Reading between the lines - Using text analysis to estimate the loss function of the ECB

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ECB's definition of price stability

- In 1998, the ECB Governing Council defined price stability as a
  - *'year-on year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2% '*
- In 2003, the GC clarified that
  - *'in the pursuit of price stability it aims to maintain inflation rates below, but close to, 2% over the medium term'.*
- In July 2021, the GC adopted a new definition of price stability
  - *'[GC] considers that price stability is best maintained by aiming for a 2% inflation target over the medium term. This target is symmetric, meaning negative and positive deviations of inflation from the target are equally undesirable. '*

This paper: 'Symmetric 2%' vs.'Below but close to 2%'

- We try to assess to what extent the ECB's new definition of price stability is likely to change the ECB's policy preferences.
- New definition of price stability implies that from now onwards the ECB's loss function will be
  - symmetric
  - with a bliss point at 2.0%
- The now 'old' definition was less clear, and open to interpretation.
  - One cannot infer the ECB's loss function based on the 'old' definition of price stability only.

Key questions

- We estimate the ECB's loss function under the old definition of price stability.
- Key questions:
  1. Was the loss function symmetric or asymmetric with respect to inflation?
  2. Was the bliss point 2.0%? If not, how much did it differ from 2.0%?
- Addressing these questions allows us to compare the ECB's old and new definitions of price stability.

Reading between the lines

- What does qualitative communication reveal about the ECB GC's preferences?
- How semantic content of ECB's introductory statements and the Eurosystem/ECB staff macroeconomic projections are related?
- Shapiro and Wilson (RES, forthcoming) approach
  - Apply text mining techniques (language processing) to introductory statements in order to infer the ECB's preferences directly
  - Construct net negativity index (tone) which measures the sentiment (positive, negative) in the introductory statements
    - Use it as a proxy for the loss in order to estimate parameters of the loss function

Text analysis vs. reaction function estimations

- The new definition of price stability implies that the ECB's *loss function* should be symmetric, with a bliss point at 2.0%
  - This does not necessarily mean that the reaction function will be symmetric. For example the ELB may imply asymmetric reactions (even outside the ELB).
- Inferring the loss function from the reaction function involves making assumptions about the overall structure of the economy.
- Reaction function estimations should
  - end at the ELB (2014 Q2 for the euro area)
  - or rely on highly uncertain shadow rate estimates

Net negativity index (tone)

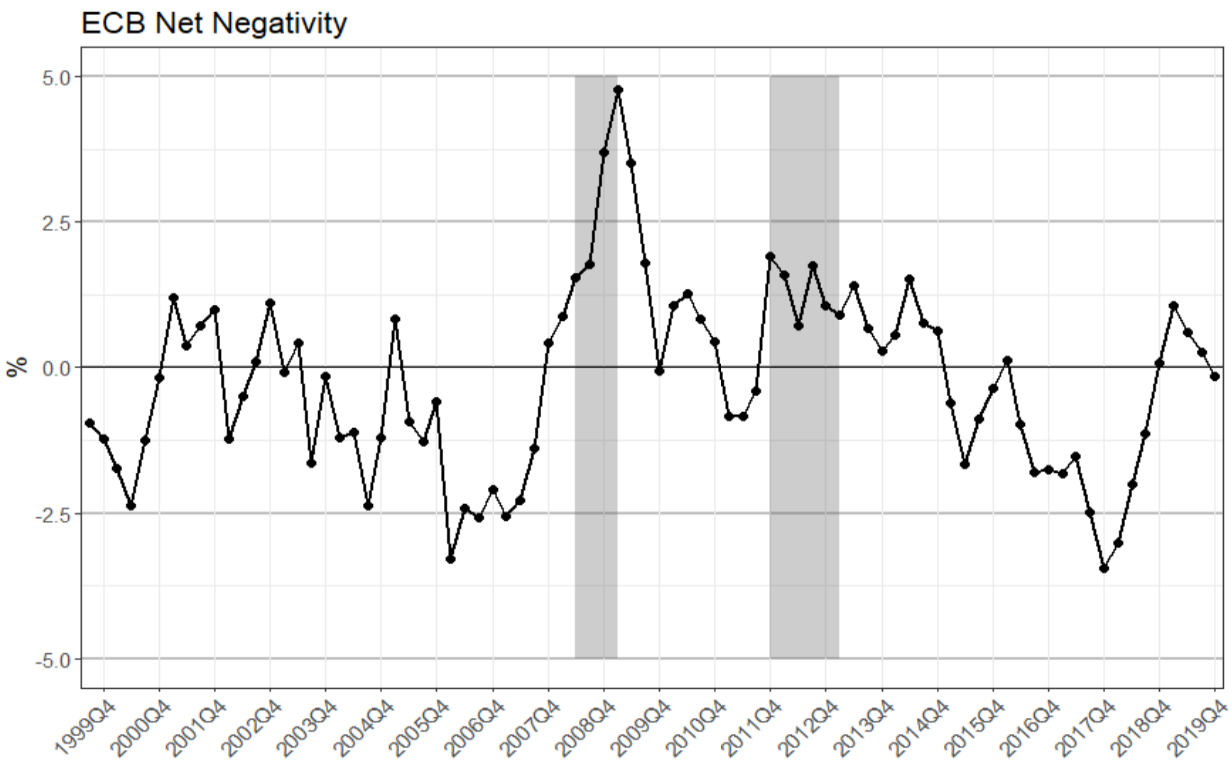
- Use Loughran & McDonald (2011) finance-specific dictionary
- Calculate the difference of the number of negative and positive words, normalized with the total number of words in the ECB introductory statement:

$$N_t = \frac{\#Neg - \#Pos}{\#Tot} \tag{2}$$

Example: Positive, Negative
'The risks surrounding the economic outlook for the euro area continue to be on the downside. In particular, the weakening in the euro area's growth momentum, alongside heightened geopolitical risks, could dampen confidence and, in particular, private investment. In addition, insufficient progress in structural reforms in euro area countries constitutes a key downward risk to the economic outlook.'

