Short-term Forecasting of Czech Quarterly GDP Using Monthly Indicators

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STF of GDP by MI

Overview

A. Motivation
B. Tested models
C. Data
D. Results

A. Motivation

- Quarterly data of GDP – national accounts
  - published cca. 10 weeks after the end of the quarter
- A lot of monthly indicators are available (~70–100)
  - published early, i.e. end of a month or just a few weeks later
- Several models recently available in the literature can:
  - deal with mixed frequency data and unbalanced panels
  - condition the forecast on a large set of indicators
  - reduce forecast errors as opposed to univariate models
- A comprehensive study of recent short-term models for Czech GDP is missing. It is useful for forecasting at CNB.

B. Tested models

We follow the ECB study Barhoumi etal. (2008):

1. Moving average (naive model)
2. NTF framework of CNB
3. Averaged bivariate VAR-s **VAR**
4. Bridge equations **BEQ**
5. Static principal components **PC**
6. DFM ala Doz etal. 2007 **DFM**
7. GDFM ala Forni etal. 2005 **GDFM**

B. Tested models

1. Moving averages (naive model)
   average of last 4 quarters

2. Near-Term Forecasting (NTF) framework of CNB
   – GDP forecast = smoothed sum of expenditure components

Note: GDP will be henceforth denoted as “y“

B. Tested models

3. Bivariate VAR-s

$$x_{i,t}^{Q} = \frac{1}{3}\sum_{s=0}^{2} x_{i,\tau-s}$$ quarterly aggregation of N indicators

$$z_{i,t}^{Q} = \left\{ y_{t}^{Q},\, x_{i,t}^{Q} \right\}$$ for all pairs of y and $x_{i,t}$, i = 1..N

$$z_{i,t}^{Q} = \mu_i + \sum_{s=0}^{p_i} A_s\, z_{i,t-s}^{Q} + \varepsilon_{i,t}^{Q}$$ we estimate a VAR(2,p_i)

$$\hat{y}_{t+h|t}^{Q} = N^{-1}\sum_{i=1}^{N} \hat{y}_{i,t+h|t}^{Q}$$ pairwise GDP forecasts are averaged

B. Tested models

4. Bridge equations (BEQ)

$$x^{Q}_{i,t+h} = \frac{1}{3}\sum_{s=0}^{2} x_{i,\tau+H-s}$$ quarterly aggr. of forecasted x-s (H=3h)

$$y^{Q}_{t} = \mu_i + \sum_{s=0}^{q_i} \beta_{i,s}\, x^{Q}_{i,t-s} + \varepsilon_{i,t}$$ BEQ for all pairs i of N

$$\hat{y}^{Q}_{t+h|t} = N^{-1}\sum_{i=1}^{N} \hat{y}^{Q}_{i,t+h|t}$$ pairwise GDP forecasts are averaged

B. Tested models

5. Static principal components (PC)

$$x_{i,\tau} = \sum_{j=1}^{r} \lambda_{i,j} F_{j,\tau} + \upsilon_{i,\tau}$$

estimation of static factors (PC)

$$F_{j,t}^{Q} = \frac{1}{3} \sum_{s=0}^{2} F_{j,\tau-s}$$

quarterly aggregation of factors

$$y_{t+h}^{Q} = \mu + \beta' f_{t}^{Q} + \varepsilon_{i,t}$$

forecasting GDP (OLS)
„bridging with factors“

B. Tested models

6. Alternative principal components (PC-Q)

Differs from PC in three ways:

- PCs estimated on the quarterly aggregates
- # of static factors is selected by the Kaiser criterion (PC eigenvalues > 1)
- Incomplete quarters of monthly indicators are simply omitted

B. Tested models

7. DFM ala Doz etal. 2007

a) we estimate static factors by principal components, number of factors based on Bai and Ng (2002)

b) we estimate the parameters of dyn. factors by OLS

(number of dyn. factors based on Bai and Ng)

c) given parameters from the previous step, we estimate dynamic factors and idiosyncratic terms by Kalman filter

(flexible assumptions on the idiosyncratic terms)

d) we aggregate forecasted factors to quarterly freq.: f^{Q}_{t}

e) we regress y_{t+h} on f^{Q}_{t+h} by OLS

(on quarterly data; h is the forecast horizon)

