NÁRODNÁ BANKA SLOVENSKA
EUROSYSTÉM

Short-term Forecasting of Real GDP Using Monthly Data

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- Searching and selection
- Models for short-term forecasting
- Forecast evaluation
- How to deal with results

Why monthly data and DFM model?

- Real GDP release with delay 10 weeks
- Monthly data provides partial information already during the given quarter, as opposed to quarterly data
- There are a large variety of monthly indicators, enabling us to make a selection of the most relevant ones as far as GDP growth is concerned
- Not only "hard data" – "Soft" data (surveys, sentiments and confidence indicators) are available earlier than "hard" data

Searching and selection (1)

- Initial database consists of 71 variables (from Jan-2000 to Dec-2014)
  - Hard data - *Financial(12), Output and Activity(10), Labour and Wages(4), Prices(4), Trade(4)*
  - Soft data – *Domestic surveys (23), Foreign surveys (14)*
  - Data transformation – *level, m/m(-3), m-m(-3)* , normalized to zero mean and unit variance

- Selection one – expert judgment/correlation analysis
  - Pairwise correlations to GDP (qq growth) and expert judgement
    - best candidates from each area
    - Selected 11 variables
- Criticism for simplicity of searching method

Searching and selection (2)

- Selection two – soft thresholding (21 indicators tested)
  - Idea of leading and coincident indicators – 2 subsets with intersection
  - Stepwisefit reggression (p-value=0.1)
    - Used 3+3 core variables as an initial model
    - Core variables - ('Industrial confidence indicator‘, 'Turnover in selected branches, sa, current prices‘, 'Industrial production, DE, sa‘, 'Industry confidence indicator, production expectations, sa‘, 'Ifo DE, expectations‘, 'Eurozone manuf. PMI; composite index')
    - Significant 7+8 variables
    - Disadvantage of this method is that is locally optimal not globally
  - LASSO – first 5+5 variables selected

Searching and selection (3)

- Selection three – soft thresholding (21 indicators tested)
  - Stepwisefit reggression and LASSO with Core variables used
    - Union from both methods
    - Significant 11 variables

Searching and selection (4)

DFM(expert-11), Bridge(expert-11)	DFM(statistic-2f), Bridge(statistic 7+8)	DFM(statistic-11), Bridge(statistic-11)
		Cons. major purchases over next 12 m., EU
	Coicident indicators - NOWCAST	World Trade
CLI amplitude adusted_ea	Ifo DE	Eurozone manuf. PMI; composite index
Consumer confidence indicator EU	Consumer confidence indicator EU	ESI EU
Industrial production, DE, sa	Industrial production, DE, sa	Industrial production, DE, sa
Turnover in selected branches, sa, current prices	Turnover in selected branches, sa, current prices	Turnover in selected branches, sa, current prices
Industrial confidence indicator	Industrial confidence indicator	Industrial confidence indicator
Consumer confidence indicator	Consumer confidence indicator	Goods trade balance, nominal, sa
Number of registered unemployed, sa	Monthly employment, selected branches, sa	Construction production, constant prices, sa
Industrial production index, sa	**Leading indicators - FORECAST**	Major purchases over next 12 months
Export of goods, nominal, sa	Wages and Salaries	Wages and Salaries
Real effective exchange rate, PPI	Industry confidence indicator, production expectations, sa	
Spread govt. vs money market	Manufacturing new orders, current prices, sa	
	Ifo DE, expectations	
	Eurozone manuf. PMI; composite index	
	Share price index, Germany	
	Cons. major purchases over next 12 m., EU	
	World Trade	

Models for short-term forecasting

- DFM (dynamic factor model) – based on principal component analysis (PCA)

- Bridge equations (BE)

DFM model

Database(11, 7+8, 11)
Transformation - level, m/m(-3), m-m(-3) , normalized to zero mean and unit variance
Balancing – Factor forecast, AR(p) - BIC

