Survey Data as Coincident or Leading Indicators

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Motivation

- ✓ Survey variables represent a very timely piece of economic information, but their role and quality is a bit controversial. In the U.S. none of them (neither the Consumer Sentiment index by the University of Michigan) is listed among the set of series that enter the Conference Board and the Stock and Watson (1989) coincident index; by contrast in EU surveys by the European Commission are featured in the Eurocoin indicator for the euro area produced by the CEPR.
- ✓ Frale, Marcellino, Proietti and Mazzi (FMMP) concluded that the survey variables did not contribute significantly to the factor based indicator of the euro area monthly GDP. It turns out that this evidence was in part the consequence of imposing a single common factor on the series, and of neglecting the timeliness of the economic data.
- ✓ We report a modification of FMMP that deals with the introduction of a second common factor, capturing the contribution of the survey variables as coincident indicators and allows for low frequency movements, still in a mixed frequency (monthly/quarterly) framework.
- ✓ We also compare the short term forecasting performance of the model, with respect to the original FMMP formulation and a more standard autoregressive distributed lag (ADL) model.

Results

Looking ahead to the results, we anticipate that the second factor loads significantly on the survey variables for the Industry sector and for Exports. However, the resulting monthly measure of euro area GDP is very similar to that by FMMP.

Instead, the forecasting performance of the survey based factor model improves substantially over both the single factor model and ADL specifications.

Outline

- ✓ Motivation
- ✓ Survey-based factor model
- ✓ Euro Area application
- ✓ Forecasting performance
  - Real time analysis
  - Revisions
- ✓ Conclusion

Extending FMMP

FMMP: Disaggregation of the chain-linked quarterly value added at constant prices from the output side and from the expenditure side by using a parametric dynamic factor model at the monthly level and indicators of economic activity, taking the temporal aggregation constraint into account. The chained-linked total GDP results via a multistep procedure that exploits the additivity of the volume measures expressed at the prices of the previous year. The final estimate is obtained by combining the two estimates (output side and expenditure side) with weights reflecting their relative precision.

The extensions of the original model specification in FMMP are twofold:

1. we bring in an additional common factor, which ex post will turn out to be driven by the survey variables.
2. We model the first common factor as an integrated modified high-order autoregressive process, referred to as ZAR(p), originally proposed by Morton and Tunnicliffe-Wilson (2004) as a model with improved resolution at the low frequencies.

The two index SW model with surveys

$$
\begin{aligned}
\mathbf{y}_t &= \vartheta_{\mathbf{0}}\mu_t + \vartheta_{\mathbf{1}}\mu_{t-1} + \widetilde{\vartheta}_{\mathbf{0}}\widetilde{\mu}_t + \widetilde{\vartheta}_{\mathbf{1}}\widetilde{\mu}_{t-1} + \boldsymbol{\gamma}_t + \mathbf{X}_t\beta, & t &= 1, \ldots, n, \\
\phi(L)\Delta\mu_t &= (1-\theta L)^p \eta_t, & \eta_t &\sim \mathrm{NID}(0, \sigma^2_\eta), \\
\widetilde{\phi}(L)\Delta\widetilde{\mu}_t &= \widetilde{\eta}_t, & \widetilde{\eta}_t &\sim \mathrm{NID}(0, \sigma^2_{\tilde{\eta}}), \\
\mathbf{D}(L)\Delta\boldsymbol{\gamma}_t &= \boldsymbol{\delta} + \boldsymbol{\xi}_t, & \boldsymbol{\xi}_t &\sim \mathrm{NID}(\mathbf{0}, \boldsymbol{\Sigma}_\xi),
\end{aligned}
$$

$(1-\theta L)^p \eta_t$ is the pre-specified MA(p) term which squeezes the spectrum in the interval $(1-\theta)/(1+\theta)$ and therefore accounts for low frequency cycles (Morton & Tunnicliffe-Wilson, G. (2000)).

$\phi(L)$ and $\widetilde{\phi}(L)$ are autoregressive polynomials of order p and $\widetilde{p}$ with stationary roots
The matrix polynomial $\mathbf{D}(L)$ is diagonal and $\Sigma_\xi = \mathrm{diag}(\sigma^2_1, \ldots, \sigma^2_N)$.