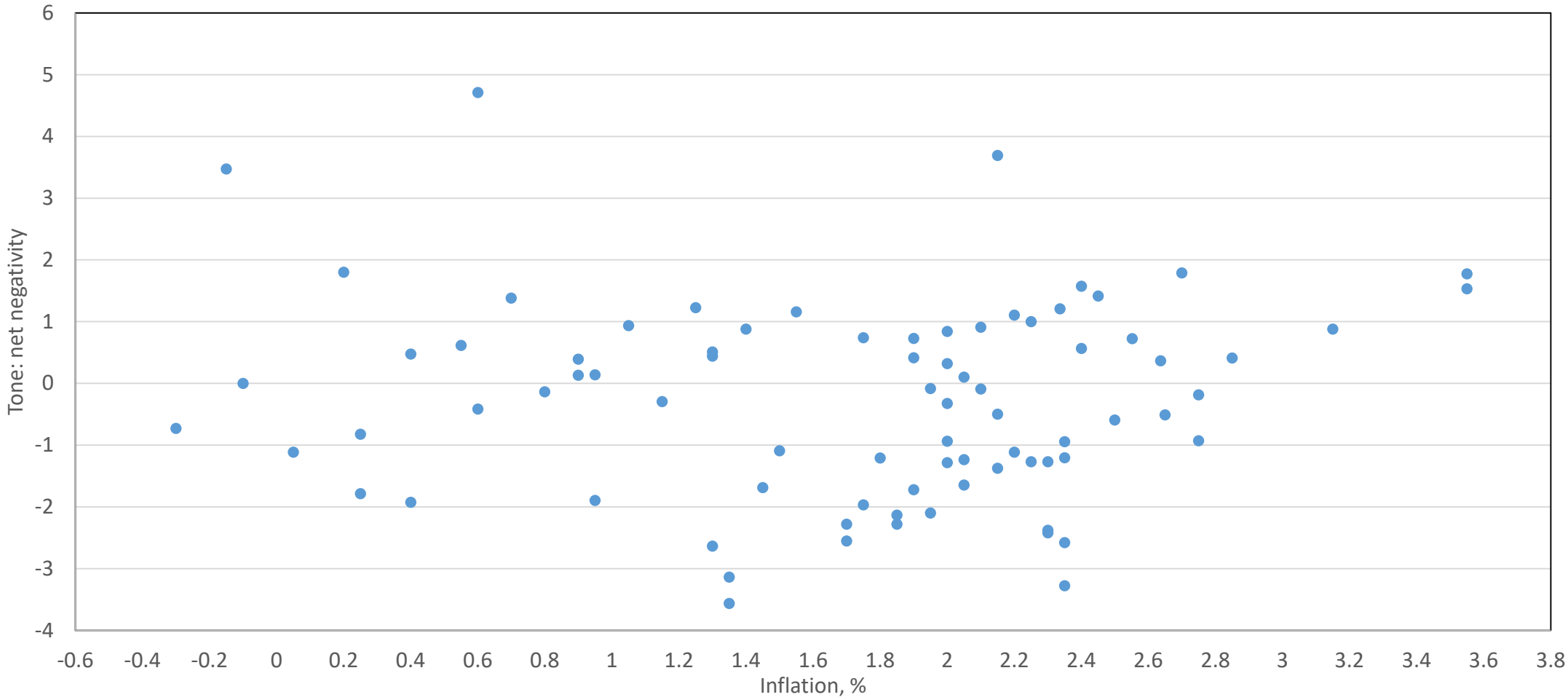
- Handling negations: e.g. *insufficient progress*

Tone (net negativity)

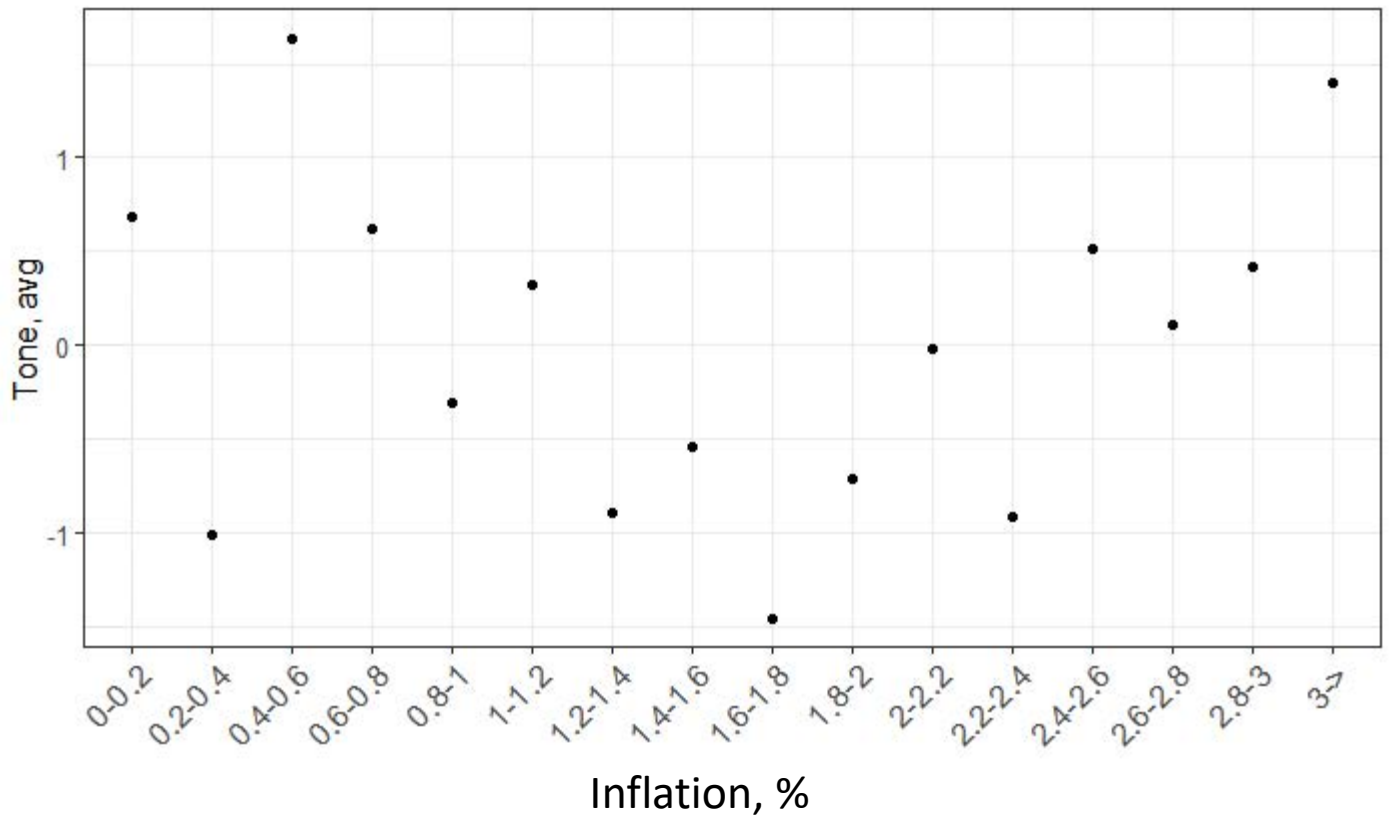


- Decreasing before the financial crisis
- After the peak in the middle of the financial crisis, a gradual fall (increasingly more positive) until the end of 2017
- European debt crisis also associated with increased net negativity

Tone and inflation



Tone and inflation: averages in 0.2 pp buckets



Constructing loss function

- Assume that CB's loss is a function of deviation of inflation from the target such that

$$L_t = |\pi - \pi^*| \tag{3}$$

- and that we can relate the tone to this loss such that

$$N = \alpha + \delta L \tag{4}$$

- Then we can attempt to estimate a loss function (ref. reaction function) such that

$$N_t = \alpha + \boldsymbol{\delta} |\pi_t - \pi^*| + \epsilon_t \tag{5}$$

- δ parameter reveals how strongly the CB feels about inflation deviating from the target
- We can also attempt to estimate π^*

Extension to analyse asymmetry

- Split the right hand side into two separate segments (piecewise linear loss function)

$$N_t = \alpha + \delta_B \tilde{\pi}_t (1 - D) + \delta_A \tilde{\pi}_t D + \varepsilon_t \tag{6}$$

- add the output gap terms

$$N_t = \alpha + \delta_B \tilde{\pi}_t (1 - D) + \delta_A \tilde{\pi}_t D + \beta_1 \Delta \tilde{y}_t + \beta_2 \Delta \tilde{y}_t^{\,2} + \varepsilon_t \tag{7}$$

- . . . and we can estimate (and test) directly the degree of asymmetry in the CB's preferences.