Estimation PCA (11, 7+8, 11)

Forecast PCA AR(p) – BIC
Transformation monthly to quarterly data

Estimation of bridge equation to GDP $y_t = \mu + \sum_{j=1}^{p} \phi_j y_{t-1} + \sum_{j=1}^{q} \beta_j' \hat{f}_{t-j} + d_t + u_t$

Forecast of GDP q-o-q

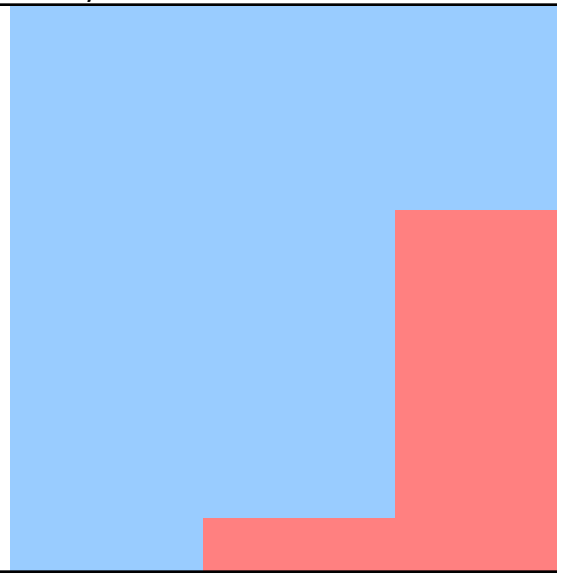
Balancing data

Not all data available at the same time – to use as long horizon for estimation models as possible – balancing data necessary

- Expert judgement
- AR(p) – p determined by means of the Bayesian information criteria (BIC)
- Using factor prediction

Balancing data – delays example

Around 15th Aug-2014	May-2014	Jun-2014	Jul-2014
Industrial confidence indicator			
Consumer confidence indicator			
Consumer confidence indicator EU			
Spread govt. vs money market			
Number of registered unemployed, sa			
Industrial production index, sa			
Export of goods, nominal, sa			
Real effective exchange rate, PPI			
Turnover in selected branches, sa, current prices			
Industrial production, DE, sa			
World Trade			



Note: "blue area" = available data at the time of the forecast procedure, "red area" = missing data

Bridge equations

Database(11, 40, 7+8)

Balancing – AR(p) - BIC

Transformation monthly to quarterly data (level/q-o-q)

Estimation simple bridge equations with GDP (OLS) (q-o-q)

$$y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 x_{t-L} + d_t + u_t$$

Forecast from each equation (forecasts of GDP q-o-q)

Weighted average of forecasts (based on AIC); „forecast combination"

Forecast of GDP q-o-q

Forecast evaluation 1 – models

- ARMA - benchmark model
- DFM(expert-11) (*correlation selection – 11*)
- DFM(statistic-2f) (*2 Factors, Stepwise, LASSO selection 7+8*)
- DFM(statistic-11) (*Stepwise, LASSO selection - 11*)
- Bridge(expert-11) (*correlation selection – 11*)
- Bridge(large-40) (*expert selection – 40*)*
- Bridge(statistic 7+8) (*Stepwise, LASSO selection 7+8*)

*Regularly applied as a supporting tool in past NBS forecasts. It includes monthly indicators of the Slovak economy such as business surveys, industrial production and orders, interest rates and spreads and labour market variables.

