

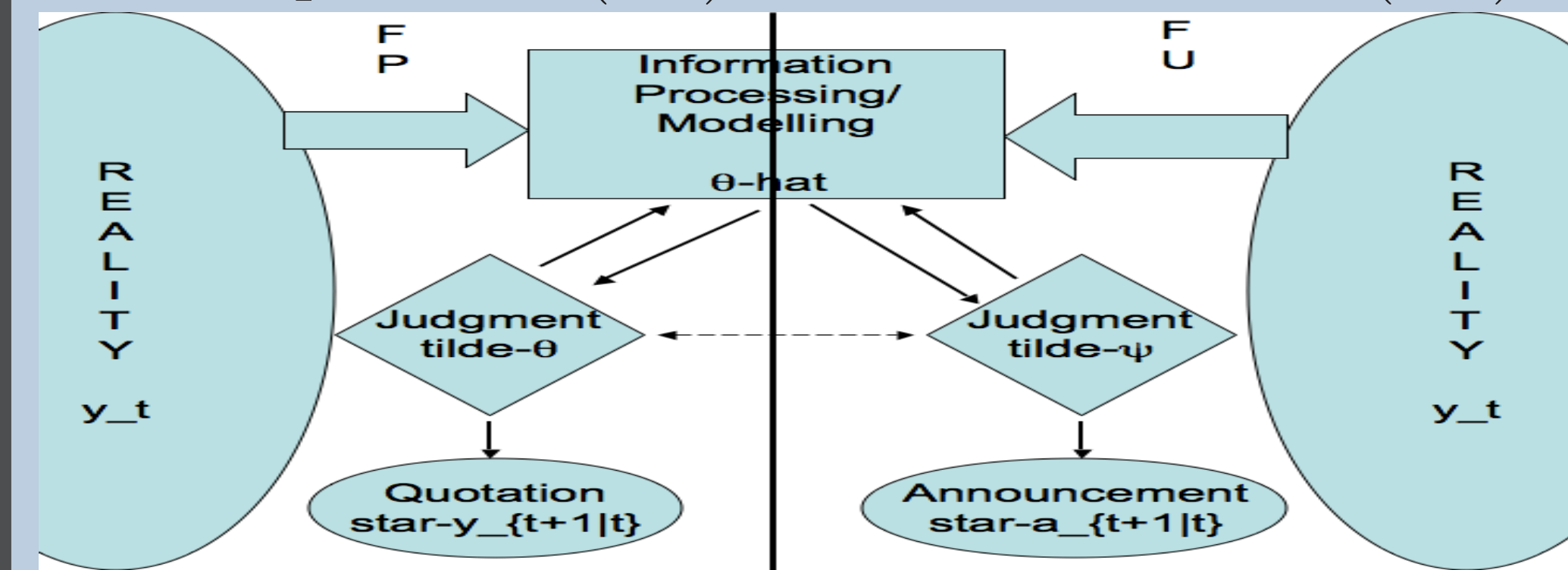
Strategic Judgment: its game-theoretic foundations, its econometric elicitation



