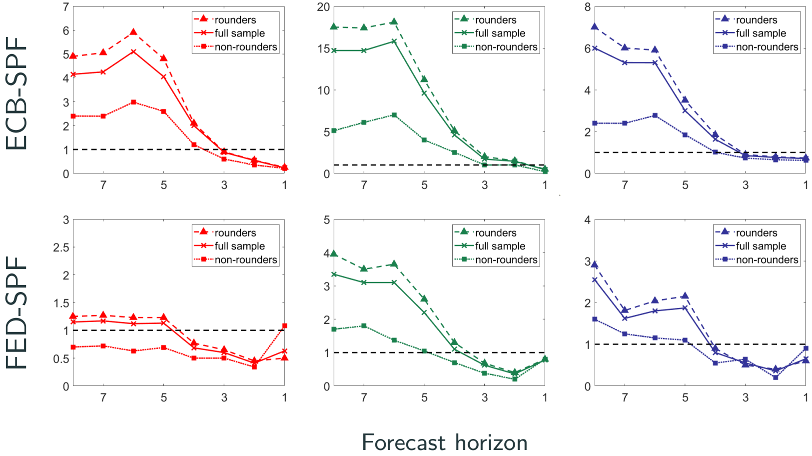

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Conclusion

- Rounding as a reliable indicator of misalignment between ex-ante and ex-post variances.
- Empirically, we confirm that rounders in the SPF...
  - ...use fewer of the available bins and report smaller ex-ante variances than the non-rounders
  - ...do not differ in terms of forecast errors from the non-rounders.
- Consensus ex-ante uncertainty based solely on non-rounders is about twice as high as overall consensus, also distinct dynamics.
- Next steps: Application of corrected macroeconomic uncertainty indexes in SVARs for Euro area and U.S.
- Extension to uncertainty measures from household and firm surveys of the Deutsche Bundesbank.

Link to data set and slides

Previous work on rounding and uncertainty

- **Rounding as a source of information**
  - Rounding behavior of surveyed forecasters sometimes interpreted as indicator of uncertainty – "Round numbers suggest round interpretations" (RNRI), Fischhoff and Bruine de Bruin (1999).
  - Binder (2017) and Goldfayn-Frank and Wohlfart (2020) use rounding as a means to quantify uncertainty.
- **Rounding as a loss of information**
  - Heitjan and Rubin (1991) regard rounded survey responses as *coarse data*, with
    missing data $\prec$ coarse data $\prec$ complete data
  - Informative content of higher moments from survey-based histogram forecasts called in question e.g. by D'Amico and Orphanides (2008) or Clements (2014, 2016).

Contribution

This study

- traces misalignment between ex-ante uncertainty and ex-post uncertainty to characteristics of 2 subsamples of the cross section,
- uses rounding behavior as a means to distinguish skillful variance forecasters from the rest,
- shows that computing ex-ante uncertainty from subsample of skillful forecasts alone provides better indication of realized forecast uncertainty.

Section 1 – Data

Survey of Professional Forecasters (SPF)

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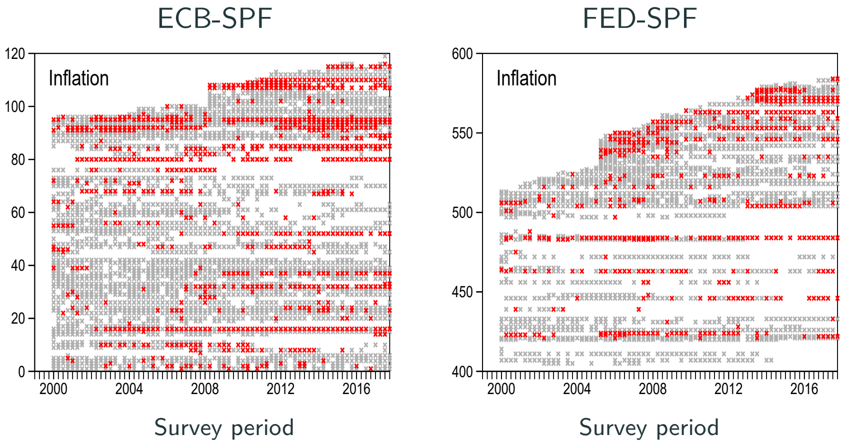
Forecaster panel for inflation



Notes: Graphs depict forecaster participation for the (current year) inflation rate in the ECB- (left) and FED-SPF (right). The sample period is 1999Q1-2017Q4.