B. Tested models

7. DFM ala Doz etal. 2007

$$x_{it} = \lambda_i F_t + \omega_{i,t}$$

estimate static factors (PC)

$$f_t = \sum_{k=1}^{P} A_k f_{t-k} + B v_{i,t}$$

estim. & forecast dyn. factors (KF)

$$f_{j,t+h}^{Q} = \frac{1}{3} \sum_{s=0}^{2} f_{j,\tau+H-s}$$

quarterly aggreg. of factors (H=3h)

$$y_{t+h}^{Q} = \mu + \beta' f_{t+h}^{Q} + \varepsilon_{i,t}$$

forecasting GDP (OLS)

„bridging with factors“

B. Tested models

8. One-sided GDFM ala Forni etal. 2005

   a) monthly indicators are aggregated to quarterly frequency

      (balancing by EM algorithm)

   b) GDFM is estimated on the combined database of quarterly indicators and GDP

      (max. no. of dyn. and stat. factors fixed, actual numbers selected by information criteria of Bai and Ng)

   c) GDP forecast is derived directly from the factor model as the forecast of common components

B. Tested models

8. One-sided GDFM ala Forni etal. 2005

$$x_{i,t}^{Q} = \frac{1}{3}\sum_{s=0}^{2} x_{i,\tau-s}$$

quarterly aggregation of indicators

$$z_t^{Q} = \left\{ y_t^{Q}, x_t^{Q} \right\}$$

y is GDP

$$z_t^{Q} = \Lambda f_t^{Q} + \upsilon_t$$

estimate GDFM on quarterly data

$$z_{1,t+h}^{Q} = \lambda_1 f_{t+h}^{Q} + \upsilon_t$$

forecast (z_1 = y = GDP)

C. Data

Monthly indicators (98 series):

- Industry, construction and services (43)
- Labour market (5)
- Foreign trade (4)
- Price data (11)
- Financial indicators (19)
- Czech confidence indicators (6)
- Foreign leading indicators (9)
- Czech electricity consumption (1)

Adjustment of GDP and monthly data:

- Seasonal adjustment, quarterly growth rates
- Some of monthly indicators further differenced to achieve stationarity

C. Data

Indicator pre-selection – our rule of thumb:

- Used only for large-scale models (5.-8.)
- Goal: focus on indicators with most relevant information for GDP when estimating factor models
- Include if abs(corr.) with GDP growth > 0.5
- If abs(corr.) between any two indicators is > 0.9, only the one more correlated with GDP is kept
- From the full set of 98 only 27 series survive
- Result: reduced forecast errors for models 5.,7.,8.

C. Data

Series No.	Name	Correlation with GDP*	Included in factor models?	Number of log differences**
1	IPI manufacturing	0.57	Y	1
2	IPI leather	0.51	Y	1
3	IPI machinery	0.63	Y	2
4	IPI motor vehicles excl. motorcycles	0.51	Y	1
5	Industry sales	0.55	Y	1
6	Sales - wholes., retail, service and maint. of motor vehicles	0.63	Y	2
7	Sales - services total	0.86	Y	2
8	Sales - accommodation, catering and hospitality	0.52	Y	2
9	Sales - information and communication services	0.51	Y	2
10	Sales - professional, scientific and technical services	0.58	Y	2
11	Sales - administrative and complementary activities	0.63	Y	2
12	Free vacancies	0.73	Y	1
13	Newly registered unemployed (inflows)	-0.77	Y	2
14	Unemployment rate (total)	-0.72	Y	2
15	Export (current prices)	0.53	Y	1
16	Import (current prices)	0.57	Y	1
17	Eurozone PPI (effective)	0.64	Y	1
18	PPI manufacturing	0.57	Y	1
19	3M PRIBOR	0.52	Y	2
20	ECB 1Y rate	0.75	Y	1
21	Confidence indicator index (entrepreneurs)	0.61	Y	1
22	Industry survey - overall economic situation	0.71	Y	2
23	Industry survey - demand	0.60	Y	1
24	The Ifo Business Climate for Germany - Business Situation	0.67	Y	2
25	OECD Composite Leading Indicator - Germany	0.81	Y	1
26	New car registrations - Germany	-0.54	Y	1
27	Euro area Business Climate Indicator	0.52	Y	1

Notes: * Correlation coefficients were calculated from q-o-q growth rates of the quarterly aggregates
** Monthly indicators were log-differenced before estimation to achieve stationarity

D. Results

Time interval:	2001:q1 – 2009:q4
Evaluation interval:	2005:q1 – 2009:q4
Forecast horizon:	1 to 3q ahead
Number of indicators:	up to 27 (98)