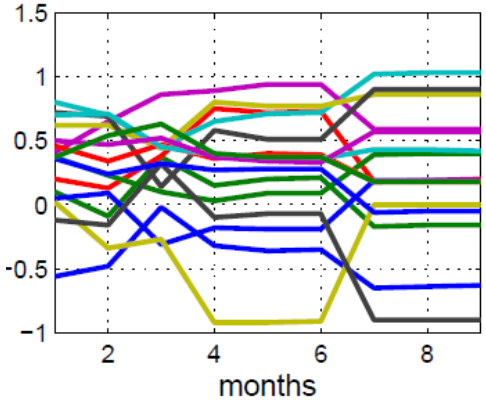
Forecast evaluation 1 – design

- Quasi real-time database
- Release GDP 4Q.2013
- Evaluation period: 1Q 2010 – 4Q 2013
- Benchmark: naive model ARMA (2,0)
- Q-o-Q growth for each quarter is estimated 9x
- Models are estimated every month (in the second half of month) incl. balancing data and factor estimation

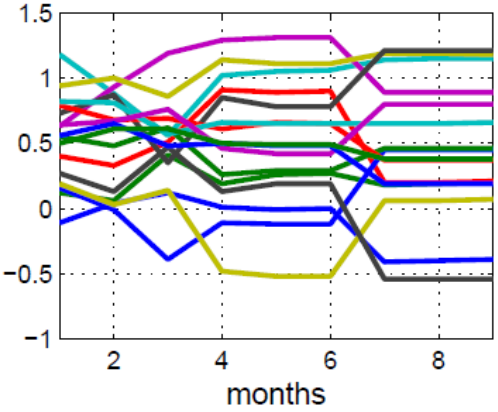
	Releases of GDP figures		
	Backcasting	Nowcasting	Forecasting
January	Q4	Q1	Q2
February	Q4	Q1	Q2
March	**Q4**	Q1	Q2
April	Q1	Q2	Q3
May	Q1	Q2	Q3
Jun	**Q1**	Q2	Q3
July	Q2	Q3	Q4
August	Q2	Q3	Q4
September	**Q2**	Q3	Q4
October	Q3	Q4	Q1
November	Q3	Q4	Q1
December	**Q3**	Q4	Q1

Forecast evaluation 1 – Forecasts over 9 months

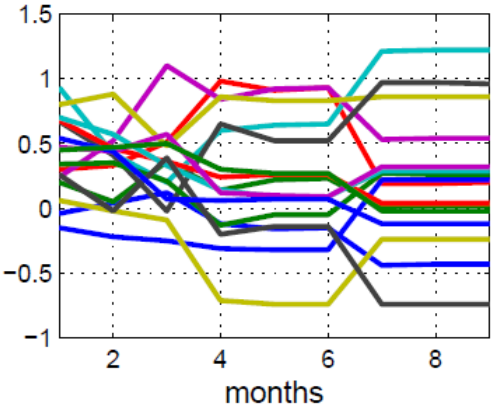
DFM(expert-11)



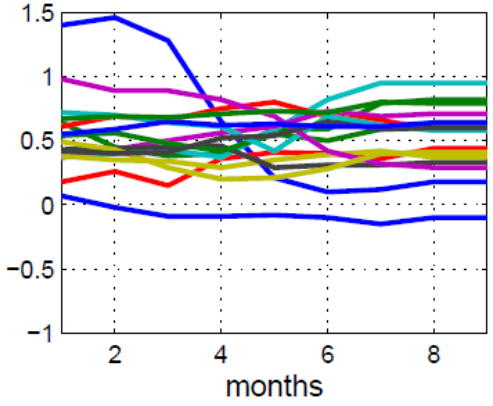
DFM(statistic-2f)



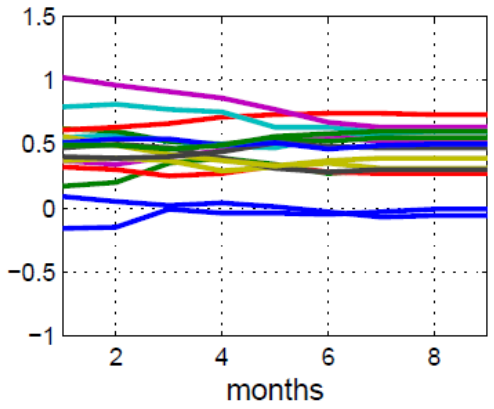
DFM(statistic-11)