Target variables

- For inflation and real GDP growth, outcome variable x_t for year $t = 1, \ldots, T$ refers to

$$x_t = 100 \times \left(\frac{X_t}{X_{t-1}} - 1 \right).$$

- X_t denotes annual average of either the respective price index or real GDP.

- For unemployment rate, x_t denotes annual average over monthly unemployment rate, i.e. $x_t = X_t$.

- First-vintage realizations drawn from
  - *Statistical Data Warehouse* of the ECB for euro area,
  - *Real-Time Data Set for Macroeconomists* of the FED Philadelphia for US.

Participants

- Majority of cross section from financial industry or research institutes.
- Most participants' names are published yet not associated with ID numbers to guarantee anonymity.
- ECB-SPF: on average, $>$50 participants each survey round between 1999 and 2017.
- Examples ECB-SPF: *Allianz SE, ifo Institute for Economic Research, Société Générale, ...*
- FED-SPF: on average, $>$30 participants each survey round between 1999 and 2017.
- Examples FED-SPF: *Oxford Economics USA, Inc., IHS Markit, Johns Hopkins University Center for Financial Economics, ...*

Moments of histogram forecasts – mean

- Participants $i = 1, ..., N$ assign probabilities $p_{i,k,t,h}$ to $k = 1, ..., K$ pre-specified outcome intervals, the 'bins'.
- We assume for each bin that all probability mass is concentrated at its center ('Mass-at-midpoint', Lahiri et al., 1988; Kenny et al., 2015).
- Mean of forecaster i's histogram is given by

$$\mu_{i,t,h} = \frac{1}{100} \sum_{k=1}^{K} p_{i,k,t,h} \times \mathfrak{m}_k,$$

with $\mathfrak{m}_k$ denoting the midpoint of the k-th bin.
- The h-step-ahead 'consensus' forecast is given by

$$\bar{\mu}_{t,h} = \frac{1}{N} \sum_{i=1}^{N} \mu_{i,t,h}.$$

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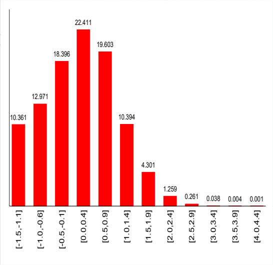
- Mean of forecaster



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Moments of histogram forecasts – variance

- Based on the means from Eqn. (1), we calculate the individual variance according to

$$\sigma^2_{i,t,h} = \frac{1}{100} \sum_{k=1}^{K} p_{i,k,t,h} \times (\mathfrak{m}_k - \mu_{i,t,h})^2.$$

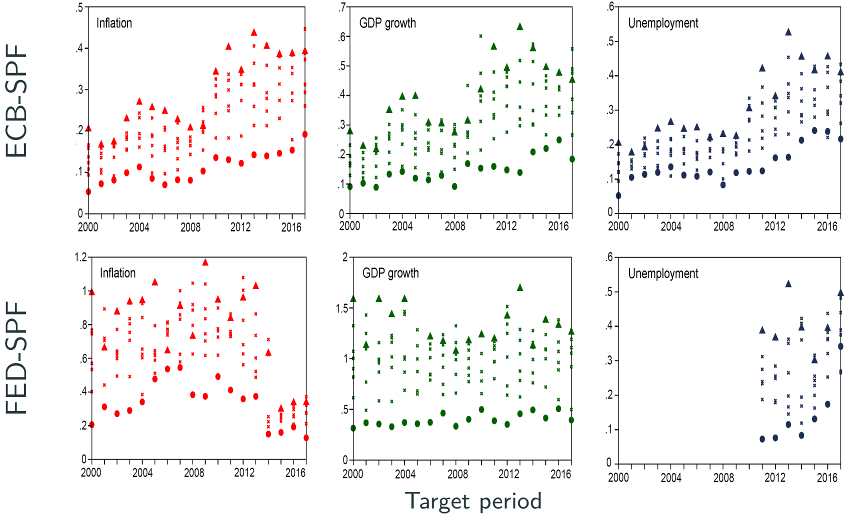
as an ex-ante measure of individual uncertainty.