D. Results

The smallest RMSE overall: PC

Smallest RMSE 1Q ahead: NTF of CNB

Relat. RMSE	+1Q	+2Q	+3Q	Average
NTF	**0.67**	0.80	0.91	0.81
VAR	0.97	1.11	1.18	1.09
BEQ	0.69	0.92	1.06	0.90
PC	0.69	**0.68**	**0.90**	**0.76**
PC-Q	0.80	1.09	1.27	1.06
DFM	0.75	0.79	0.99	0.85
GDFM	1.04	0.93	0.98	0.98

Note: relative RMSE is calculated vis-à-vis the RMSE of the moving average model

D. Results

Relat. RMSE	+1Q	+2Q	+3Q	Average
Average forecast	0.81	0.86	0.95	0.88
PC - full panel	0.92	0.82	0.95	0.89
DFM - full panel	1.06	1.10	1.04	1.07
GDFM - full panel	1.09	0.98	1.01	1.02
AR(1)	1.10	1.14	1.09	1.11
historical mean	1.13	1.02	0.97	1.03

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PC-Q	0.80	1.09	1.27	1.06
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GDFM	1.04	0.93	0.98	0.98

D. Results

Ranks of 7+4	+1Q	+2Q	+3Q	Average
Average forecast	6	5	3	4
PC - full panel	7	4	4	5
DFM - full panel	10	10	8	10
GDFM - full panel	11	8	7	11

Relative ranks	+1Q	+2Q	+3Q	Average
PC - full panel	-5	-3	-3	-4
DFM - full panel	-6	-8	-2	-7
GDFM - full panel	-2	-1	-2	-1

Ranks: model ranking based on RMSE, out of the 7 main models + 4 additional models listed in the table above

Relative rank, for example: = rank of PC – rank of PC full panel

Diebold-Mariano Test Statistic for the H0 of Equal Squared Forecast Errors

	VAR	BEQ	PC	DFM	GDFM	4Q average
VAR		2.01*	3.81**	3.28**	1.87*	2.05*
BEQ	-2.01*		2.95**	1.44	-0.41	-0.41
PC	-3.81**	-2.95**		-2.63**	-3.25**	-3.21**
DFM	-3.28**	-1.44	2.63**		-3.17**	-3.03**
GDFM	-1.87*	0.41	3.25*	3.17*		-0.02
4Q average	-2.05*	0.41	3.21**	3.03**	0.02	

Note: negative statistics indicate smaller forecast errors for the model in the row. * and ** denote significance at the 95 % and 99 % levels. Degrees of freedom equals 159.

D. Results

Results of the ECB study

Countries:	7 of the eurozone
Time period:	1991:q1 – 2005:q3
Evaluation period:	2000:q1 – 2005:q3
Forecast horizon	1 to 3q ahead
Number of indicators:	76 - 393 by country

RMSE vis-à-vis the naive model:

Relat. RMSE	+1Q	+2Q	+3Q	Average
AR	0.99	0.99	1.00	0.99
VAR	0.97	0.99	1.01	0.99
BEQ	0.93	0.96	1.00	0.97
PC	0.86	0.92	**0.94**	0.91
DFM	**0.83**	**0.90**	0.95	**0.89**
GDFM	0.91	0.92	0.98	0.94

D. Results

Results of the ECB study

Countries:	LT, HU, PL
Time period:	1995:q1 – 2005:q3
Evaluation period:	2002:q1 – 2005:q3
Forecast horizon:	1 to 3q ahead
Number of indicators:	80 – 103 by country

RMSE vis-à-vis the naive model:

Relat. RMSE	+1Q	+2Q	+3Q	Average
AR	0.91	0.95	0.99	0.95
VAR	0.95	**0.94**	**0.95**	**0.90**
BEQ	0.94	0.98	0.98	0.96
PC	1.24	1.06	1.07	1.09
DFM	1.14	1.06	1.01	1.05
GDFM	**0.90**	**0.94**	0.99	0.94

D. Results

- On CZ data, most models are more accurate than the naive model
- PC performs best overall, thus it is a good idea to condition the forecast on “many” but relevant monthly series
- Expert forecast (NTF) did at least as well as the best model (PC) 1Q ahead
- Factor models did quite well overall (PC and DFM better than VAR and BEQ)
- Factor models improved in precision if the indicator set was reduced to the most relevant subset
- Looking at errors of PC and PC-Q, timeliness of information is key
- Results (model rankings) are not quite generalizable across countries

Questions