The disturbances η_t ,$\widetilde{\eta}_t$ and ξ_t are mutually uncorrelated at all leads and lags.

The two index SW model with surveys

$$
\begin{aligned}
\mathbf{y}_t &= \vartheta_{\mathbf{0}}\mu_t + \vartheta_{\mathbf{1}}\mu_{t-1} + \widetilde{\vartheta_{\mathbf{0}}}\widetilde{\mu}_t + \widetilde{\vartheta_{\mathbf{1}}}\widetilde{\mu}_{t-1} + \boldsymbol{\gamma}_t + \mathbf{X}_t\beta, \quad && t = 1, \ldots, n, \\
\phi(L)\Delta\mu_t &= (1-\theta L)^p \eta_t, && \eta_t \sim \text{NID}(0, \sigma^2_\eta), \\
\widetilde{\phi}(L)\Delta\widetilde{\mu}_t &= \widetilde{\eta}_t, && \widetilde{\eta}_t \sim \text{NID}(0, \sigma^2_{\tilde{\eta}}), \\
\mathbf{D}(L)\Delta\boldsymbol{\gamma}_t &= \boldsymbol{\delta} + \boldsymbol{\xi}_t, && \boldsymbol{\xi}_t \sim \text{NID}(\mathbf{0}, \boldsymbol{\Sigma}_\xi),
\end{aligned}
$$

ZAR

$(1-\theta L)^p \eta_t$ is the pre-specified MA(p) term which squeezes the spectrum in the interval $(1-\theta)/(1+\theta)$ and therefore accounts for low frequency cycles (Morton & Tunnicliffe-Wilson, G. (2000)).

$\phi(L)$ and $\widetilde{\phi}(L)$ are autoregressive polynomials of order p and $\widetilde{p}$ with stationary roots
The matrix polynomial $\mathbf{D}(L)$ is diagonal and $\Sigma_\xi = \text{diag}(\sigma^2_1, \ldots, \sigma^2_N)$.

The disturbances η_t ,$\widetilde{\eta}_t$ and ξ_t are mutually uncorrelated at all leads and lags.

Estimation and time constraint procedure

The estimation procedure and the disaggregation of the quarterly GDP is as in FMMP(2008).

- The model involves mixed frequency data, e.g. monthly indicators and quarterly GDP. Following Harvey (1989) and Proietti(2006), the state vector in the SSF is suitably augmented by using an appropriately defined cumulator variable in order to traslate the time constraint into a problem of missing observations.
- The model is cast in State Space Form and, under Gaussian distribution of the errors, the unknown parameters can be estimated by maximum likelihood, using the prediction error decomposition, performed by the Kalman filter.
- Filter and Smoother are based on the Univariate statistical treatment of multivariate models by Koopman and Durbin (2000): very flexible and convenient device for handling missing values in multivariate models and reduce the time of convergence. The multivariate vectors $\mathbf{y}_t^\dagger$, $t = 1, \ldots, n$, where some elements can be missing, are stacked one on top of the other to yield a univariate time series $\{y_{t,i}^\dagger, i = 1, \ldots, N, t = 1, \ldots, n\}$, whose elements are processed sequentially.

Model specification

- ✓ Based on two criteria:
  - statistical relevance of indicators: "general to specific" approach in combination with lag length selection on the BIC criterion. Every time the possibility of 1 or 2 factor model, with or without ZAR modification, is evaluated.
  - residual diagnostics: common approach in State Space Models of basing diagnostics and goodness of fit on the innovations.
- ✓ The double factor ZAR model encompasses the standard FMMP single index model only in two, but important, cases: Industry and Exports, which represents respectively 23% and 24% of the total GDP.
- ✓ Although the BIC criterion is in favour of a double index model in almost all cases, the survey based factor model outperform the standard FMMP in forecasting only in the two mentioned cases.

