Quantifying the Quality of Macroeconomic Variables

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2011

Understanding the economy

- The oldest economics was **philosophy** (e.g. Quesney, Smith)
- 1800s: economics became **mathematical**: (e.g. Edgeworth, Marshall)
- *Physics***:** laws mathematical, **data** from experiments
- *Economics*: Mathematics+**statistics** instead of experiments

…understanding

- 60 years of **National Accounts (SNA)**; Sir Richard Stone, Nobelist 1984.
- *SNA* now taken for granted.
- How well does the chain: Economic **Philosophy > Mathematics >Statistics** work today?
- Have data brought **understanding**?

… *understanding*

- What is the **quality** of the data that statistical offices collect?
- They express it verbally: **contents, accuracy, timeliness, comparability, availability, clarity**
- Hard to measure, even harder to aggregate into one **measure**
- **Single quantitative measure** attempted at here

…understanding

- Measured quality of macro time series:

1. **Common trend:** Vintages should have a common trend, that of the final vintage, Siklos (1996), Patterson & Heravi (2004), *USA:* **yes**, Patterson (2002) *UK:* **no,** and Öller & Hansson (2004) *Sweden:* **no**.
2. **Rationality of vintages**, Swanson & van Dijk (2002). At what stage is all information used?
3. Here information is measured in **forecast errors** and **revisions** => **one global measure**

… understanding

”*The process of estimating GNP starts with forecasts made many years before a quarter has begun and continues for years after it has ended”* ,Steven McNees (1989)

… understanding

- **Forecast accuracy:** With no idea about a variable tomorrow, how to make a decision today?
- **Revisions:** How reliable is a first figure of a variable that has to be substantially and repeatedly revised? Is the final figure close(r) to truth?
- If little is known *ex post* and even less *ex ante*, the series is of doubtful practical use

Do we understand variable $\boldsymbol{x}$ better than $\boldsymbol{y}$?

Global scalar measure prefered

A quality measure

- If **theory** is inadequate, measurement is meaningless
- If **measurement** is poor, what is understood theoretically is not reflected in data, and empirical models collaps
- Both deficiencies lead to **bad forecasts**, and to measurement that has to be **reriterated**, maybe without convergence

… quality

- These arguments support the use of **forecast errors** and **revisions** to measure the quality/understanding
- Assume given a stationary macro-economic time series:

$$y_{lt},\ l = 1,\ldots, L;\ t = 1,\ldots,T\ \ .$$

… quality

- For every t the measurement is made L times. Following Croushore and Stark (2001), we call $l = 1, 2, \ldots, L$ **Vintages**

- The values of the first vintages are **forecasts**, the subsequent ones are **outcomes**

- Observation y_{1t} is the **first forecast** of obs. t.

… quality

- There is an observation $y_{\lambda t}$, $1 < \lambda < L$, which is the **first estimate** (outcome) based on data from the whole period t. This is called a **preliminary figure**
- The last estimate of period t, y_{Lt} ,is called a **final figure**
- Measurements y_{lt} are successive estimates of an unknown variable η_t , $t = 1,\ldots, T$

… quality

In empirical studies $\boldsymbol{y}_{Lt}$ is chosen as a substitute for η_t. Could be wrong!

The accuracy of vintage values can be measured by **Root Mean Square Error *(RMSE)*** :

$$\boldsymbol{RMSE}_l = \sqrt{\frac{1}{\boldsymbol{T}} \sum_{\boldsymbol{t}=1}^{\boldsymbol{T}} (\boldsymbol{y}_{\boldsymbol{lt}} - \boldsymbol{y}_{\boldsymbol{Lt}})^2}, \boldsymbol{l} = 1, \ldots, \boldsymbol{L}. \qquad (1)$$

… *quality*

- Standardize ***RMSE***: divide by std of the final figures, s_L:
- $$\boldsymbol{RMSE}_l^s = \frac{\boldsymbol{RMSE}_l}{s_L}, \quad l = 1, 2, \ldots, L$$
- $\boldsymbol{RMSE}_0 = s_L$