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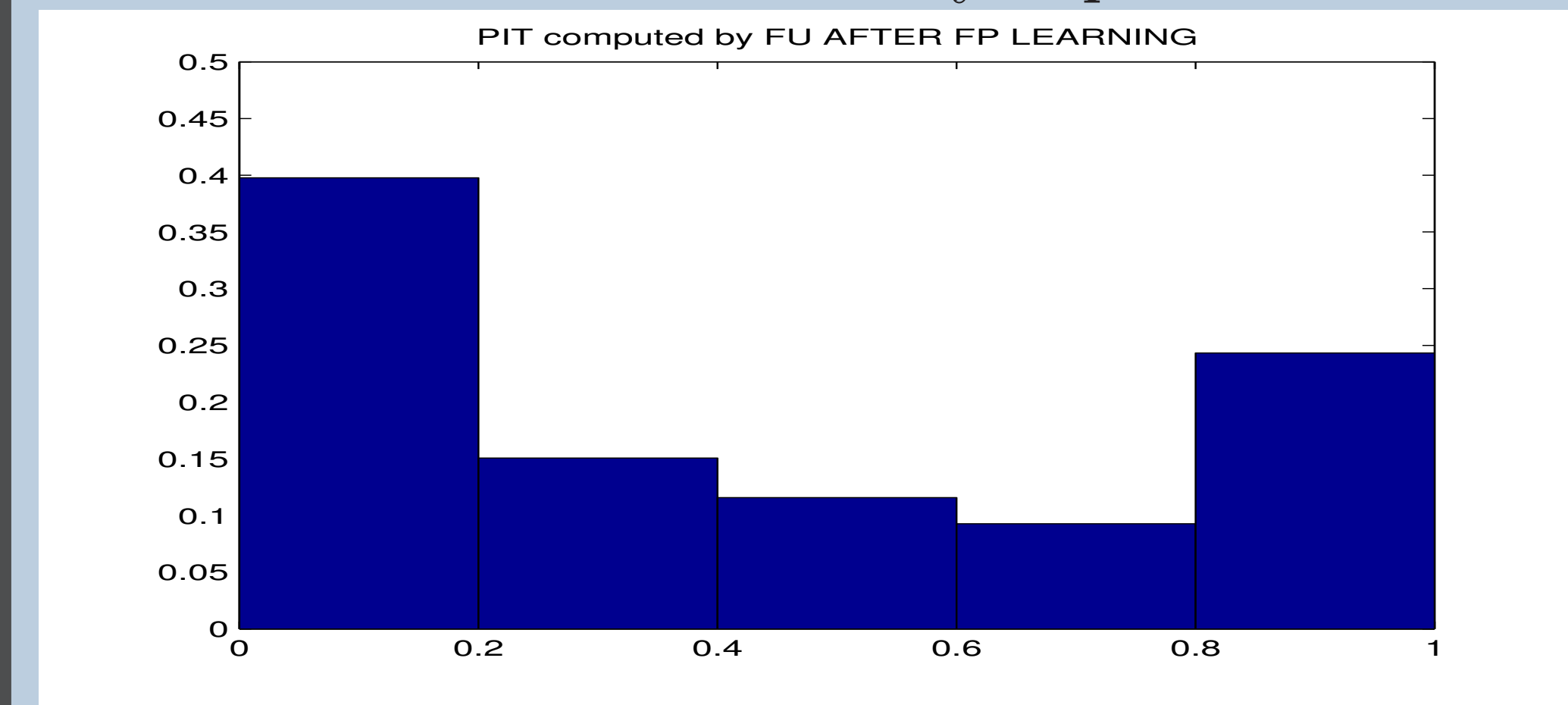
Motivation

Standard forecasting methodology considers judgmental bias as a phenomenon caused **only** by the forecast producer (FP) **or** the forecast user (FU):



Key Issue

Strategic judgment is a (partially endogenous) output of **interaction** among FP and FU. In this situation, the PITs **fails** to detect a correctly specified model.



Contribution

Our methodology considers judgmental bias as a **structure** that links **several agents**: the FP, the FU, who has capital K to preserve; and Reality.

Players act according to the following (stylized) **Forecasting Protocol**:

Forecasting Protocol:

1. $K_0 := 1$;
2. FU announces a bounded function $S : R \Rightarrow R$;
3. FP announces his (potentially biased) quotation $P(X) \in R$;
4. Reality announces $P(Y) \in R$;
5. $K_1 = K_0 + D(Y, X)$,

Winning rule: The winner is the FU if $K_1 \gg K_0$. Otherwise, the FP wins.

Cournot's Principle: no matter how the FU plays, Reality acts as though the FU does not win the game.

Modelling Strategic Judgment

The STAR-type Scoring Structure with exogenous regressors (STARX-SS) is defined as:

$$y_t = \phi^T z_t + G(\gamma, w_t, c_k) \theta^T z_t + \epsilon_t,$$

$$G(\gamma, w_t, c_k) = \left(1 + \exp \left\{ -\gamma \prod_{k=1}^K (w_t - c_k) \right\} \right)^{-1},$$

$$\gamma > 0, c_1 < \dots < c_k, < \dots < c_K,$$

$$\epsilon_t \sim iid(0, \sigma^2)$$

$z_t = (1, y_{t-1}, \dots, y_{t-p})'$: endogenous regrs;

$w_t = a' x_t \odot s$: composite transition variable

$$a = [a_1, \dots, a_p]', a_i = \begin{cases} 0 & \text{if } i = d \\ 1 & \text{if } i \neq d \end{cases}$$

$x_t = (1, y_{t-1}, \dots, y_{t-p})'$: FP's quotations,

$s = vec(s \otimes i)$: Bregman-type scoring rule,

ϕ, θ : linear/nonlinear AR parameters

c_k, γ : location and slope parameters.

Testing for strategic judgment

Theorem 1 A density forecast P is **structurally coherent** if and only if $S(y, P)$ is **local**.

Remark: An m -local scoring rule is a function S depending only on realization y_t and its first m -derivatives. Necessary and sufficient conditions are provided by [3].