Estimation results

INDUSTRY

Parameters	*prod*	*howk*	*S.clime*	*S.prod.exp*	*S.price.exp*	*Value added*
θ_{i0}	0.608	0.156	-0.005	-0.020	-0.0007	0.649
	(0.113)	(0.062)	(0.013)	(0.030)	(0.024)	(0.140)
$\widetilde{\theta}_{i0}$	0.042	0.022	0.164	0.249	0.097	0.041
	(0.020)	(0.011)	(0.023)	(0.048)	(0.048)	(0.019)
δ_i	0.012	-0.147	0.002	0.055	0.019	0.221
	(0.004)	(0.066)	(0.007)	(0.196)	(0.02)	(0.066)
d_{i1}	0.461	-0.620	1.824	0.831	0.788	
d_{i2}	0.481	-0.130	-0.847	-0.327	0.173	
$\sigma^2{}_\eta$	0.274	0.274	0.031	0.119	0.230	0.300

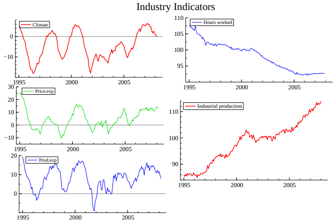
$$\left(1-0.44L-0.41L^2\right)\Delta\mu_t=(1+0.5L)^2\eta_t,\quad \eta_t\sim N(0,1)$$
$$\left(1-1.36L+0.41L^2\right)\Delta\widetilde{\mu}_t=\widetilde{\eta}_t,\quad \widetilde{\eta}_t\sim N(0,1)$$

EXPORTS

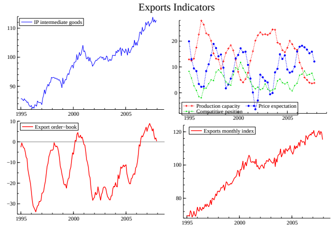
Parameters	*exp*	*IP.int*	*S.exp.order*	*S.prodcap*	*S.exp.expect*	*S.comp*	*NA*
θ_{i0}	1.107	0.621	-0.001	0.321	0.425	0.130	1.543
	(0.280)	(0.202)	(0.017)	(0.321)	(0.518)	(0.278)	(0.710)
$\widetilde{\theta}_{i0}$	-0.002	0.005	0.168	-0.368	0.308	0.138	0.021
	(0.022)	(0.019)	(0.021)	(0.064)	(0.130)	(0.048)	(0.048)
δ_i	0.352	0.349	0.01	1.121	0.637	0.015	0.973
	(0.108)	(0.108)	(0.02)	(0.478)	(0.254)	(0.005)	(0.169)
d_{i1}	0.032	-0.645	1.780	1.352	0.233	1.779	
d_{i2}	-0.178	-0.226	-0.804	-0.619	0.607	-0.78	
$\sigma^2{}_\eta$	1.142	0.595	0.001	0.095	0.704	0.133	1.100

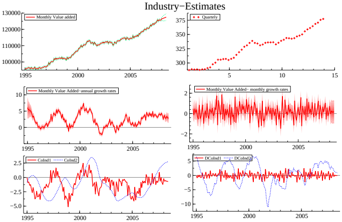
$$\left(1-0.57L-0.43L^2\right)\Delta\mu_t=(1+0.5L)^2\eta_t,\quad \eta_t\sim N(0,1)$$
$$\left(1-1.35L+0.371L^2\right)\Delta\widetilde{\mu}_t=\widetilde{\eta}_t,\quad \widetilde{\eta}_t\sim N(0,1)$$