(The mean can be regarded as a naive forecast at $l = 0$ for y_t)

…quality

- As in the **Theil Measure**, a value of $\overline{\boldsymbol{RMSE}}_{I}$ at or above unity indicates a worthless forecast or preliminary figure, because:
- A **mean** of final observations would have been at least as accurate

… *quality*

- The forecast/revision history of a variable over vintages:

$$\overline{\boldsymbol{RMSE}}_{1}, \overline{\boldsymbol{RMSE}}_{2}, \ldots, \overline{\boldsymbol{RMSE}}_{L},$$

$$\overline{\boldsymbol{RMSE}}_{0} = 1, \boldsymbol{RMSE}_{L} = \overline{\boldsymbol{RMSE}}_{L} = 0$$

… quality

- **Accuracy measure,** the **S**ignal to **N**oise **R**atio ***(SNR)*****:**

- $\boldsymbol{I_l = 1 - MSE_l / s_L^2}$, $l = 1, 2, \ldots, L$

- Analogue: **coefficient of determination**
- If $\boldsymbol{I_l} < 0$ then this vintage has no information
- We substitute $\boldsymbol{I_l}$ => 1 in this case => $0 \leq \boldsymbol{I_l} \leq 1$

Information window

- Consider the expression:

  $$II = ½\sum_{l=1}^{L-1}(I_l + I_{l+1})\tau(l, l+1)$$

- This is the white area under the curve in *Figure* 1
- Here $\tau(l, l+1)$ is the length of the interval between vintages l and $l+1$
- II can be normalized so that the sum of intervals is unity, so that *Fig*.1 is a unit square