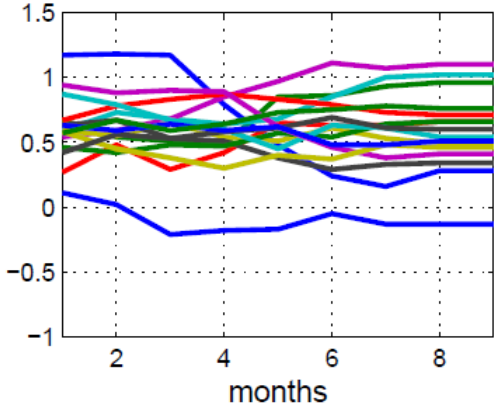
Bridge(expert-11)



Bridge(large-40)



Bridge(statistic-7+8)



Forecast evaluation 1 – MSE & BIAS

MSE

	Months									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**average**
ARMA	0.47	0.47	0.47	0.46	0.46	0.46	0.44	0.44	0.44	0.46
DFM(expert-11)	**0.22**	0.21	**0.18**	0.28	0.28	0.28	0.31	0.31	0.31	0.26
DFM(statistic-2f)	0.38	0.38	0.36	0.47	0.47	0.47	0.46	0.46	0.46	0.43
DFM(statistic-11)	0.25	**0.17**	**0.18**	0.25	0.25	0.25	0.29	0.29	0.29	0.25
Bridge(expert-11)	0.27	0.26	0.25	0.26	0.26	0.30	0.33	0.33	0.33	0.29
Bridge(large-40)	0.28	0.27	0.25	**0.23**	**0.23**	**0.22**	**0.22**	**0.22**	**0.22**	**0.24**
Bridge(statistic 7+8)	0.31	0.32	0.32	0.33	0.34	0.41	0.42	0.43	0.43	0.37

BIAS

	Months									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**average**
ARMA	0.63	0.63	0.63	0.62	0.62	0.62	0.61	0.61	0.61	0.62
DFM(expert-11)	**0.31**	**0.27**	**0.30**	0.26	0.26	0.26	0.23	0.24	0.24	**0.26**
DFM(statistic-2f)	0.52	0.51	0.50	0.50	0.50	0.50	0.45	0.45	0.45	0.49
DFM(statistic-11)	0.40	0.32	**0.30**	**0.22**	**0.21**	**0.22**	**0.21**	**0.21**	**0.21**	**0.26**
Bridge(expert-11)	0.45	0.45	0.45	0.45	0.46	0.49	0.50	0.52	0.52	0.48
Bridge(large-40)	0.44	0.44	0.44	0.43	0.43	0.42	0.42	0.42	0.42	0.43
Bridge(statistic 7+8)	0.51	0.52	0.51	0.52	0.53	0.58	0.58	0.58	0.58	0.55