- Consensus ex-ante uncertainty obtains as

$$\overline{\sigma^2_{t,h}} = \frac{1}{N} \sum_{i=1}^{N} \sigma^2_{i,t,h},$$

the ex-ante uncertainty of the consensus forecast $\bar{\mu}_{t,h}$ as proposed by Lahiri and Sheng (2010).

Consensus ex-ante uncertainty



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Rounders vs. Non-rounders – Classification schemes

Integer-based categorization

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- Consider a histogram forecast by forecaster $i = 1, \dots, N$, consisting of probabilities, $p_{i,k}$, for outcome intervals ('bins') $k = 1, \dots, K$.
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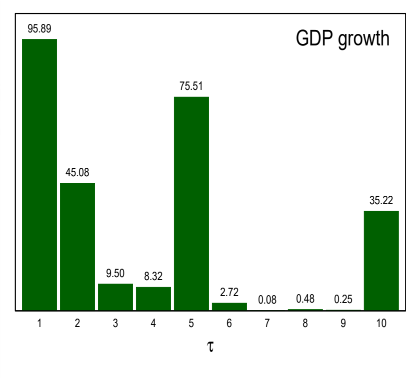

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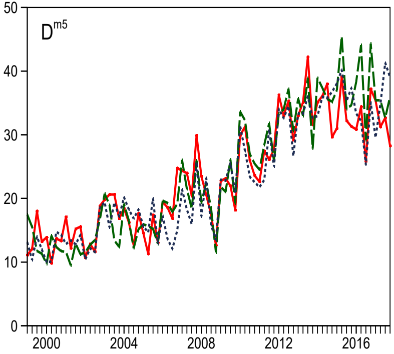
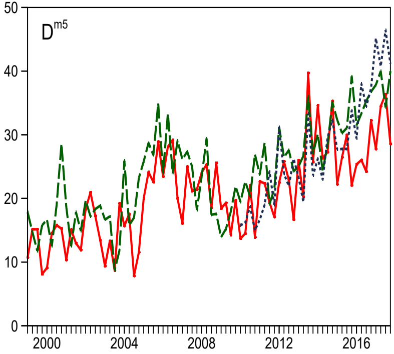
Time-variation in the share of non-rounded histograms

ECB-SPF



Survey period

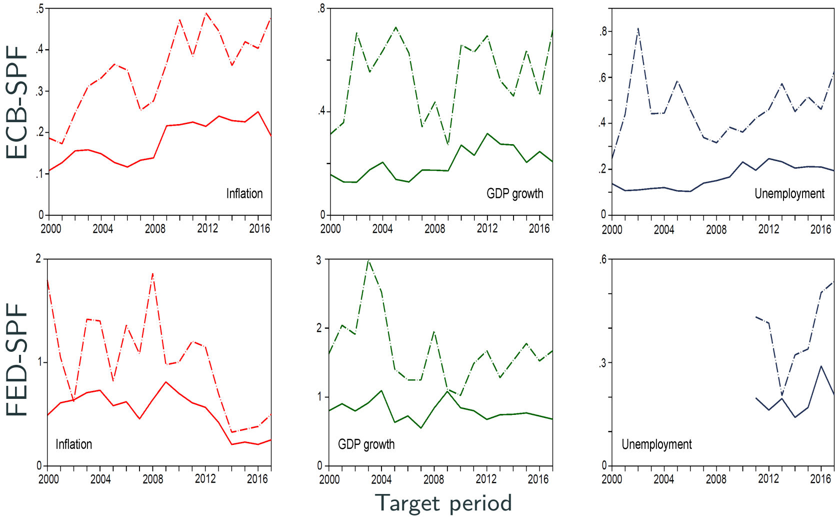
FED-SPF



Survey period

Notes: These graphs depict the time series of the share of non-rounded observations in the ECB- (left) and FED-SPF (right) for inflation, output growth and unemployment. The sample period is 1999Q1-2017Q4, except for the unemployment rate forecasts from the FED-SPF, which are available since 2010Q1 for our purposes.