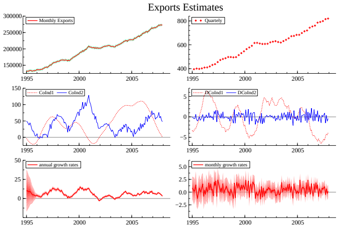
INDUSTRY



EXPORTS

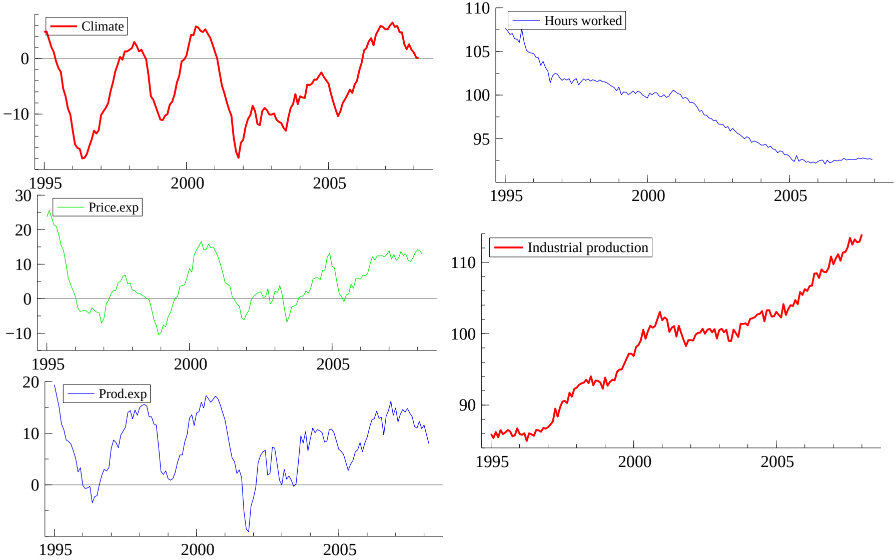




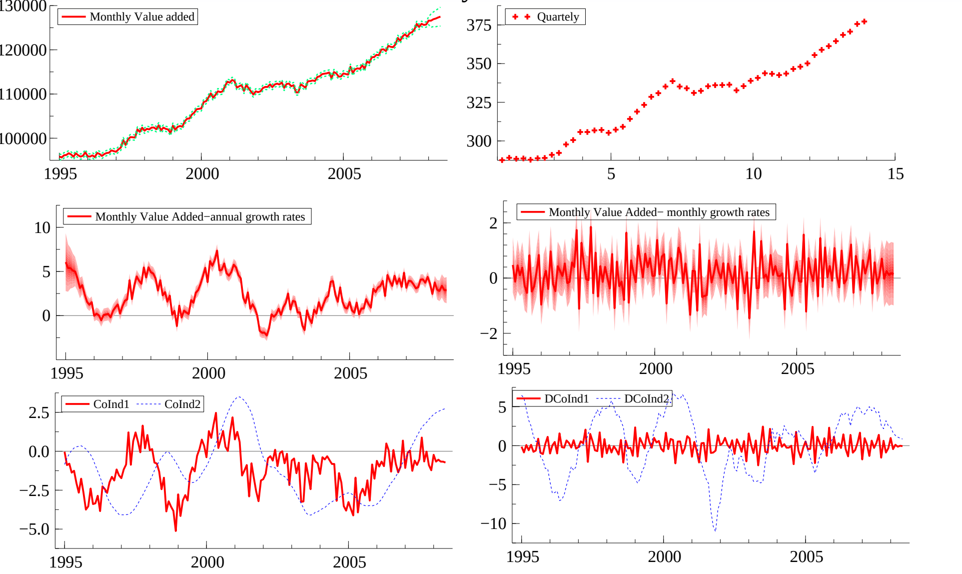


▶ GDP

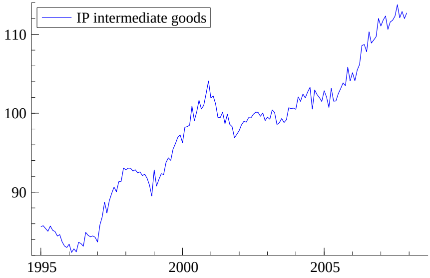
Industry Indicators

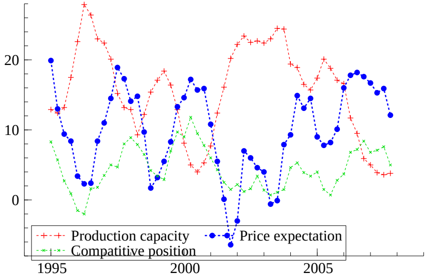


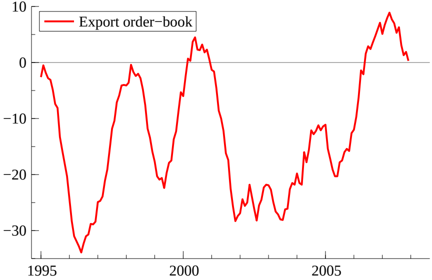
Industry−Estimates

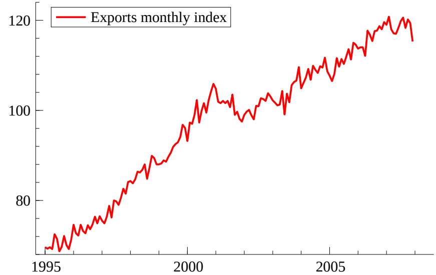


Exports Indicators