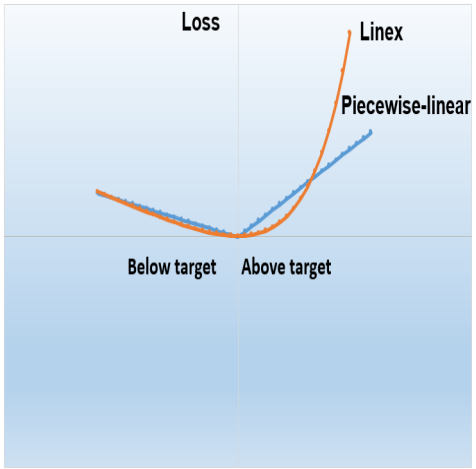
Extension with Linex (linear exponential) loss function

- Piecewise linear loss function does not allow any convexity in the preferences, so we consider also Linex loss function such that

$$N_t = \alpha + \gamma \frac{exp\left[\theta\left(\pi_t - \pi^*\right)\right] - \theta\left(\pi_t - \pi^*\right) - 1}{\theta^2} + \varepsilon_t \tag{8}$$

- Larger the parameter θ, more averse the CB is for inflation rates above the target (asymmetry is captured by one parameter)

Right hand side variables



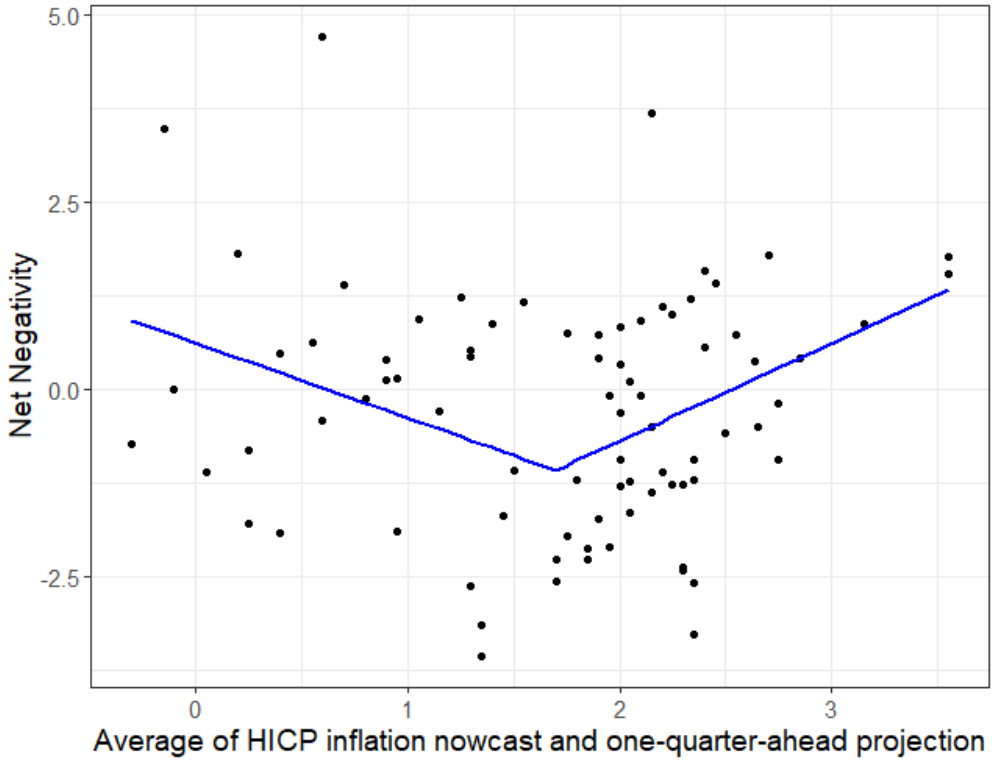
- We use short run *real time* Eurosystem/ECB staff macroeconomic projections for inflation and output gap (BMPE/MPE)
  - *The average of the inflation nowcast and one-quarter-ahead projected inflation rate*
  - *The average of the output gap nowcast and one-quarter-ahead projected output gap*
- We either fix or estimate the *"de facto"* inflation target

Overview of Results

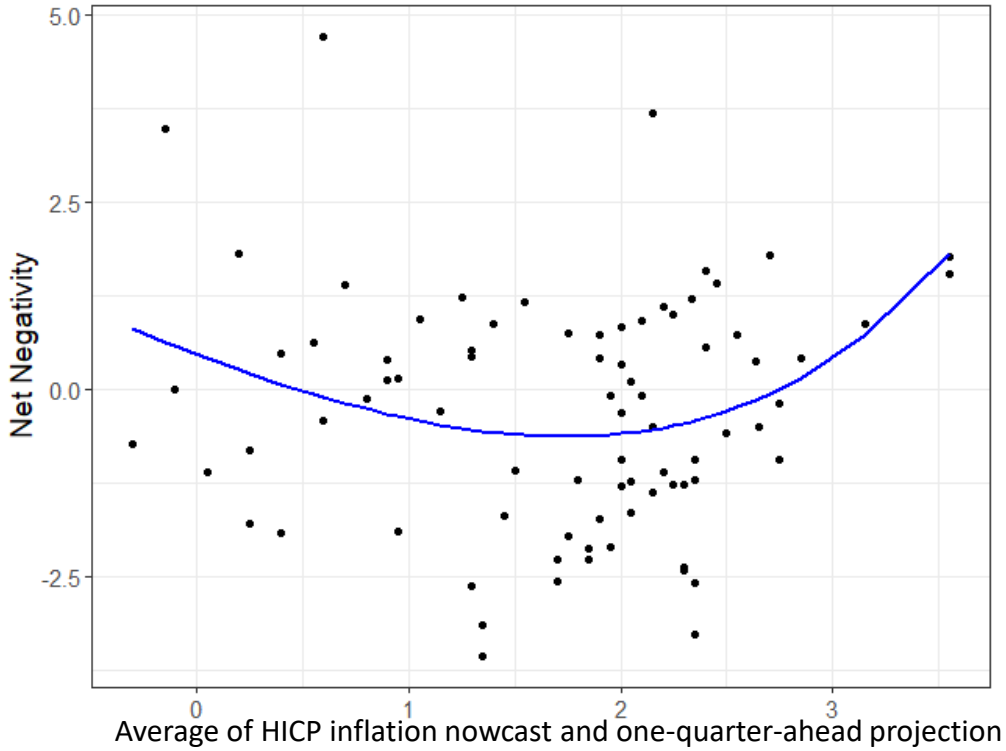
- The ECB has been either more averse to inflation above 2% or *"de facto"* inflation aim has been considerably below 2%
  - Results are robust to
    - the tone measure (general/inflation specific)
    - the functional form of the loss function (piecewise linear/Linex)
    - inclusion/exclusion of output gap terms to the loss function