Forecast evaluation 2

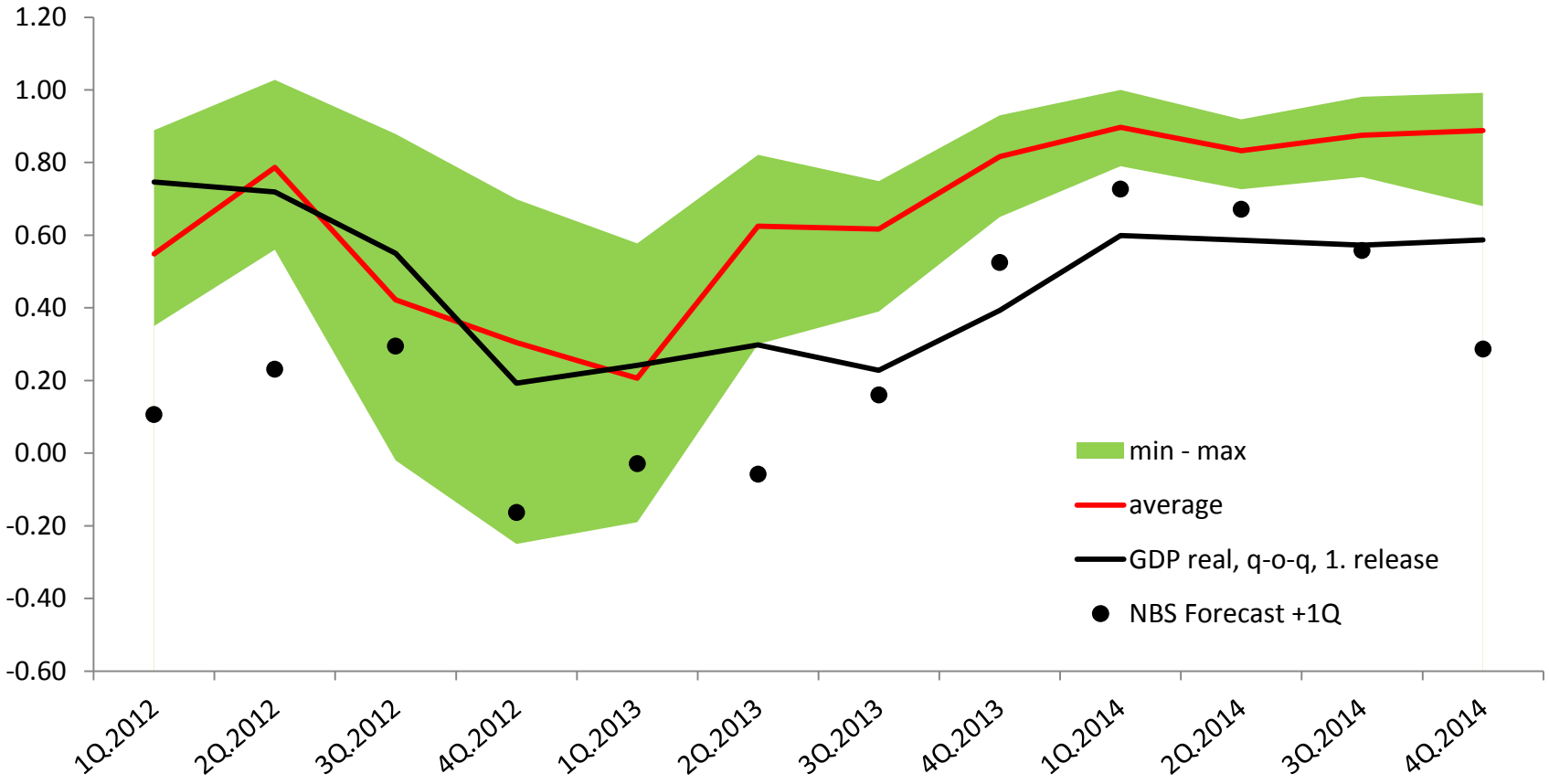
- Real time database 2012-2014 (only February, May, August, November)
- Evaluation results compared with 1st release of real GDP
- Timing synchronized with NBS Forecast (1Q-February, 2Q-May, 3Q-August, 4Q-November)
- NBS Forecast +1Q (NOWCAST), NBS Forecast +2Q (FORECAST)

  - NBS Forecast – Benchmark
  - DFM(expert-11) (*correlation selection – 11*)
  - DFM(statistic-11) (*Stepwise, LASSO selection - 11*)
  - Bridge(expert-11) (*correlation selection – 11*)
  - Bridge(large-40) (*expert selection – 40*)
  - Bridge(statistic 11) (*Stepwise, LASSO selection 11*)