Average ex-ante uncertainty for $h = 4$



Dashed lines: uncertainty from non-rounded forecasts,
solid lines: uncertainty from rounded forecasts.

Rounding and variance misalignment

Horizon-specific variance misalignment

- Individuals' ex-ante uncertainty at horizon h is computed as:

$$\overline{\sigma^2_{i,h}} = \frac{1}{T_{i,h}} \sum_{t=1}^{T_{i,h}} \sigma^2_{i,t,h}$$

- Ex-post uncertainty is defined as the mean squared error:

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- Average misalignment ratio (Clements, 2014):

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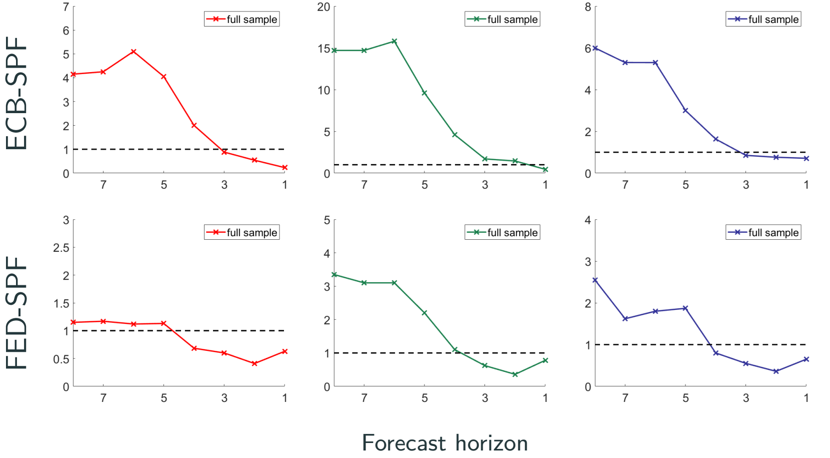
Variance misalignment



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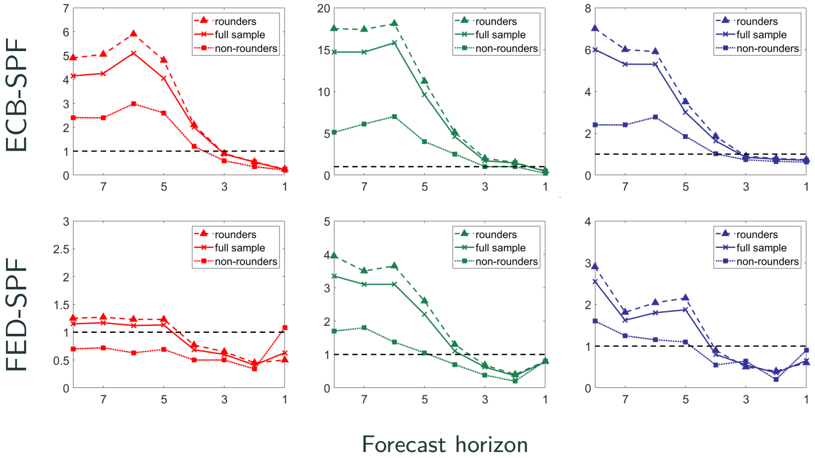

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Sources of misalignment

For $h \in \{8, \ldots, 1\}$, we estimate

$$y_{i,t,h} = \alpha_h + \beta_h D^{\text{m5}}_{i,t,h} + \gamma_{2,h} D2_{t,h} + \ldots + \gamma_{T,h} DT_{t,h} + \varepsilon_{i,t,h}.$$