Estimated loss functions

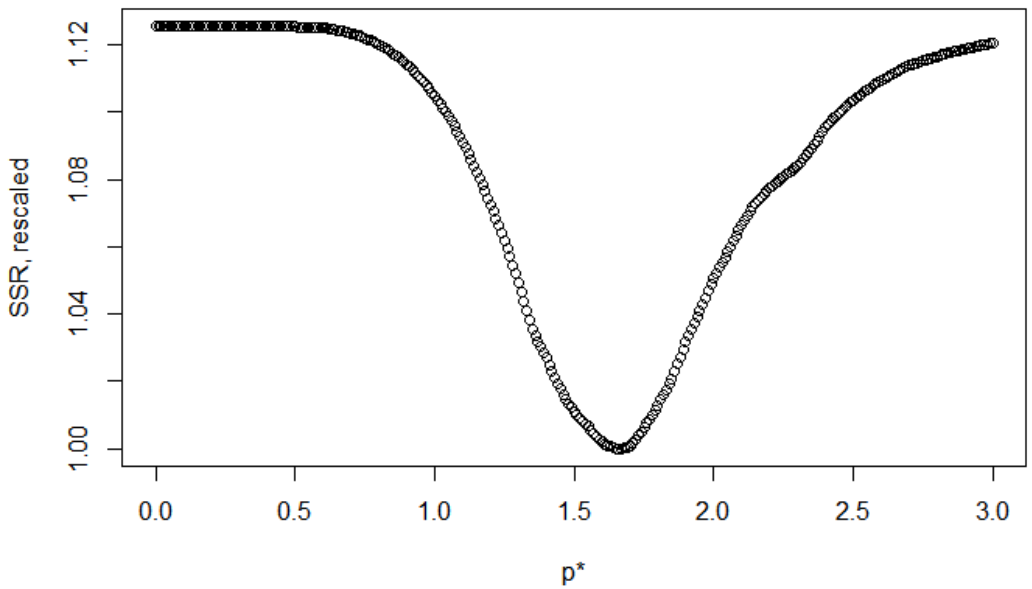
V-shaped



Linex



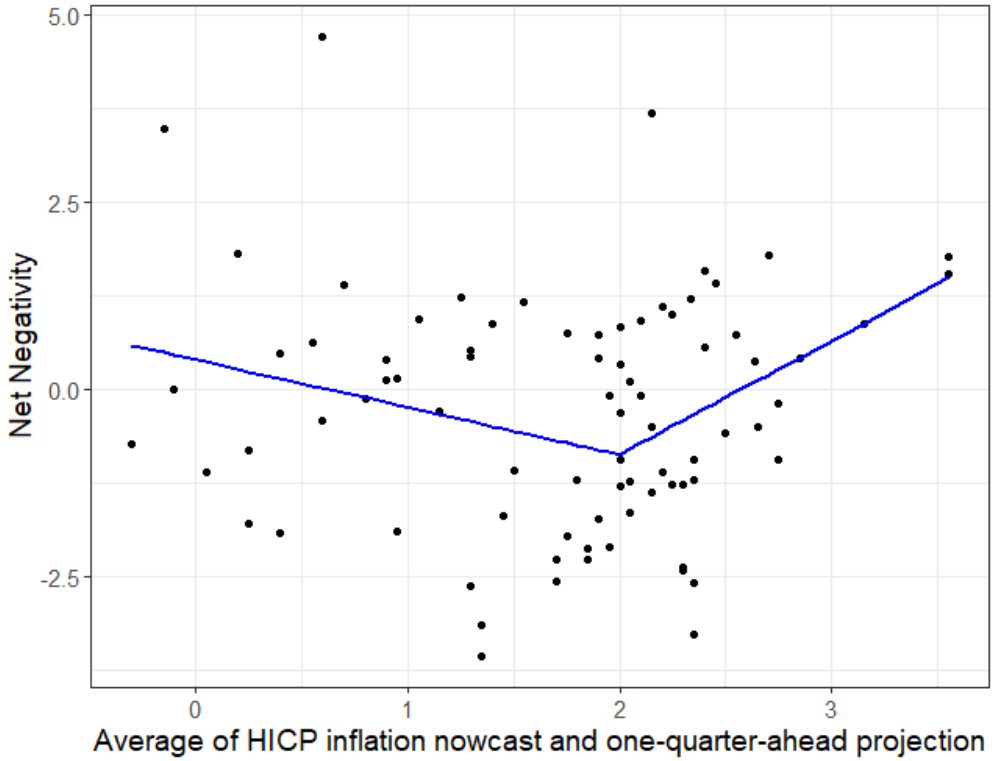
Selecting the de facto inflation target π*



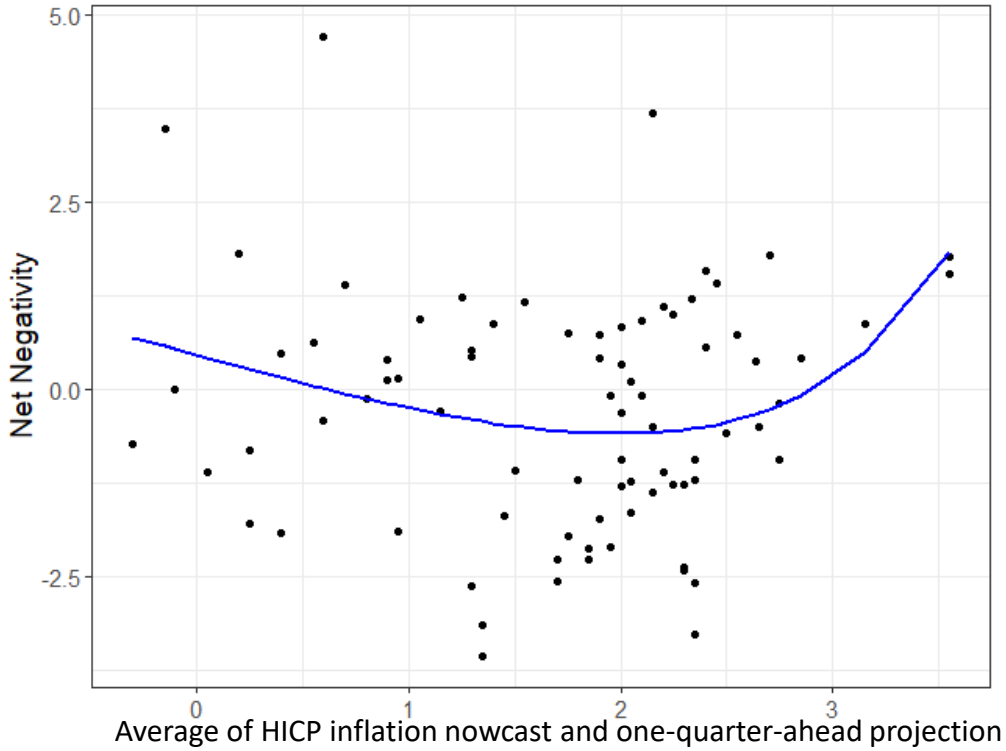
- Grid search
- Selection criterion: minimize the sum of squared residuals (SSR)