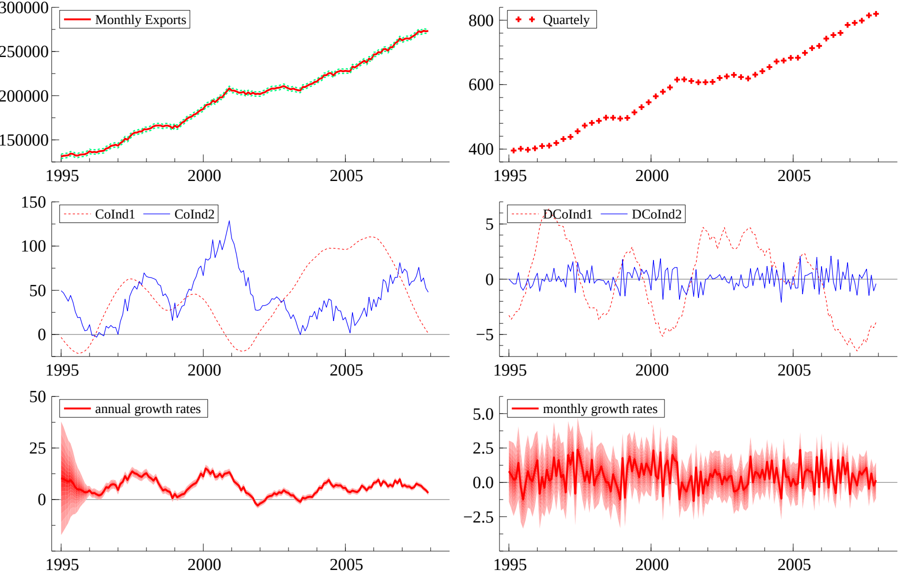








Exports Estimates



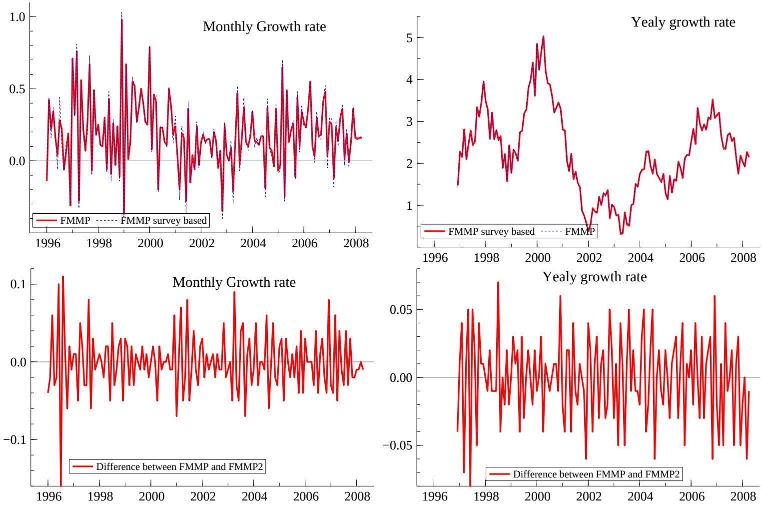


Figure: Estimated Monthly GDP: FMMP and FMMP survey-based

Forecast performance

We check empirically the forecasting performance of the survey based model by comparing the forecast accuracy of: a naive model (ADL in differences), the FMMP single index model and the FMMP-survey specification of this paper.