- Histogram characteristics $y_{i,t,h}$ include
  - variables related to ex-ante uncertainty ($K^\star_{i,t,h}$, $\sigma^2_{i,t,h}$) and
  - variables related to ex-post uncertainty ($|e_{i,t,h}|$, $e^2_{i,t,h}$)
- $K^\star_{i,t,h} \in \{0, \ldots, K\}$: Number of bins containing nonzero probability
- Time-fixed effects $D2_{t,h}, \ldots, DT_{t,h}$
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Misalignment ratio

$$m_h = \frac{1}{N_h} \sum_{i=1}^{N_h} \frac{\text{MSE}_{i,h}}{\overline{\sigma^2_{i,h}}}$$

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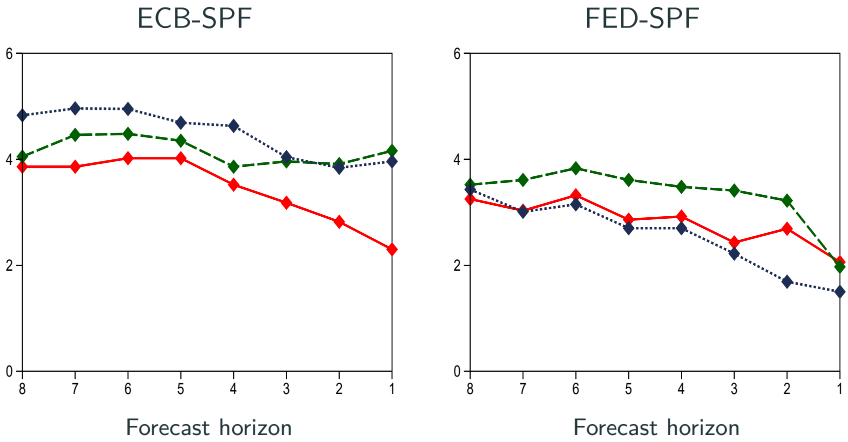
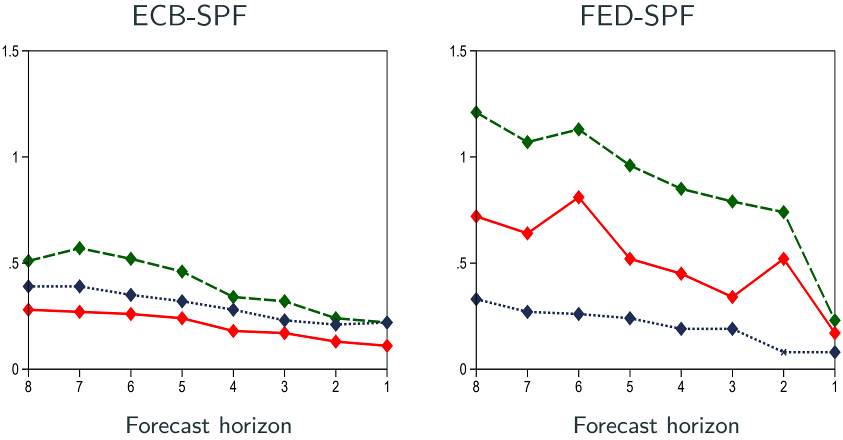
Deviations in $K^{\star}_{i,t,h}$



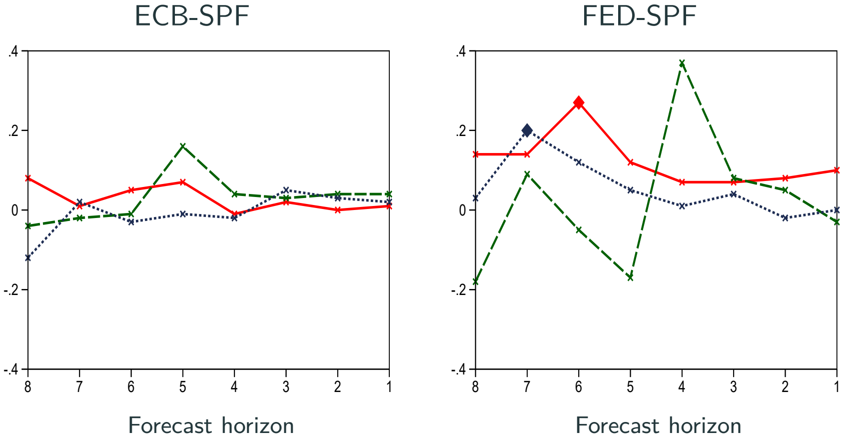
Notes: For each h, the graphs depict the estimates of β_h for inflation, output growth and unemployment in the ECB- (left) and FED-SPF (right) when $K_{i,t,h}$ is considered as the dependent variable. A diamond "$\diamond$" indicates that the estimate is significantly different from zero at the 5% level. A cross "$\times$" marks an insignificant estimate. The sample period is 1999Q1-2017Q4, except for the unemployment rate forecasts from the FED-SPF, which are available since 2010Q1 for our purposes.

