# Short-term forecasts of euro area GDP growth.*

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**Abstract**

This paper evaluates models that exploit timely monthly releases to compute early estimates of current quarter GDP (now-casting) in the euro area. We compare traditional methods used at institutions with a new method proposed by Giannone, Reichlin, and Small (2005). The method consists in bridging quarterly GDP with monthly data via a regression on factors extracted from a large panel of monthly series with different publication lags. We show that bridging via factors produces more accurate estimates than traditional bridge equations. We also show that survey data and other 'soft' information are valuable for now-casting.

# 1 Introduction

Now- and Forecasts of quarterly GDP from monthly data

Make efficient use of staggered releases of monthly data

*Traditionally*: bridge equations that use selected indicators

*More recently*: dynamic factor models that employ large data sets

This paper conducts forecast comparison exercise for euro area

## 2 Paper outline

Forecast evaluation from pseudo-real time design (over 7 months)

We use

(i) Selected bridge equations (Rünstler and Sedillot, 2003, Diron, 2005)

(ii) Pooling from many bridge equations (Kitchen and Monaco, 2003)

(iii) Factor model by Giannone and Reichlin and Small (JME, 2008)

Will also address black box nature of DFMs

# 3 Bridge equations (BE)

$$y_t^Q = \mu + \sum_{i=1}^{k} \beta_i^j(L) x_{it}^{jQ} + \varepsilon_t^{jQ},$$

Consider vectors of stationary monthly indicators $x_t^j = (x_{1,t}^j, \ldots, x_{k,t}^j)'$,

1 - Forecast missing monthly values to obtain $x_{it}^{jQ}$ from univariate AR.

2- Forecast quarterly GDP growth $y_t^Q$ from quarterly aggregates $x_{it}^{jQ}$.

# 4 BE strategies

BES - A few equations using carefully selected indicators

BEA - Many equations (single indicators) and average forecasts

Table 1: Bridge equations for euro area GDP growth-(*BES* model).

| | Equation | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Explanatory variables | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Industrial production (total) | * | * | * | * | * | * | * | * | * | | | |
| Ind production construction | | * | * | * | * | * | | * | * | | | |
| Retail sales | | * | * | * | * | * | * | * | * | | | |
| New car registrations | * | * | * | * | | | | | | * | | |
| Service confidence | | | | * | * | | * | | * | | | |
| Unemployment rate | | | | | * | * | | | | | | |
| Money M1 | | | | | | | | * | * | | | |
| Business confidence | | | | | | | | | | * | | |
| EuroCoin (CEPR) | | | | | | | | | | | * | |
| OECD leading indicator | | | | | | | | | | | | * |

# Euro area data set

## (85 series ordered by arrival)

| Series group | Nr | Lag |
|---|---|---|
| Surveys (EC) | 24 | 0 wks |
| Financial data | 22 | 0 wks |
| US data (various) | 7 | 2-4 wks |
| Retail sales | 1 | 4 wks |
| Money | 4 | 4 wks |
| Industrial prod | 19 | 6 wks |
| Trade | 4 | 6 wks |
| Labour market | 5 | 6 wks |

# 5 Bridging with factors (BF)

$$
\begin{aligned}
x_t &= \Lambda f_t + \xi_t, & \xi_t &\sim \mathbb{N}(0, \Sigma_\xi), \\
f_t &= \sum_{i=1}^{p} A_i f_{t-i} + \zeta_t, & & \\
\zeta_t &= B\eta_t, & \eta_t &\sim \mathbb{N}(0, I_q).
\end{aligned}
$$

Forecast for monthly GDP $\widehat{y}_t$

$3^{rd}$ month of the quarter: evaluate fcst for quarterly GDP growth, $\widehat{y}_t^Q$

$$
\begin{aligned}
\widehat{y}_t &= \beta' f_t \\
\widehat{y}_t^Q &= \frac{1}{3}(\widehat{y}_t + \widehat{y}_{t-1} + \widehat{y}_{t-2})
\end{aligned}
$$

$$\begin{bmatrix} x_t \\ y_t^Q \end{bmatrix} = \begin{bmatrix} \Lambda & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} f_t \\ \widehat{y}_t \\ \widehat{y}_t^Q \end{bmatrix} + \begin{bmatrix} \xi_t \\ \varepsilon_t^Q \end{bmatrix}$$

$$\begin{bmatrix} I_r & 0 & 0 \\ -\beta' & 1 & 0 \\ 0 & -\frac{1}{3} & 1 \end{bmatrix} \begin{bmatrix} f_{t+1} \\ \widehat{y}_{t+1} \\ \widehat{y}_{t+1}^Q \end{bmatrix} = \begin{bmatrix} A_1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & \Xi_{t+1} \end{bmatrix} \begin{bmatrix} f_t \\ \widehat{y}_t \\ \widehat{y}_t^Q \end{bmatrix} + \begin{bmatrix} \zeta_{t+1} \\ 0 \\ 0 \end{bmatrix}$$