Dimensions: level or growth rates; Month of the quarter; horizon of forecast; real time indicators; revisions

1. Forecast error
2. DM test equal accuracy
3. revisions

1. Forecast error

Results are very clear: The ADLD model is almost always outperformed by the multivariate models, between which the FMMP-survey model makes globally the lowest forecast error, with a few exceptions. This evidence is stronger as the forecast horizon increases and the information set shrinks (1st month), especially for Exports. The gains from the survey-based model emerge both for Exports and Industry, in level as in growth rates, slightly greater in the latter case.

We run a similar forecasting experiment for Investment, focusing for simplicity on the MSFE measure. It turns out that the FMMP-survey is systematically worse than FMMP, even if it was better in terms of BIC. Similar results hold for the other components of GDP.

Table: Industry-Statistics on forecast performance with estimated parameters for 36 rolling estimates (2003M10-2006M8).

LEVELS

		ADL(1,1)D Model			FMMP			FMMP survey		
		1-step	*2-step*	*3-step*	*1-step*	*2-step*	*3-step*	*1-step*	*2-step*	*3-step*
ME	1^{st} M	-961	-3214	-5466	-67	-736	-1578	24	-21	-237
	2^{nd}	-516	-2540	-4899	93	-453	-1277	19	64	2
	3^{rd}	-1706	-4041	-6277	-356	-1192	-1954	-23	-225	-449
MAE	1^{st} M	1665	3716	5755	733	1650	2629	697	1595	2579
	2^{nd}	1099	2898	5291	811	1779	2638	773	1627	2456
	3^{rd}	2071	4423	6370	1265	2764	3753	1215	2284	3093
sMAPE	1^{st} M	0.48	1.06	1.63	0.21	0.47	0.74	0.2	0.46	0.74
	2^{nd}	0.32	0.83	1.51	0.23	0.51	0.75	0.22	0.47	0.7
	3^{rd}	0.59	1.26	1.80	0.36	0.78	1.06	0.35	0.65	0.88
RMSFE	1^{st} M	1845	4311	6677	965	1980	3103	909	1844	2857
	2^{nd}	1468	3511	5950	924	2047	3060	866	1914	2861
	3^{rd}	2379	4894	7205	1548	3184	4212	1544	2840	3729
mRAE	1^{st} M				0.44	0.47	0.42	0.36	0.38	0.35
	2^{nd}				0.73	0.59	0.40	0.85	0.47	0.32
	3^{rd}				0.6	0.63	0.52	0.46	0.38	0.31

The smallest values for each measure are underlined, unless for mRAE where the benchmark is 1.

Table: Industry-Statistics on forecast performance with estimated parameters for 36 rolling estimates (2003M10-2006M8).

GROWTH RATES

		ADL(1,1)D Model			**FMMP**			**FMMP survey**		
		1-step	*2-step*	*3-step*	*1-step*	*2-step*	*3-step*	*1-step*	*2-step*	*3-step*
ME	1^{st} M	-0.27	-0.64	-0.64	-0.02	-0.19	-0.23	0.01	-0.01	-0.06
	2^{nd}	-0.15	-0.58	-0.67	0.03	-0.15	-0.23	0.01	0.01	-0.01
	3^{rd}	-0.49	-0.66	-0.63	-0.10	-0.23	-0.21	0	-0.05	-0.06
MAE	1^{st} M	0.48	0.67	0.72	0.21	0.36	0.46	0.2	0.35	0.42
	2^{nd}	0.32	0.61	0.71	0.23	0.37	0.46	0.22	0.33	0.42
	3^{rd}	0.59	0.71	0.70	0.36	0.46	0.43	0.35	0.4	0.43
sMAPE	1^{st} M	200	193	240	263	234	137	121	106	99
	2^{nd}	335	417	179	200	129	137	743	90	98
	3^{rd}	594	193	217	107	137	134	90	109	101
RMSFE	1^{st} M	0.53	0.77	0.82	0.28	0.45	0.54	0.26	0.44	0.52
	2^{nd}	0.42	0.70	0.82	0.27	0.47	0.54	0.25	0.46	0.52
	3^{rd}	0.68	0.82	0.80	0.44	0.53	0.53	0.45	0.49	0.53
mRAE	1^{st} M				0.44	0.4	0.54	0.36	0.45	0.38
	2^{nd}				0.73	0.44	0.54	0.85	0.21	0.34
	3^{rd}				0.60	0.55	0.51	0.46	0.42	0.53