Deviations in $\sigma^2_{i,t,h}$



Notes: For each h, the graphs depict the estimates of β_h for inflation, output growth and unemployment in the ECB- (left) and FED-SPF (right) when $\sigma^2_{i,t,h}$ is considered as the dependent variable. A diamond "$\diamond$" indicates that the estimate is significantly different from zero at the 5% level. A cross "$\times$" marks an insignificant estimate. The sample period is 1999Q1-2017Q4, except for the unemployment rate forecasts from the FED-SPF, which are available since 2010Q1 for our purposes.

Deviations in $e^2_{i,t,h}$



Notes: For each h, the graphs depict the estimates of β_h for inflation, output growth and unemployment in the ECB- (left) and FED-SPF (right) when $e^2_{i,t,h}$ is considered as the dependent variable. A diamond "$\diamond$" indicates that the estimate is significantly different from zero at the 5% level. A cross "$\times$" marks an insignificant estimate. The sample period is 1999Q1-2017Q4, except for the unemployment rate forecasts from the FED-SPF, which are available since 2010Q1 for our purposes.

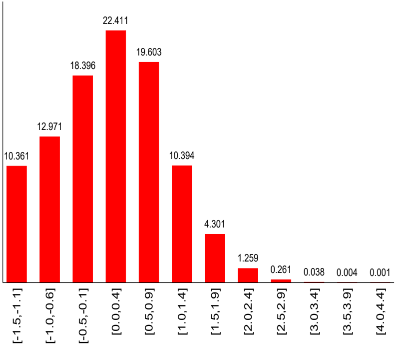
Discussion – Direct effect of rounding

Counterfactual rounding of non-rounded histograms

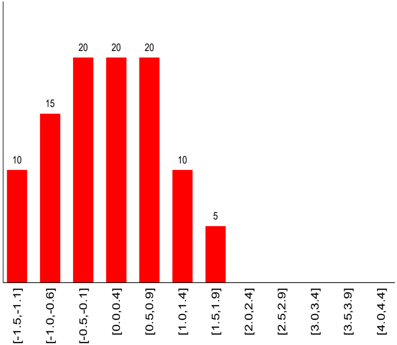
- We have seen: Rounding indicates deficiencies in ex-ante uncertainty.
- Rounded forecasts are often forecasts with very few bins.
- Next: Isolate direct effect of rounding.
- Strategy:
  - Consider forecasts that are non-rounded.
  - Round the reported probabilities in all bins to the nearest multiple of 5.
  - Obtain counterfactual uncertainty $\sigma^2_{i,t,h}(Co)$.
  - Compare reported ex-ante uncertainty $\sigma^2_{i,t,h}$ with $\sigma^2_{i,t,h}(Co)$.