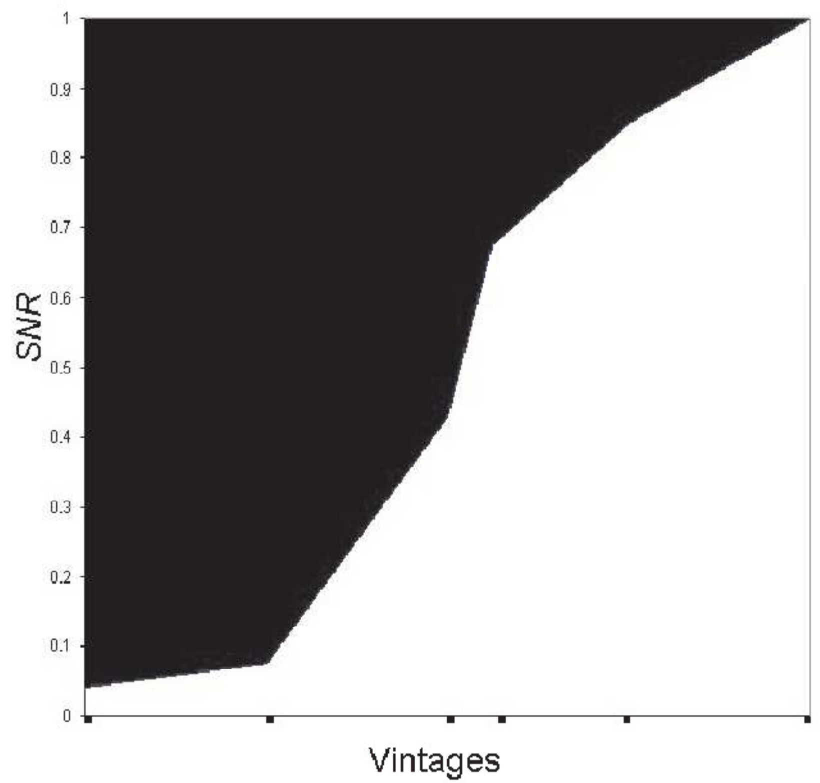


Figure **1. Information window**

Producer's information

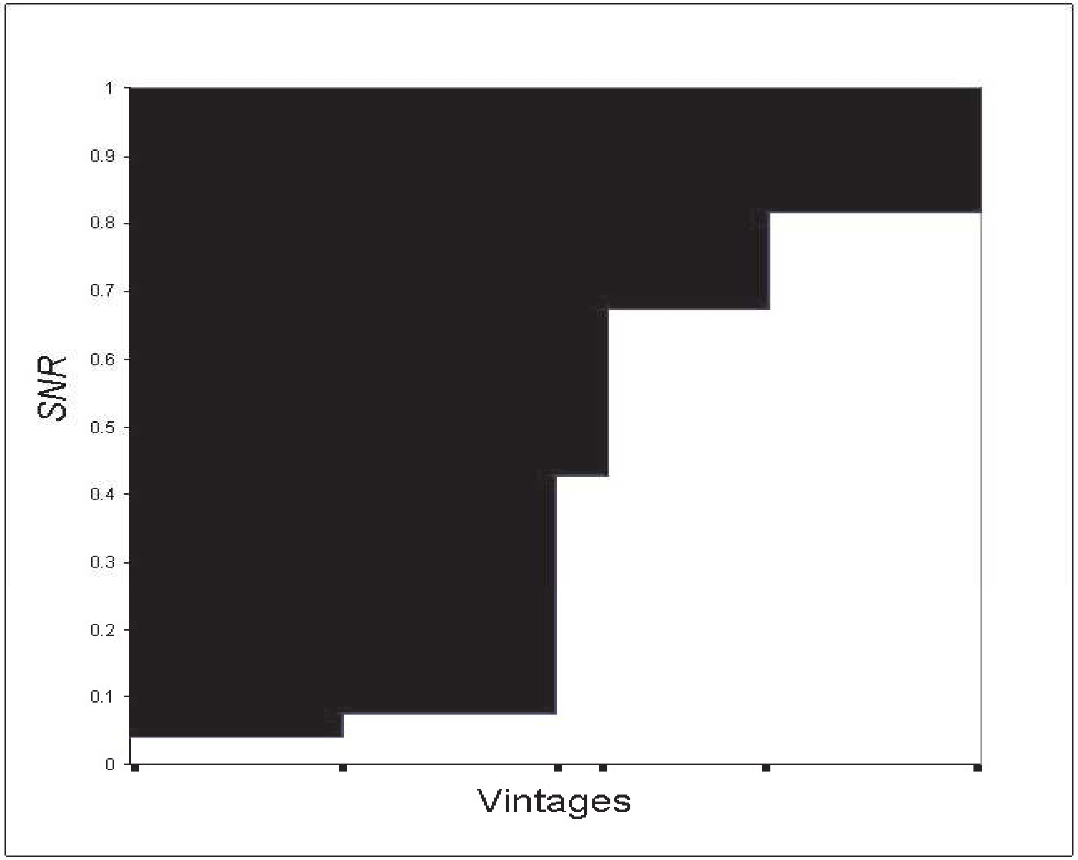


Figure 2. **Information window**

User’s information (monopoly producer)