The smallest values for each measure are underlined, unless for mRAE where the benchmark is 1.

2. DM test

We assess the statistical significance of the differences in forecast accuracy for Industry and Exports by means of the Diebold and Mariano (1995) test.

Although the FMMP and FMMP-survey models are nested, rolling estimation validates the applicability of the Diebold-Mariano test.

It turns out that there is strong evidence of significant differences in MSE between multivariate factor models and univariate ADLD model, while the performance of the FMMP and FMMP-survey is not statistically different, with few exception for Exports growth rate forecast.

To conclude, overall this forecasting evaluation provides support for multivariate models, especially the FMMP-survey that includes timely information from survey data.

Table: Diebold-Mariano test (p-values) of equal forecast accuracy by horizon of forecast (1,2,3 quarters) and month of the prevision (1st, 2nd, 3td of the quarter).

LEVELS

Industry	*1-step*	*2-step*	*3-step*
FMMP *vs* ADLD	0.000	0.000	0.000 ✓
FMMP-survey *vs* ADLD	0.000	0.001	0.000 ✓
FMMP-survey *vs* FMMP	0.243	0.344	0.393
	1^{st} *Month*	2^{nd} *Month*	3^{rd} *Month*
FMMP *vs* ADLD	0.011	0.007	0.017 ✓
FMMP-survey *vs* ADLD	0.039	0.035	0.050 ✓
FMMP-survey *vs* FMMP	0.721	0.698	0.449

GROWTH RATES

Industry	*1-step*	*2-step*	*3-step*
FMMP *vs* ADLD	0.000	0.000	0.000 ✓
FMMP-survey *vs* ADLD	0.002	0.001	0.000 ✓
FMMP-survey *vs* FMMP	0.121	0.228	0.212
	1^{st} *Month*	2^{nd} *Month*	3^{rd} *Month*
FMMP *vs* ADLD	0.002	0.010	0.011 ✓
FMMP-survey *vs* ADLD	0.034	0.075	0.050 ✓
FMMP-survey *vs* FMMP	0.361	0.349	0.270

Table: Diebold-Mariano test (p-values) of equal forecast accuracy by horizon of forecast (1,2,3 quarters) and month of the prevision (1st, 2nd, 3td of the quarter).

LEVELS

Exports	*1-step*	*2-step*	*3-step*
FMMP *vs* ADLD	0.000	0.000	0.000
FMMP-survey *vs* ADLD	0.051	0.000	0.000
FMMP-survey *vs* FMMP	0.138	0.940	0.535
	1^{st} *Month*	2^{nd} *Month*	3^{rd} *Month*
FMMP *vs* ADLD	0.000	0.000	0.000
FMMP-survey *vs* ADLD	0.000	0.000	0.000
FMMP-survey *vs* FMMP	0.316	0.362	0.496

GROWTH RATES

Exports	*1-step*	*2-step*	*3-step*
FMMP *vs* ADLD	0.000	0.000	0.000
FMMP-survey *vs* ADLD	0.038	0.000	0.000
FMMP-survey *vs* FMMP	0.252	0.352	0.045
	1^{st} *Month*	2^{nd} *Month*	3^{rd} *Month*
FMMP *vs* ADLD	0.000	0.000	0.000
FMMP-survey *vs* ADLD	0.000	0.000	0.000
FMMP-survey *vs* FMMP	0.073	0.752	0.045

3.Revisions

We attempt to isolate the news content of each block of series used in the estimation of GDP, namely survey data and hard data, by using vintages of time series from the Euro area Real Time database (EABCN).