Counterfactual rounding of non-rounded histograms

As reported:



Artificially rounded:

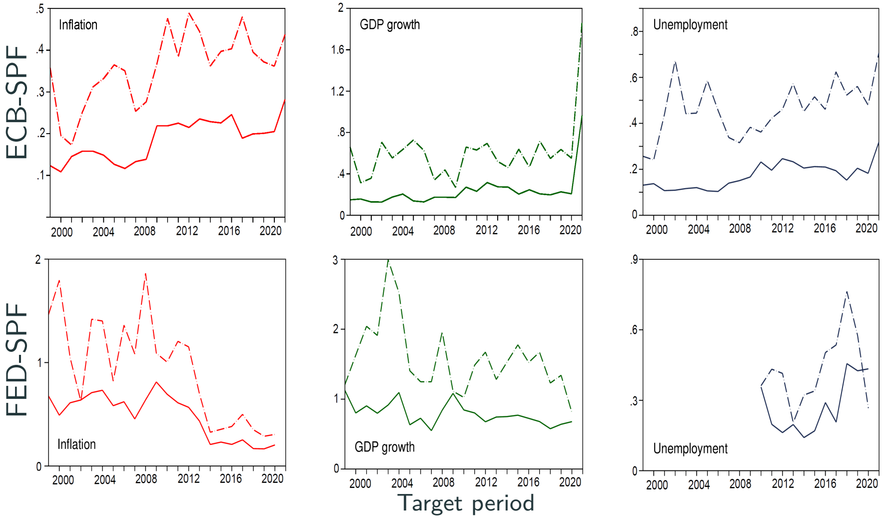


$\Rightarrow$ Both $K_{i,t,h}$ and $\sigma^2_{i,t,h}$ decline: $\sigma^2_{i,t,h} = 0.72$, $\sigma^2_{i,t,h}(Co) = 0.67$.

$\Rightarrow$ Holds for the full sample as well: Reduction of 7%-10% (ECB-SPF) and 10%-11% (FED-SPF), depending on outcome variables.

Discussion – SPF forecasts in the COVID-19 environment

Average ex-ante uncertainty for $h = 4$ until 2021Q1

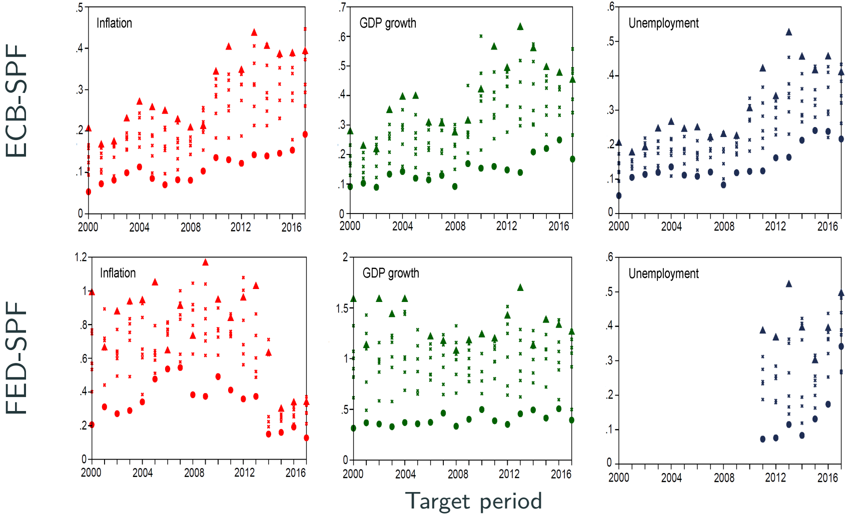


Dashed lines: uncertainty from non-rounded forecasts,

solid lines: uncertainty from rounded forecasts.