Producer's vs. consumer's information

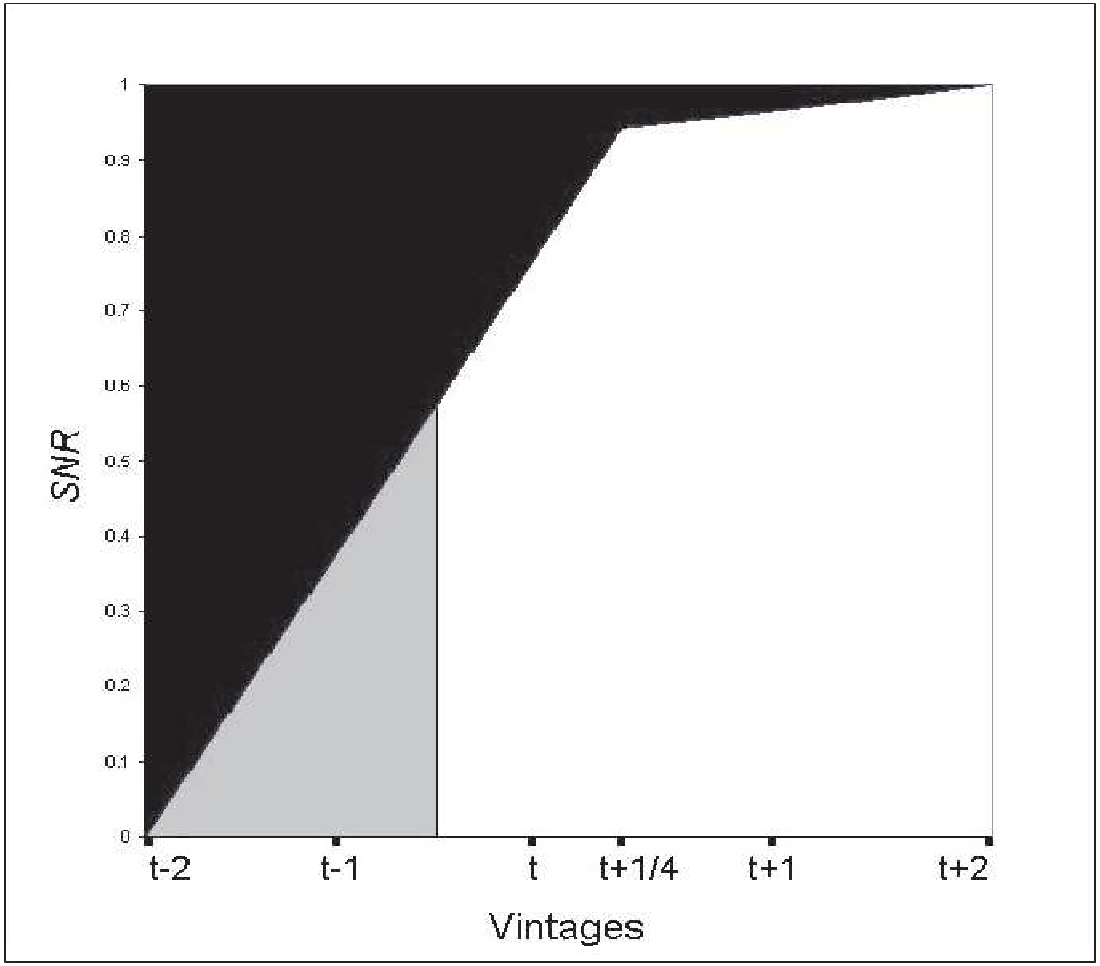
- We can postulate that the producer's information increases linearly between publications (*Fig*. 1)
- The consumer's only source is the producer, so her/is Information increases stepwise (*Fig*. 2)and the *SNR* measure is
- $II^U = \sum_{l=1}^{L-1} I_l \tau(l, l+1)$

Two examples

- Consider three forecasts: $t-2$, $t-1$ and t, and
- Outcomes: $t + ¼$, $t+1$ and $t+2$
- $L = 6$
- Final figure at $t+2$
- Variable 1: **Private Consumption**
- Variable 2: **Central Government Consumption**