As for the forecast exercise, we consider 36 rolling forecasts staring from 2003M10, so that the last estimated quarter is 2007Q2.

The model is run more than once per month, and in particular every time a block of indicators is made available. Since we consider only two blocks of variables, hard and soft data, twice per month a new estimate of the value added is calculated and compared with the previous one.

Table: Industry: Averaged size of the news in the estimation and Forecast errors, real time vintages for 36 rolling forecasts (2003M10-2006M8).

INDUSTRY

Information set news*		FMMP 1-step	FMMP 2-step	FMMP 3-step	FMMP-survey 1-step	FMMP-survey 2-step	FMMP-survey 3-step
SURVEY ARRIVE							
	1^{st} Month				0.03	0.15	0.26
	2^{nd}				0.01	0.07	0.17
	3^{rd}				0.00	0.04	0.11
HARD DATA ARRIVE							
	1^{st} Month	0.24	0.30	0.31	0.23	0.31	0.30
	2^{nd}	0.11	0.21	0.22	0.10	0.21	0.21
	3^{rd}	0.01	0.29	0.27	0.00	0.30	0.26
RMSFE respect to first National Accounts vintage							
	1^{st} Month	7651	11657	15755	7668	11645	15599
	2^{nd}	7678	11778	15921	7653	11680	15684
	3^{rd}	912	8331	12333	858	8286	12047
RMSFE respect to last National Accounts vintage							
	1^{st} Month	28138	28744	29396	28084	28246	28429
	2^{nd}	28214	28939	29590	28216	28589	28783
	3^{rd}	26509	26765	27143	26527	26487	26219

(*) The news is measured by the Mean Absolute Relative difference between two consecutive vintages : $100 * abs[(Y1 - Y0)/Y0]$

Table: Exports: Averaged size of the news in the estimation and Forecast errors, real time vintages for 36 rolling forecasts (2003M10-2006M8).

EXPORTS

Information set news*	FMMP 1-step	FMMP 2-step	FMMP 3-step	FMMP-survey 1-step	FMMP-survey 2-step	FMMP-survey 3-step
SURVEY ARRIVE						
1^{st} Month				0.35	0.55	0.74
2^{nd}				0.19	0.40	0.57
3^{rd}				0.28	0.48	0.59
HARD DATA ARRIVE						
1^{st} Month	0.39	0.36	0.36	0.61	0.80	1.03
2^{nd}	0.14	0.20	0.20	0.47	0.69	0.82
3^{rd}	0.13	0.27	0.28	0.50	0.85	0.99
RMSFE respect to first National Accounts vintage						
1^{st} Month	19892	24913	34780	20365	26322	37627
2^{nd}	19825	26890	35498	20722	28806	36798
3^{rd}	10618	22144	27486	12349	23738	28219
RMSFE respect to last National Accounts vintage						
1^{st} Month	49726	52718	58084	51127	54833	63803
2^{nd}	51059	54331	58951	52434	55922	60616
3^{rd}	46904	49807	53138	45168	47035	49420

(*) The news is measured by the Mean Absolute Relative difference between two consecutive vintages : $100 * abs[(Y1 - Y0)/Y0]$

Summary and conclusion

- ✓ This paper deals with the timely estimation and forecasting of low frequency variables in the presence of higher frequency information, such as quarterly GDP growth for whose components several monthly indicators are available. The aim is to explore whether the inclusion of the high frequency data might improve estimation accuracy and forecast ability.
- ✓ The methodology we propose for the estimation of Euro Area GDP at the monthly level is based prominently on the disaggregation procedure developed by FMMP (2007). However, we suggest to extend their framework to allow for more than one common factor, survey based, and to correct for low frequency cycles. We also assess the forecasting performance of the model, evaluate the role of data revisions, and examine the news content in each block of survey and hard data.
- ✓ We find evidence in favour of the inclusion of a second survey based factor in two important components of GDP, namely, the Industry sector and the Exports demand component. The dominance of the two factor model is evident both in sample and out of sample. As far as the news content of data is concerned, information from survey matters, but mostly as long as hard data do not become available.