Estimated loss functions: π* set to 2.0%

V-shaped



Linex



Estimated Piecewise-Linear loss function, general tone

	(1) Symmetric V	(2) Symmetric V	(3) Asymmetric V	(4) Asymmetric V	(5) Asymmetric V	(6) Asymmetric V	(7) Asymmetric V	(8) Asymmetric V
α	-1.0552***	-1.5695***	-1.0909***	-1.6508***	-1.0776***	-0.8711***	-1.4469***	-1.4895***
δ	1.1035***	0.7475***						
$\delta_B\ (D=0)$			-1.0392***	-0.5477*	-0.9977***	-0.6342**	-0.2216	-0.3086
$\delta_A\ (D=1)$			1.2525***	1.0967***	1.3002***	1.5286***	2.2903***	1.6002***
β_1		-1.2599***		-1.2286**			-1.3024***	-1.3154***
β_2		-0.1161**		-0.0970*			-0.1054**	-0.1097**
Observations	81	81			81	81	81	81
Adjusted R^2	0.1	0.50	0.09	0.51	0.09	0.08	0.55	0.58
$\widehat{\pi^*}$	1.66	1.66			1.70		2.3	
π^*_{fixed}			1.66	1.66		2		2
F-test symmetry p-value	-	-	0.6032	0.082*	0.4684	0.0897*	0.0001***	0.0014***
Likelihood-ratio test						0.1204		0.2218
95% C.I.	[1.30, 1.95]	[0.11, 2.05]						

95% confidence interval is obtained using bootsrap procedure

Likelihood − ratio test is performed between restricted model (π^*_{fixed}) and unrestricted model ($\widehat{\pi^*}$)

$^*p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

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Estimated Linex loss function, general tone

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
α	-0.6629***	-0.6555***	-0.6063***	-0.6477***	-1.3352***	-1.3300***	-1.2888***	-1.3391***
θ	0.420	0.4986	1.1463**	0.5815	1.1768	1.2322	1.8470**	1.1372
γ	1.0600***	1.0585***	1.0396***	1.056***	0.6180	0.6287	0.6492	0.6072
β_1					-0.1018**	-0.1028**	-0.1064**	-0.1009**
β_2					-1.2683***	-1.2701***	-1.2763***	-1.2667***
Observations	81	81	81	81	81	81	81	81
$\widehat{\pi^*}$				1.74				1.63
π^*_{fixed}	1.66	1.70	2		1.66	1.70	2	
Likelihood-ratio test p-value	0.7895	0.8924	0.4417		0.913	0.807	0.2255	

Likelihood − ratio test is performed between restricted model (π^*_{fixed}) and unrestricted model ($\widehat{\pi^*}$)
$*p < 0.10, **p < 0.05, ***p < 0.01$

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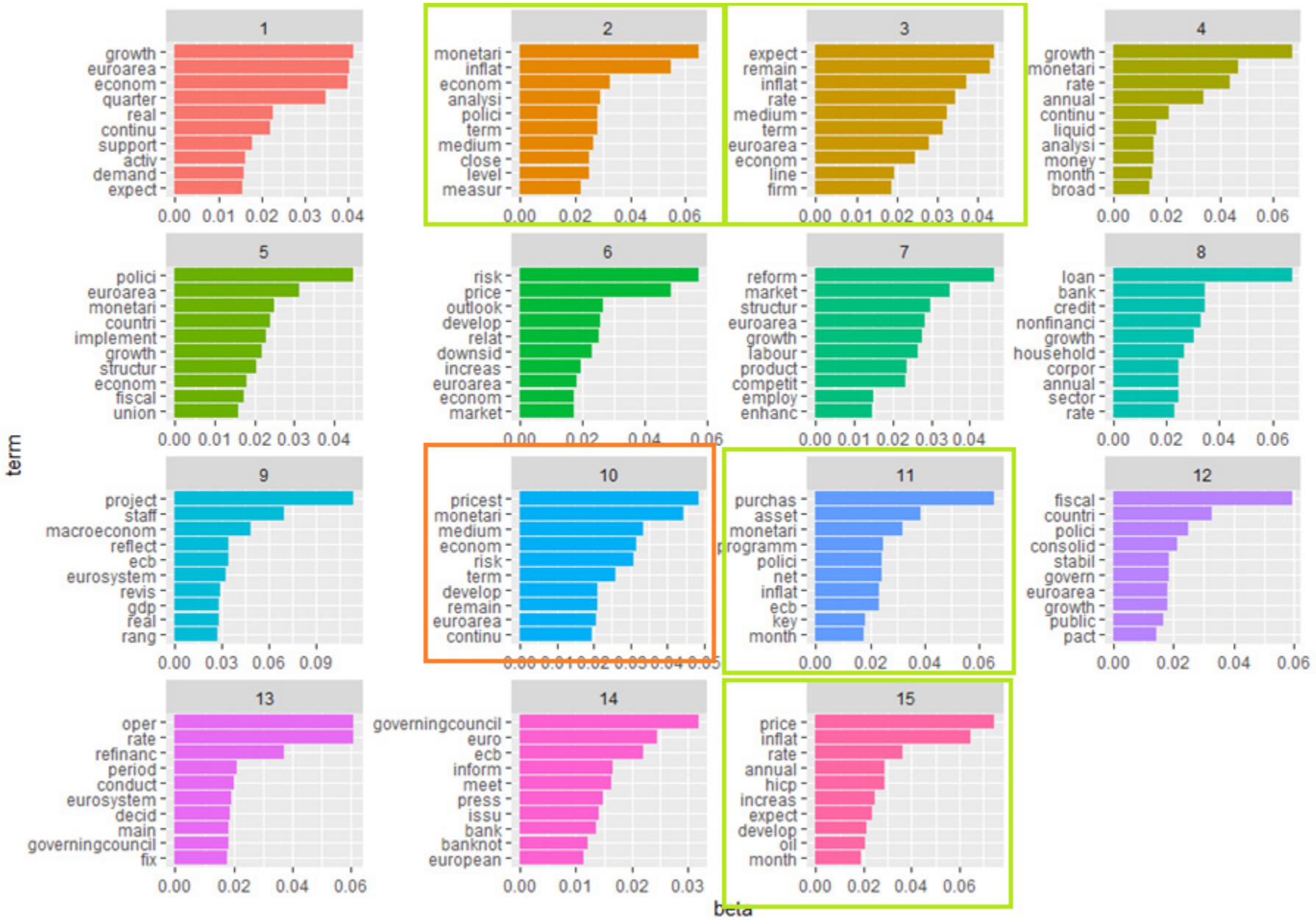
Alternative tone based on inflation texts