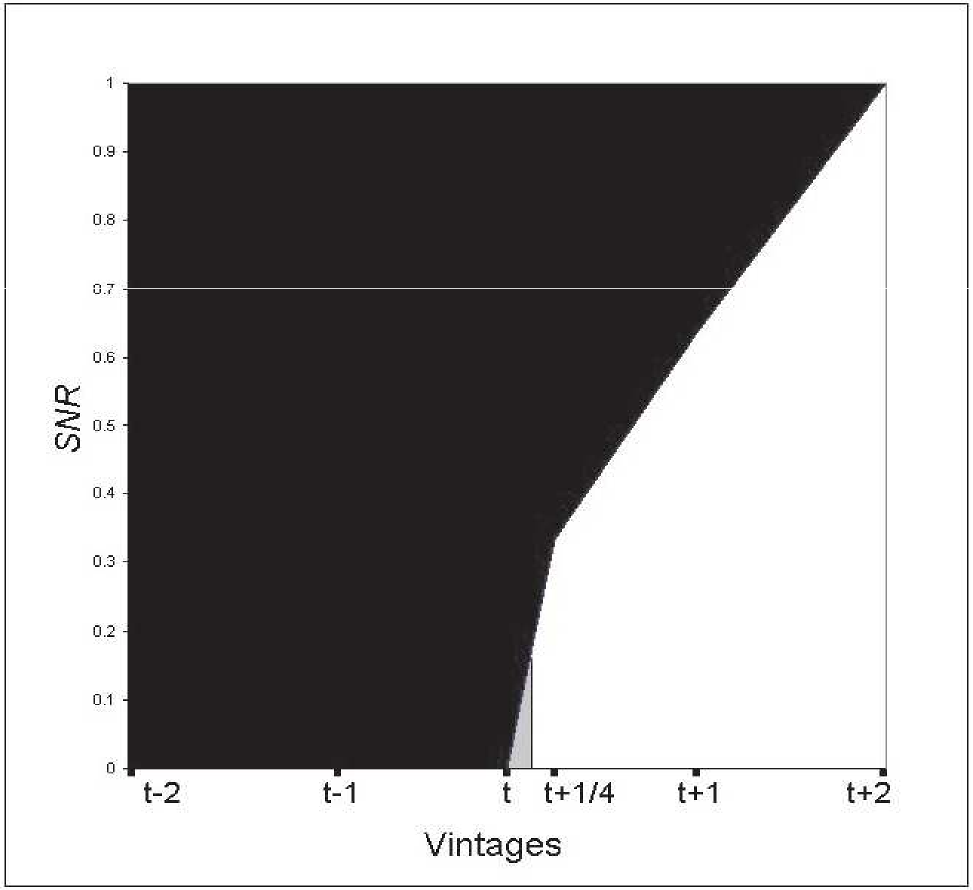
Private Consumption

***II* = 0.69,** gray area: Anderson-Darling test



Central Governments Consumption

***II* = 0.31,** gray area: Anderson-Darling test



Information Theory Approach

- Henry Theil (1966 & 1967)
- Forecasts and revisions
- Forecast variance decomposed in *variable, time* and *vintage.*
- Parametric approach, needs much data
- Consider a nonparametric method

Information theory…

- Prior to $t - 2$ all we know is history i.e. minimum information of the future
- At $t + 2$ we asume full knowledge
- Gaussian has largest entropy:

$$N(0, s^2{}_L) \equiv \varphi(y_L)$$

- Divide real axis into K intervals

Information…

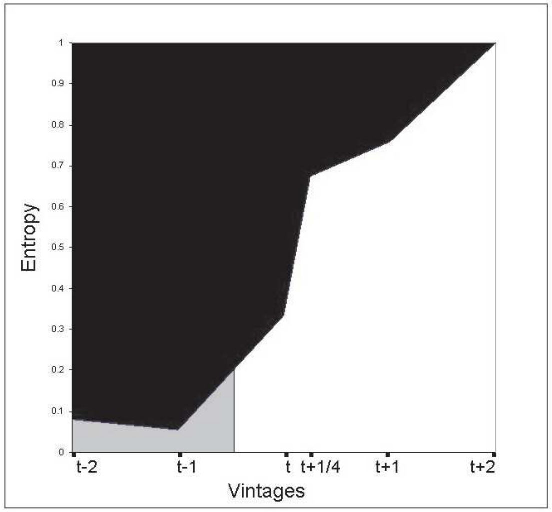
- The prior probability of a forecast error/revision is $1/K$
- For every vintage $l = 1,\ldots, L$ you get an empirical distribution f_{lk}
- Consider the entropy:

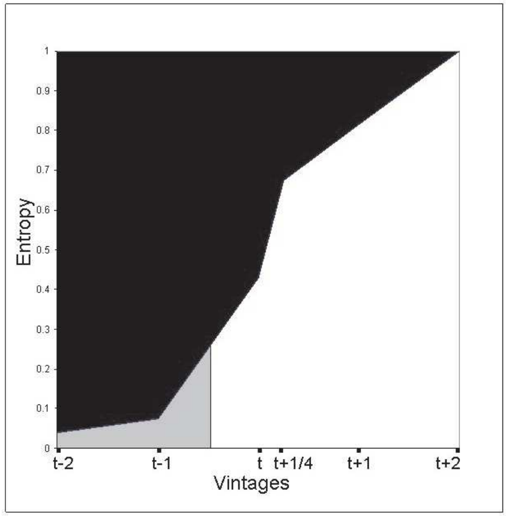
$$H_l = -\sum_{k=1}^{K} f_{lk} \ln f_{lk}$$

Information…

- This is a nonparametric alternative to Theil's measure, $0 \leq H_l \leq 1$, $l = 1,\ldots, L$

Private Consumption, $H = 0.45$ **Centr. Gov. Consum. $H = 0.31$**



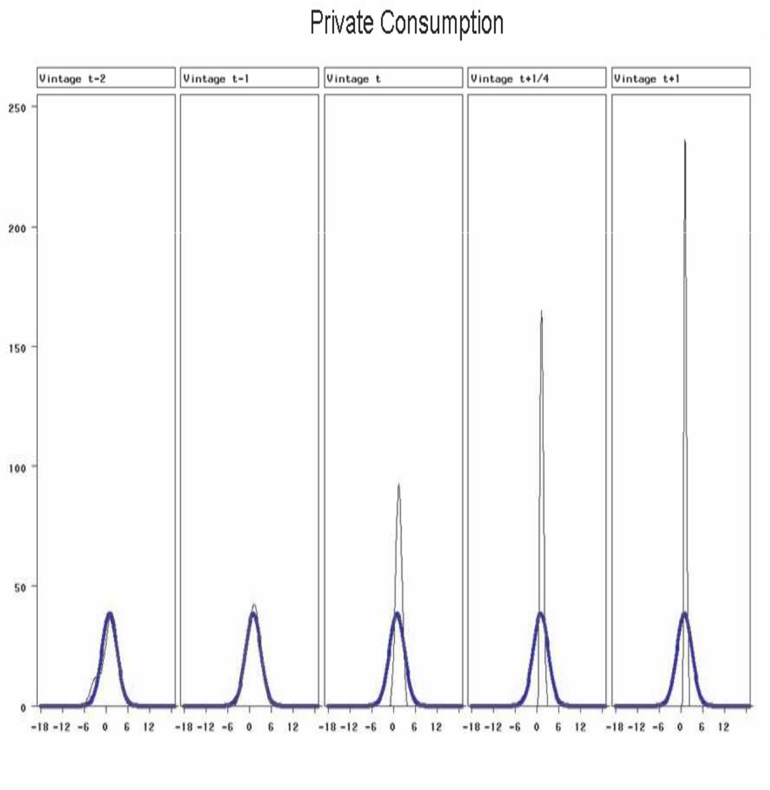


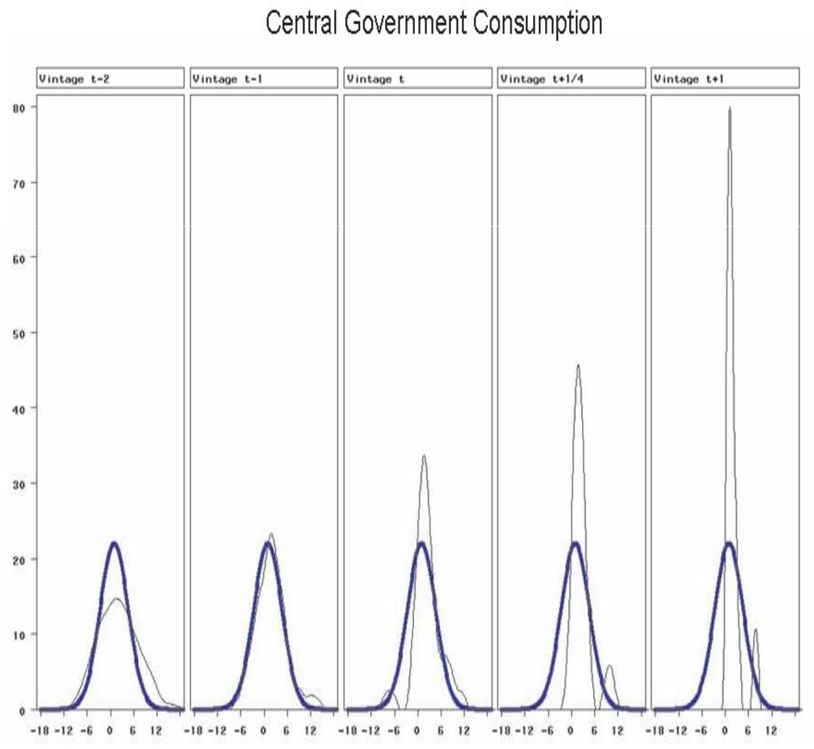
Information…

- The gray area: **Anderson-Darling test**. Diebold-Mariano, Granger-Newbold altenatives.