Suppose $\{y_t, x_t\}$ follows a STARX-SS. By linearizing the model via Taylor expansion:

$$y_t = \phi' z_t + \theta' z_t T_3 G(\cdot, \cdot, \cdot) + \epsilon'_t \quad (2)$$

and regressing the resulting auxiliary model, it is possible derive a LM-type test for the null hypothesis of linearity of (1).

We demonstrate that **linearity** in STAR-SS **implies locality** of SR.

Hence, testing for linearity in (1) is equivalent to testing the null hypothesis of **no strategic judgment** (or coherence).

Data

1) **U.S. data:** Quarterly data from 1975Q1 to 2020Q4 of U.S. GDP and unemployment rate (UNR) from Survey of Professional Forecasters (FP) and FED (FU).

2) **U.K. Inflation:** Monthly data from 2015M1 to 2020M6 + out-of-sample forecasts of U.K. CPI Inflation (UNR) from Survey of External Forecasters (FP) and Bank of England's Monetary Policy Committee (FU).

3) **Norway's Output Gap:** Quarterly data from 2008Q1 to 2017Q4 on Norway's Output Gap (OG) from Bank of Norway's Monetary Policy Report (FU). FP has been simulated via STAR(2) model.

Equal Predictive Ability Tests

[1] test to compare forecasts of data where strategic judgment is **not heavy**.

We compare the Bank of England (BoE) and Bank of Norway's (NB) density forecasts (S^f) to those derived from a simplistic STAR(2) time series model (S^g) that uses a rolling estimation window of length $m_i = \{4Q, 6M\}$, $i = \{BoE, NB\}$.

f : FP's from survey data given a **non-local** SS.

g : benchmark GSTAR(2) for BoE (STAR(2), for NB) given a **non-local** SS

Comparison at a prediction horizon of $k = 1$ for BoE ($k = 4$ for NB) quarters (months) ahead, for a test period ranging from 2018:M1 to 2020Q12 for UK, and 2008Q1 to 2017Q1, for NB.

Results

COHERENCE TESTS: in all dataset there are cases in which the null hypothesis of no strategic judgment cannot be rejected.

US GDP										
d	$h = 0$		$h = 1$		$h = 2$		$h = 3$		$h = 4$	
	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value
1	8.690	<0.001	8.708	<0.001	6.129	<0.001	4.285	<0.001	3.308	<0.001
2	1.225	0.269	1.290	0.228	1.229	0.266	2.000	0.027	1.754	0.059
3	0.919	0.528	1.628	0.087	1.368	0.185	2.232	0.012	1.916	0.035
4	1.276	0.237	0.985	0.465	2.042	0.023	1.662	0.079	2.767	0.002

UK Inflation						
d	CPI Inflation		Core CPI Inflation		Contribution of Energy	
	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value
1	1.500	0.049	2.190	0.001	3.526	<0.001
2	1.351	0.109	2.075	0.015	2.822	<0.001
3	1.374	0.097	1.763	0.011	2.550	<0.001
4	1.386	0.091	1.524	0.042	1.968	0.003

NOR OG						
d	LM_1		LM_2		LM_3	
	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value
1	2.391	0.009	3.582	<0.001	1.326	0.221
2	2.510	0.007	2.335	0.011	1.890	0.041
3	1.544	0.118	1.991	0.030	1.006	0.497
4	1.032	0.469	1.409	0.174	1.294	0.241

EQUAL PREDICTIVE ABILITY:

(a) BoE: **Not clear superiority** of the BoE forecasts with respect to the GLSTAR. In 2/3 of the cases the null hypothesis cannot be rejected. NB: Similarly, NB forecast are **not unambiguously superior** to FP ones. But less rejections.

(b) In general, there is a variety of the SRs that **fails to reveal a winner**. This means that electing ex-ante the form of the SR does not ensure coherence.

(c) In turn, this Score Invariance principle is explained by the fact that FP and FU faces **costly deliberation with imperfect maximization** [2].

Conclusions

(i) Strategic Judgment requires **new tools** for forecast evaluation.

(ii) Strategic Judgment is **endemic** in Macroeconomics.

(iii) Often, due to Score Invariance, the Predictive Ability tests among FU and FP outputs **do not identify** a winner.

(iv) More research is wished to understand the **dynamics** of the strategic judgment.

References

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- [2] Ilut, C. and Valchev (2020), Economic agents as imperfect problem solvers, Mimeo;
- [3] Parry, M., Dawid, A. and Lauritzen, S. (2012), AoS, 40, 51-59.