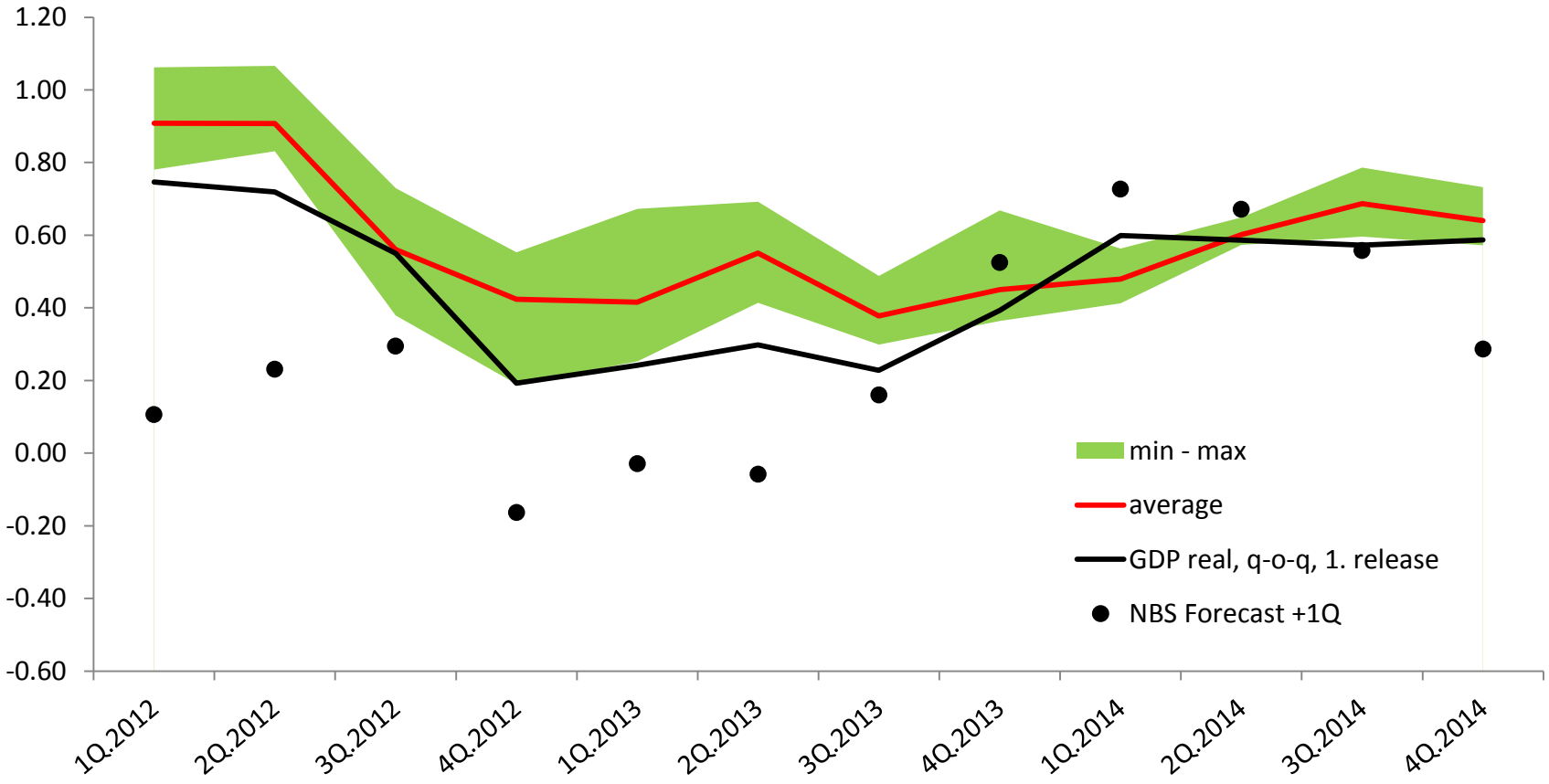
How to deal with results

- Direct approach – results from models are used as forecast
  - disadvantage – significant systematic bias
- Signal approach – signal (movement/difference between 2 quarters of forecasted GDP) plus last available value of GDP is used to make a forecast of GDP