# 7 Kalman filter & smoother

For state space form

$$\begin{aligned} z_t &= W\alpha_t + u_t, \qquad u_t \sim N(0, \Sigma_u) \\ \alpha_{t+1} &= T_t\alpha_t + v_t, \qquad v_t \sim N(0, \Sigma_v), \end{aligned}$$

and any *unbalanced* data $\mathcal{Z}_t$ the KF provides MMSE estimates of $\alpha_{t+h}$,

$$\begin{aligned} a_{t+h|t} &= \mathbb{E}\left[\alpha_{t+h}|\mathcal{Z}_t\right] \\ P_{t+h|t} &= \mathbb{E}\left[a_{t+h|t} - \alpha_{t+h}\right]\left[a_{t+h|t} - \alpha_{t+h}\right]', \end{aligned}$$

Flexible handling of missing observations

# 8 Pseudo realtime forecasts

Data downloaded on 25, February 2008

We replicate the flow of information

Start forecasting 7 months before release of flash estimate)

2 Forecasts per month

Evaluation over 1999Q1 - 2007Q2

Model selection either via rec RMSE or information criteria

Figure 2: RMSE from pseudo real-time exercise 1999Q1 - 2005Q4.

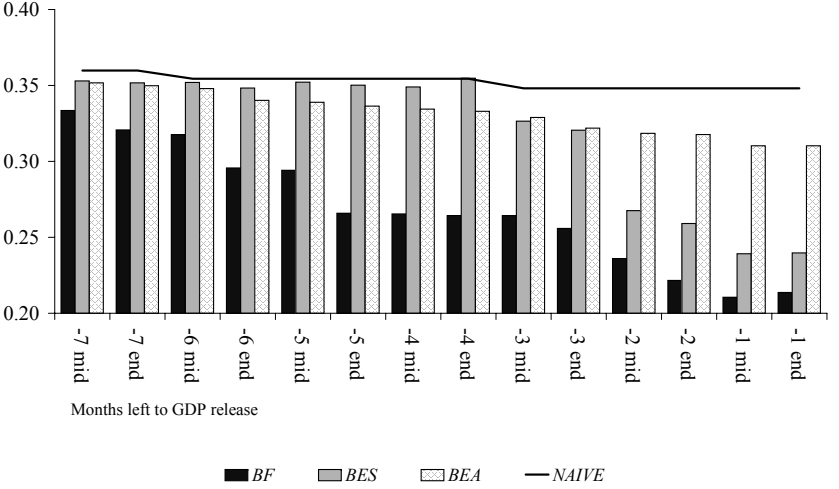

Table 2: Root mean squared error from short-term forecasts (1999Q1 - 2007Q2).

| Quarter | Months to GDP release | Vintage | Benchmarks | | *BF* Model | | | | BE Models | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Best | | *BEA* | | |
| | | | NAIVE | AR(1) | RecRMS | Avg | IC | ex-post | *BES* | RecRMS | Avg | IC |
| Next | -7 | -7 mid | 0.3598 | 0.3559 | .3440 | .3335 | .3392 | .3208 | .3530 | .3511 | .3517 | .3473 |
| | | -7 end | 0.3598 | 0.3559 | .3223 | .3210 | .3361 | .3037 | .3517 | .3488 | .3498 | .3448 |
| Next | -6 | -6 mid | 0.3544 | 0.3423 | .3195 | .3176 | .3293 | .3016 | .3520 | .3462 | .3479 | .3423 |
| | | -6 end | 0.3544 | 0.3423 | .3118 | .2957 | .3123 | .2812 | .3483 | .3381 | .3402 | .3350 |
| Next | -5 | -5 mid | 0.3544 | 0.3423 | .3125 | .2941 | .3063 | .2805 | .3522 | .3363 | .3389 | .3331 |
| | | -5 end | 0.3544 | 0.3423 | .2775 | .2659 | .2661 | .2463 | .3502 | .3336 | .3364 | .3304 |
| Current | -4 | -4 mid | 0.3544 | 0.3423 | .2740 | .2654 | .2616 | .2447 | .3490 | .3322 | .3344 | .3281 |
| | | -4 end | 0.3544 | 0.3423 | .2710 | .2643 | .2713 | .2400 | .3548 | .3305 | .3330 | .3266 |
| Current | -3 | -3 mid | 0.3481 | 0.2955 | .2600 | .2642 | .2662 | .2338 | .3265 | .3264 | .3289 | .3224 |
| | | -3 end | 0.3481 | 0.2955 | .2618 | .2559 | .2671 | .2404 | .3205 | .3197 | .3219 | .3150 |
| Current | -2 | -2 mid | 0.3481 | 0.2984 | .2299 | .2360 | .2370 | .2119 | .2676 | .3159 | .3185 | .3116 |
| | | -2 end | 0.3481 | 0.2984 | .2172 | .2216 | .2277 | .2052 | .2591 | .3152 | .3177 | .3111 |
| Previous | -1 | -1 mid | 0.3481 | 0.2984 | .1987 | .2105 | .2089 | .1894 | .2392 | .3075 | .3103 | .3043 |
| | | -1 end | 0.3481 | 0.2984 | .2057 | .2137 | .2116 | .2031 | .2397 | .3074 | .3103 | .3042 |