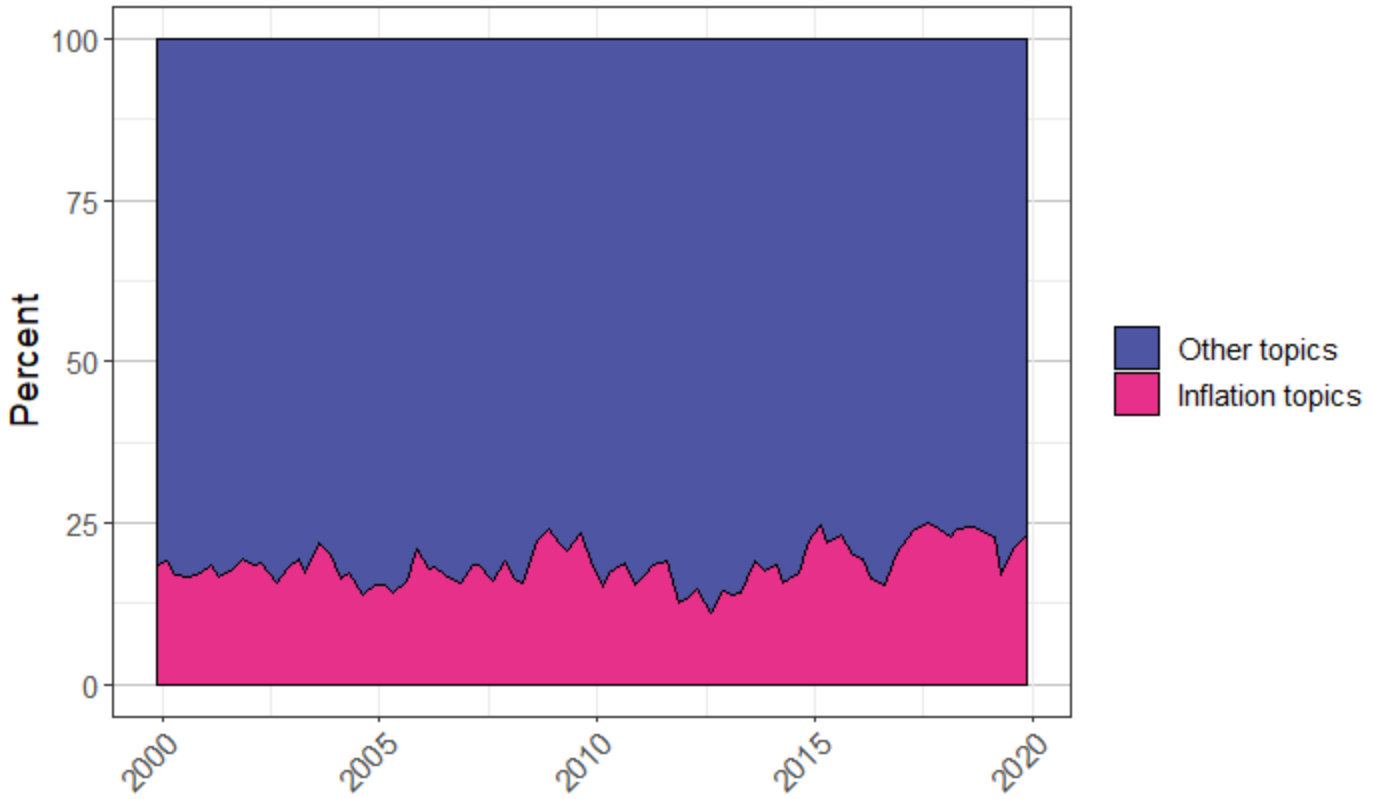
- We repeat our estimations using an alternative proxy for the ECB's tone.
- We focus on a subsample of the total corpus associated only with inflation
- We extract paragraphs of the introductory statements concerning inflation by employing Latent Dirichlet Allocation (LDA)
- Then, we calculate the tone (net negativity) based on these inflation relevant texts.

Topics discovered by LDA

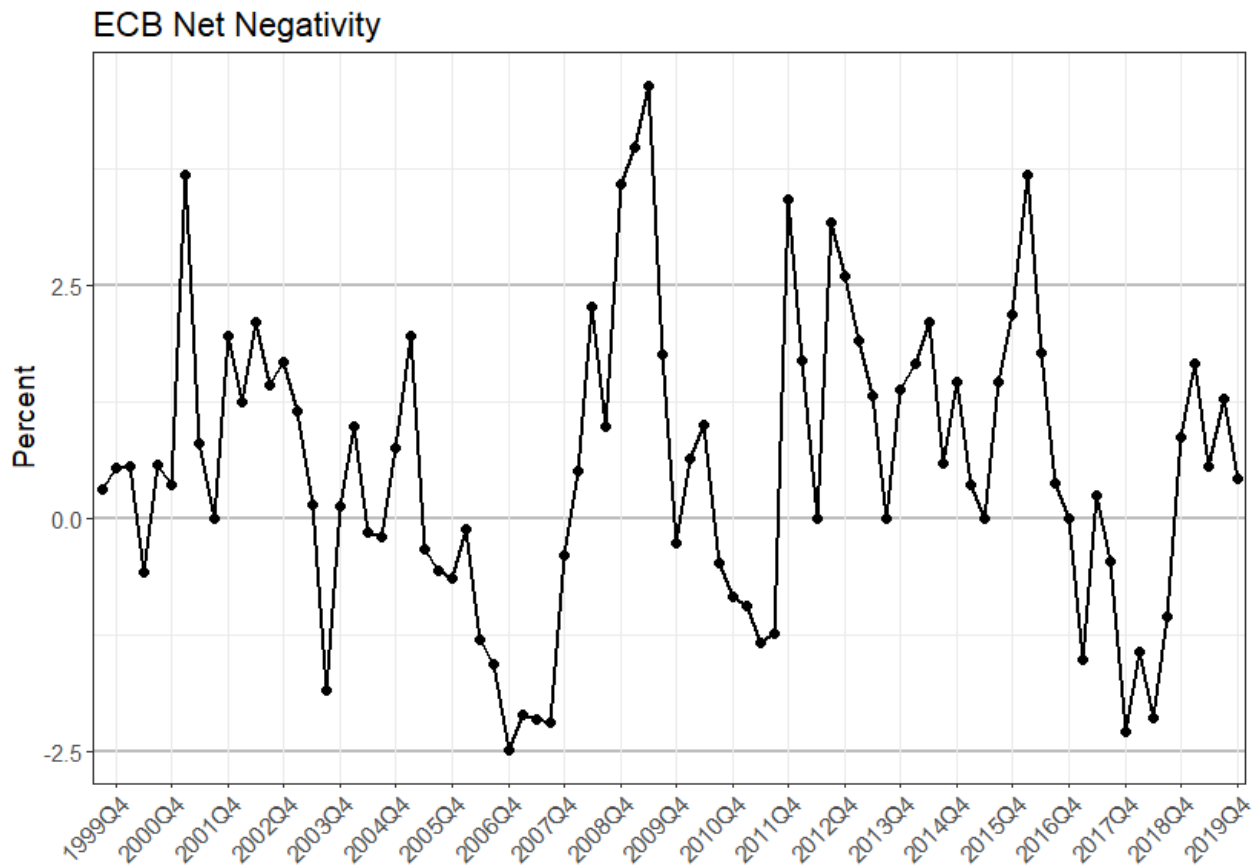
Infaltion texts:
Topics 2, 3, 10, 11, 15