Discussion – Bin width and ex-ante uncertainty

Consensus ex-ante uncertainty

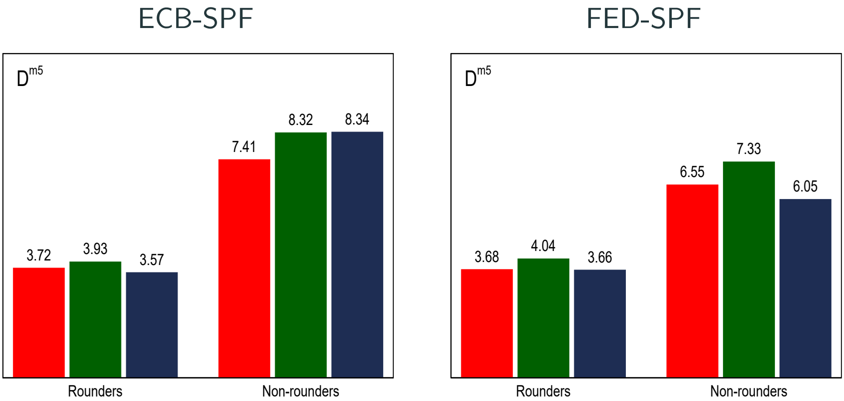


Notes: Graphs depict the cross-sectional averages over the variances derived from the individual histograms, i.e. $\sigma^2_{i,t,h}$, at forecast horizons $h \in \{8, 7, \ldots, 1\}$. Triangles "$\triangle$" depict the 8-step-ahead variance forecasts and bullets "$\bullet$" the 1-step-ahead variance forecast. The sample period is 1999Q1-2017Q4.

Bin widths in percentage points

	Inflation	GDP growth	Unemployment rate
ECB-SPF	0.4	0.4	0.4
FED-SPF	0.9	0.9	0.4
	0.4 from 2014Q1		

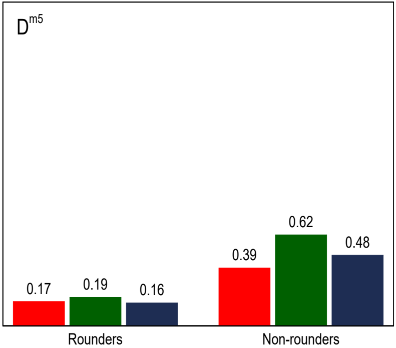
Average numbers of bins



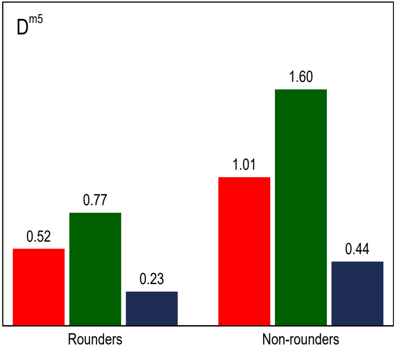
Notes: $\bar{K} = \frac{1}{NTH} \sum_{i=1}^{N} \sum_{t=1}^{T} \sum_{h=1}^{H} K_{i,t,h}$. Results are depicted for the ECB- (first row) versus FED-SPF (second row) and variables inflation, output growth and unemployment. The sample period is 1999Q1-2017Q4, except for the unemployment rate forecasts from the FED-SPF, which are available since 2010Q1 for our purposes.

Average variance

ECB-SPF



FED-SPF



Notes: $\overline{\sigma^2} = \frac{1}{NTH} \sum_{i=1}^{N} \sum_{t=1}^{T} \sum_{h=1}^{H} \sigma^2_{i,t,h}$. Results are depicted for the ECB- (first row) versus FED-SPF (second row) and variables inflation, output growth and unemployment. The sample period is 1999Q1-2017Q4, except for the unemployment rate forecasts from the FED-SPF, which are available since 2010Q1 for our purposes.

Pooled ex-post uncertainty

Pooled MSE for the ECB- and the FED-SPF

	Inflation	GDP growth	Unemployment
	Full sample MSE		
ECB-SPF	0.46	1.59	0.48
FED-SPF	0.41	1.28	0.26
	Excluding 2009		
ECB-SPF	0.37	0.77	0.37
FED-SPF	0.36	0.79	0.26

Cells contain pooled MSE statistics computed as
$\overline{MSE} = \frac{1}{NTH} \sum_{i=1}^{N} \sum_{t=1}^{T} \sum_{h=1}^{H} e_{i,t,h}^2$.

Conclusion

- Rounding as a reliable indicator of misalignment between ex-ante and ex-post variances
- Empirically, we confirm that rounders in the SPF...
  - ...use fewer of the available bins and report smaller ex-ante variances than the non-rounders
  - ...do not differ in terms of forecast errors from the non-rounders
- Consensus ex-ante uncertainty based solely on non-rounders is about twice as high as overall consensus, also distinct dynamics.
- Understanding behavior of rounders means explaining data features after 2020/2021.
- Role of bin width should be investigated – Not the aim of this paper.