- Convergence can also be shown with the L distributions $\varphi(y_l)$ juxtaposed on the ”no information” Gaussian $\varphi(y_L)$
- For the observed distributions a quadratic smoothing kernel is used
- What’s the point of forecasting Centr. Gov. Cons.?

Information…

Entropy as normal distributions





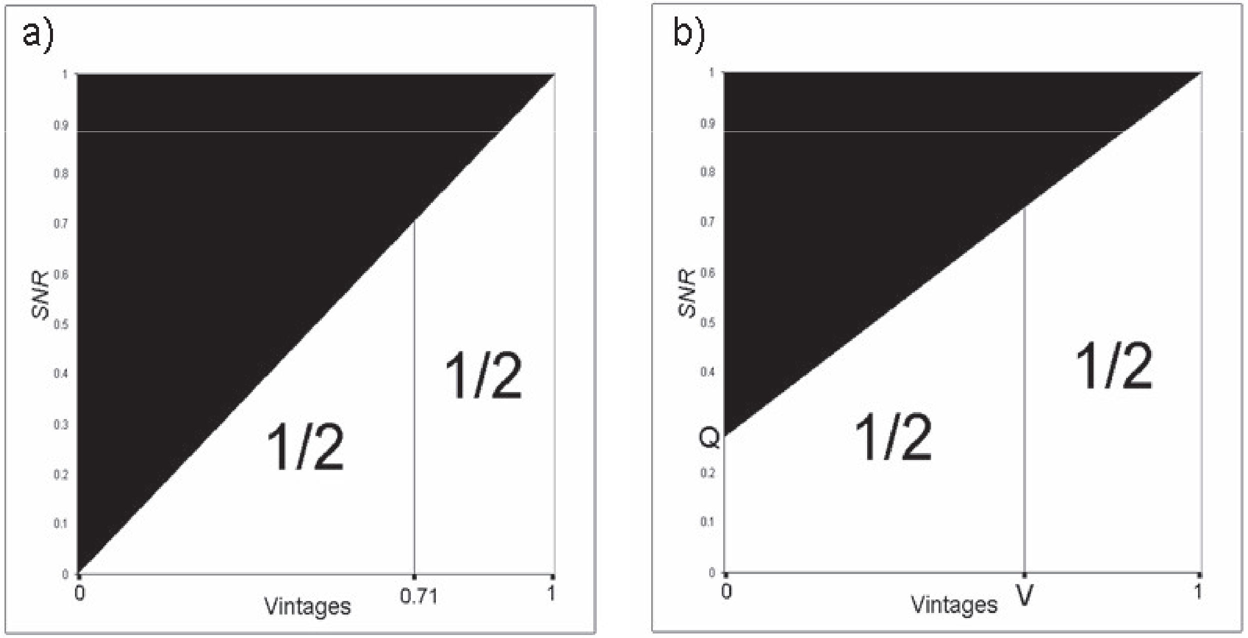
Optimal forecasting, concavity/convexity