Table 3: Adjusted Diebold-Mariano test of predictive accuracy (1999Q1 - 2007Q2).

| Quarter | Months to GDP release | Vintage | BF AR(1) | BES AR(1) | BEA AR(1) | BF BES | BF BEA | BES BEA |
|---|---|---|---|---|---|---|---|---|
| Next | -7 | -7 mid | 0.198 | 0.274 | 0.207 | 0.207 | 0.225 | 0.584 |
| | | -7 end | 0.141 | 0.214 | 0.165 | 0.146 | 0.162 | 0.660 |
| Next | -6 | -6 mid | 0.174 | 0.778 | 0.653 | 0.139 | 0.149 | 0.776 |
| | | -6 end | 0.091 | 0.686 | 0.304 | 0.089 | 0.091 | 0.883 |
| Next | -5 | -5 mid | 0.089 | 0.814 | 0.263 | 0.087 | 0.081 | 0.943 |
| | | -5 end | 0.028 | 0.751 | 0.203 | 0.026 | 0.030 | 0.939 |
| Current | -4 | -4 mid | 0.028 | 0.603 | 0.175 | 0.026 | 0.037 | 0.880 |
| | | -4 end | 0.054 | 0.768 | 0.168 | 0.064 | 0.062 | 0.935 |
| Current | -3 | -3 mid | 0.098 | 0.869 | 0.945 | 0.056 | 0.093 | 0.049 |
| | | -3 end | 0.119 | 0.826 | 0.923 | 0.078 | 0.101 | NaN |
| Current | -2 | -2 mid | 0.038 | 0.255 | 0.877 | 0.032 | 0.154 | 0.067 |
| | | -2 end | 0.036 | 0.177 | 0.876 | 0.030 | 0.130 | 0.039 |
| Previous | -1 | -1 mid | 0.012 | 0.024 | 0.773 | 0.015 | 0.188 | 0.002 |
| | | -1 end | 0.012 | 0.027 | 0.775 | 0.015 | 0.188 | 0.003 |

# 9 Forecast weights

Banbura and Rünstler (2006) based on Harvey and Koopman (2003)

Express forecasts $\widehat{y}^{Q}_{t+h|t}$ as the weighted sum of available observations in $\mathcal{Z}_t$

$$\widehat{y}^{Q}_{t+h|t} = \sum_{k=0}^{t-1} \omega_{k,t}(h) z_{t-k}$$

Weights are time-invariant for our definition of $\mathcal{Z}_t$. Inspect

- Cumulative forecast weights $\sum_{k=0}^{t-1} \omega_{k,i}(h)$ for series $i$,
- Historical contributions of series $i$ to the forecast

# 10 Model based uncertainty

GRS (2008): decompose the variance of the forecast error for $y^Q_{t+h}$

$$\text{var}(\widehat{y}^{Q,-j}_{t+h|t} - y^Q_{t+h}) = \beta' \text{var}(\widehat{f}^{Q,-j}_{t+h|t} - f^Q_{t+h})\beta + \sigma^2_\varepsilon$$

- $\widehat{y}^Q_t$ is part of state vector $\Rightarrow$
- decomposition is obtained from Kalman filter $P_{t+h|t}$

# 11 Conclusions

Paper evaluates forecast performance of bridge equations against factor mod

- Factor model improves on bridge equations for longer horizons
- Mostly because soft data are processed more efficiently
- Balanced data give a wrong picture (Banbura and Rünstler, 2006)

Compared to other work for euro area countries

- Factor model generally better than BEA (Rünstler et al, ECB WP )
- However, for some countries things do not work well