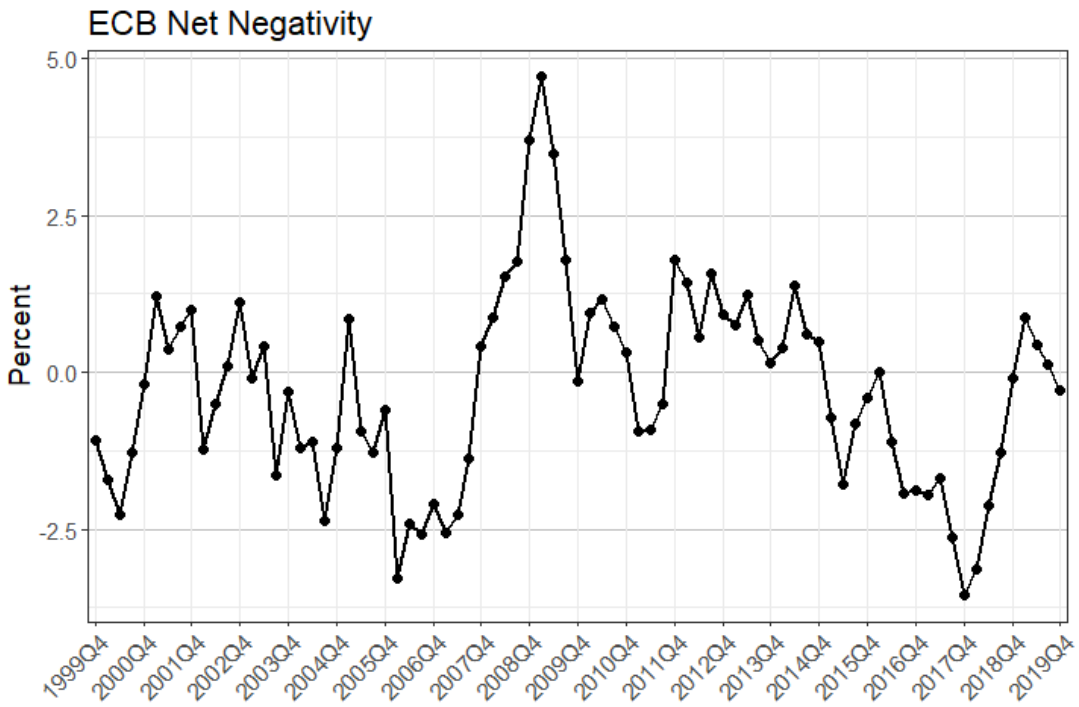
Fractions of topics in the ECB's introductory statements



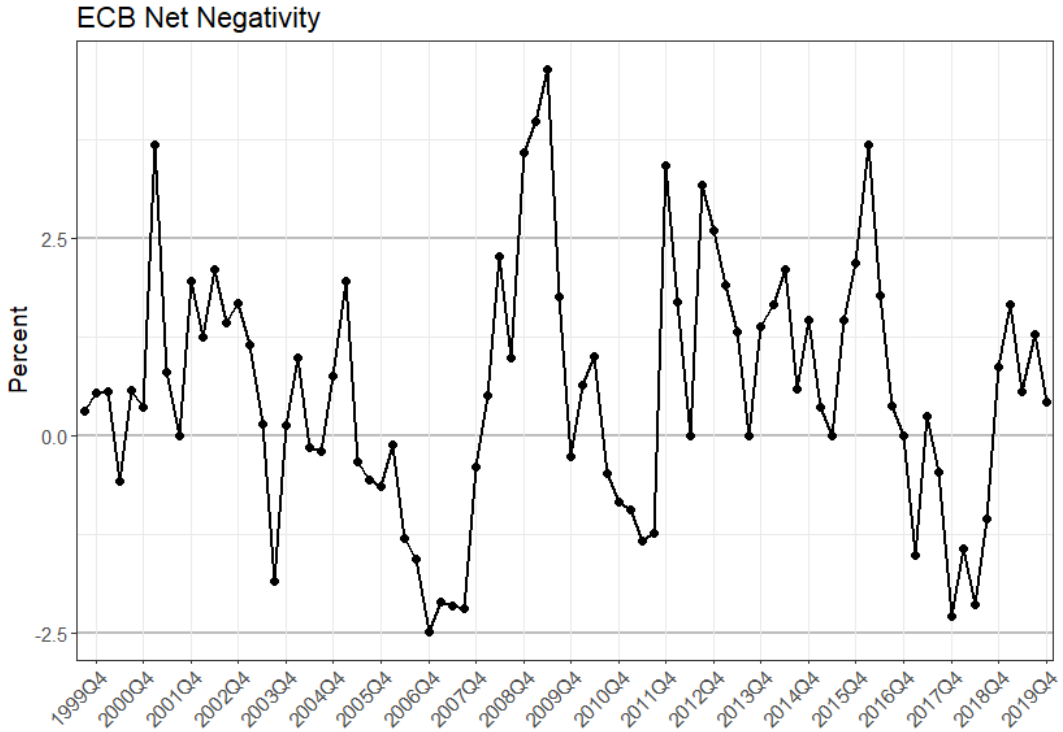
Alternative tone based on inflation texts



General tone



Alternative tone



Estimated V-shaped loss function: Alternative tone

	(1) Symmetric V	(2) Asymmetric V	(3) Asymmetric V	(4) Asymmetric V
α	0.3214	0.3263	0.3166	0.4999*
δ	0.8474**			
$\delta_B\ (D=0)$		-0.8108**	-0.8392**	-0.4976*
$\delta_A\ (D=1)$		0.8871*	0.8678*	0.965
Observations	81	81	81	81
Adjusted R^2	0.05	0.04	0.04	
$\widehat{\pi^*}$	1.67	1.70		
π^*_{fixed}			1.67	2
F-test symmetry p-value	-	0.8607	0.9469	0.4205
Likelihood-ratio test				0.7979