- Forecasting and publishing costs money
- How frequently is it worth doing it?
- Information should increase monotonously
- Marginal improvement should decrease => **concave** information curve
- **Marginal cost** should equal **marginal improv.**
- When do we have half of the information?
- Consider a linear information curve

Optimal…

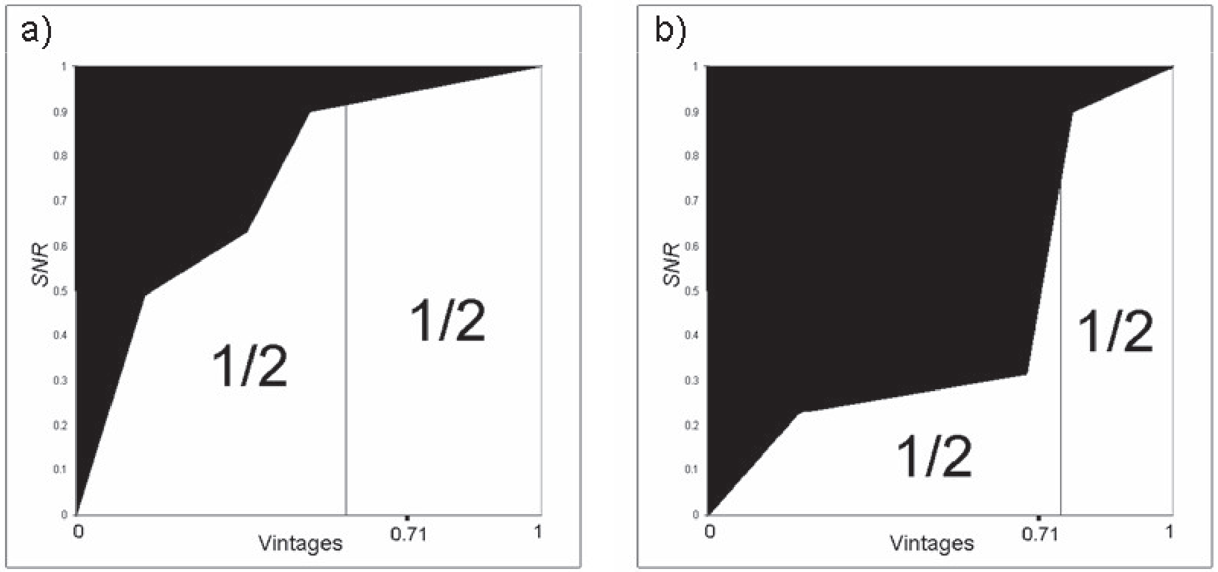
Gravity axis: half of the information

as much information as early as possible



Optimal…

Concave: early	***Convex:* late**
before 0.71=1/√2	**after** 0.71



Conclusions

- Simplicity: square **window**, global **measure**
- The more **light**, the more information (curtain)
- Include in statist./forecast **public.** (meta data)
- How **meaningful** are forecasts/prelim. figures?
- Save time and money, impute mean value
- Measures based on familiar concepts (signal to noise ratio, entropy)

Conclusions

- Information can be statistically **tested**
- Note that forecasters should not be blamed for bad data!
- If data quality improves/deteriorates it is easy to verify

Thank you!