$Likelihood-ratio\ test\ is\ performed\ between\ restricted\ model\ (\pi^*_{fixed})\ and\ unrestricted\ model\ (\widehat{\pi^*})$

$*p<0.10, **p<0.05, ***p<0.01$

Estimated Linex loss function: Alternative tone

	(1)	(2)	(3)	(4)
α	0.0064***	0.006***	0.007***	0.0065
θ	0.1936	0.2544	0.9090	0.4771
γ	0.0078*	0.0078*	0.0080*	0.0078*
Observations	81	81	81	81
$\widehat{\pi^*}$				1.81
π^*_{fixed}	1.67	1.70	2	
Likelihood-ratio test p-value	0.7676	0.8183	0.7117	

Likelihood – ratio test is performed between restricted model (π^*_{fixed}) *and unrestricted model* ($\widehat{\pi^*}$)
$*p < 0.10, **p < 0.05, ***p < 0.01$

Conclusions

- The ECB's new definition of price stability (adopted in July 2021) implies a **symmetric** loss function with a bliss point **at 2.0%**
- Under the now old definition of price stability the ECB's loss function was
  - **asymmetric**
  - and/or the bliss point was considerably **below 2.0%**
- These results are robust to
  - the tone measure (general / inflation specific)
  - the functional form of the loss function (piecewise linear / Linex)
  - frequency of observations (quarterly / monthly)
  - inclusion / exclusion of output gap terms in the loss function

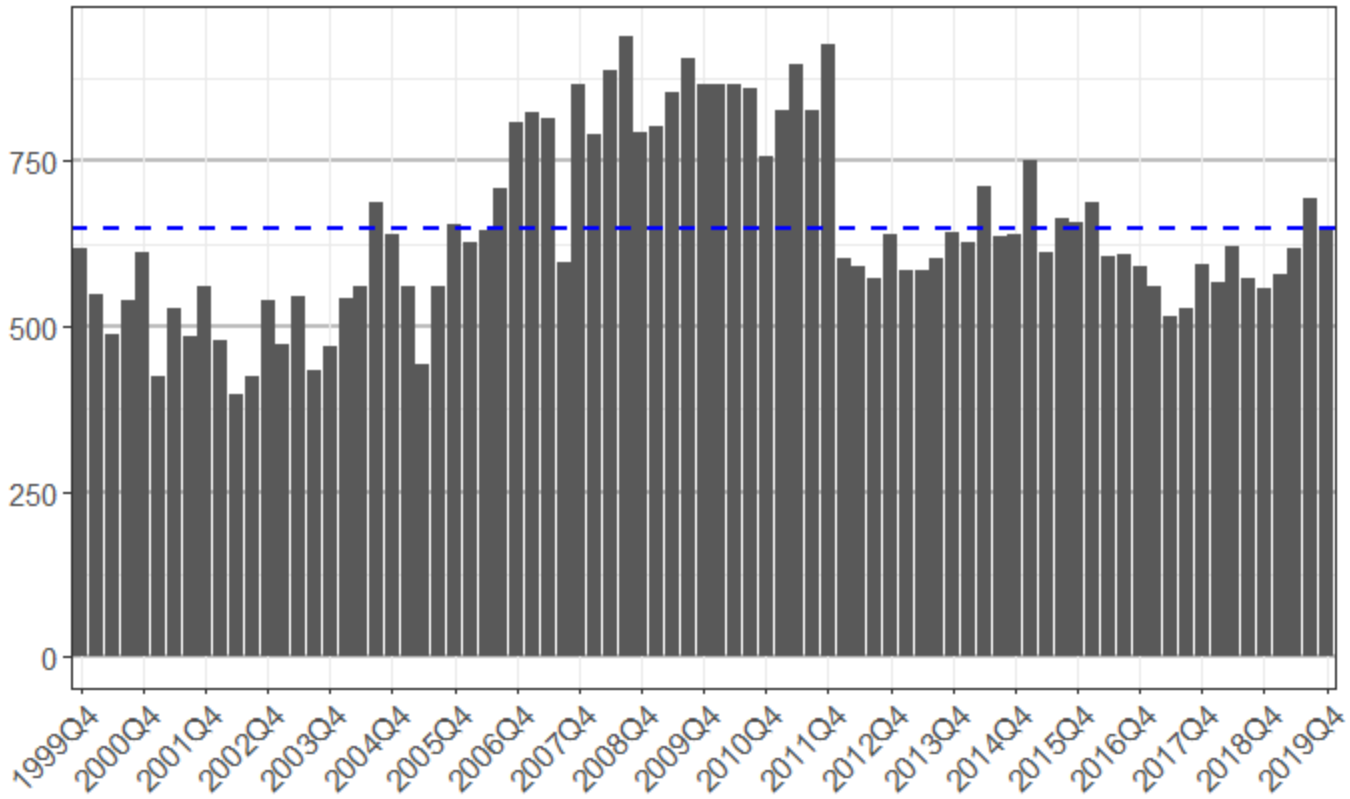
Conclusions (2)

- The two interpretations of the old definition of price stability
  - Not harmful when inflation and inflation pressures are high
  - Possibly counterproductive in a low rate environment
    - Lowered inflation expectations
    - Reduced monetary policy space
    - Increased the probability of hitting the ELB
- The new definition of price stability may be better suited for a low rate environment

Related literature

- Assessing "*de facto*" target and asymmetries
  - Hartmann and Smets (2018), Rostagno et al. (2019), Paloviita et al. IJCB forthcoming
- Analysis of monetary policy communication using text mining techniques
  - Shapiro and Wilson (2019), Baranowski et al. (2020), Picault and Renault (2017), Berger et al. (2011), Ehrmann and Talmi (2020), Hansen and McMahon's (2016), Armelius et al. (2020), Kawamura et al. (2019), Jones et al. IJF forthcoming, Kawamura et al. (2019), Bennani et al. (2020), Fraccaroli et al. (2020)
- Evaluation of real time data and central bank forecasting
  - Fujiwara (2005), Hubert (2014, 2015, 2017), Lyziak and Paloviita (2017, 2018), Potter (2011), Stockton (2012), Fawcett et al. (2015), Iversen et al. (2016), Kontogeorgos and Lambrias (2019)

Quarterly average of the number of words in the ECB's introductory statements 1999Q4-2019Q4



Pre-processing the data

- Gather introductory statements from ECB's website using automated web scraping

- Pre-processing
  - *Convert upper cases into lower, remove punctuation and numbers*
  - *Remove common English stopwords and extra whitespaces, stem words*
  - *Most common word pairs are merged into single word (governing council, financial stability etc.), handle negations*
  - *Remove greetings ('Ladies and gentlemen...')*
- Split data into tokens (single words or word sequences)
- Treat each paragraph as separate documents, aggregate documents into quarterly level