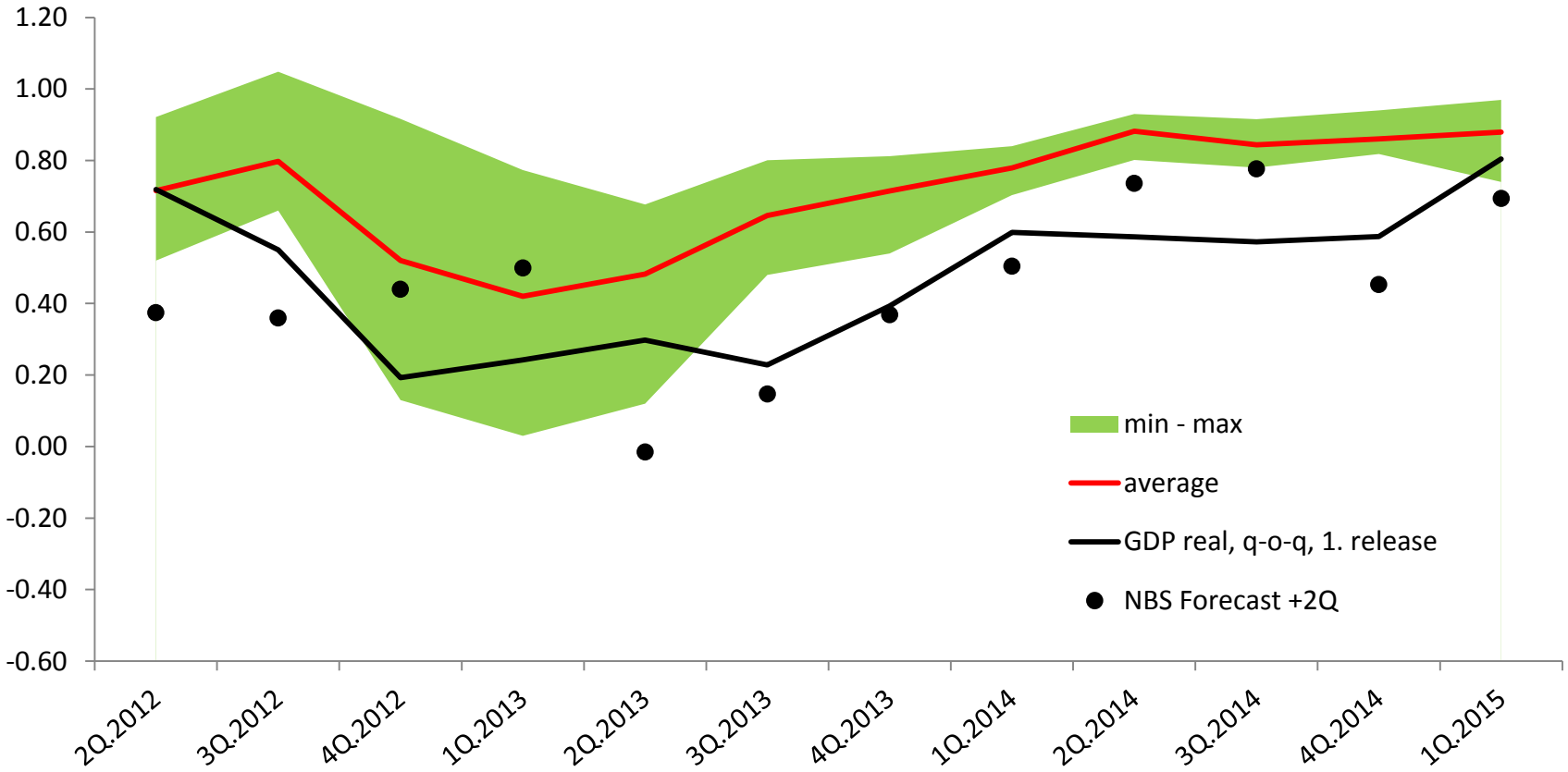
Nowcast - Direct approach



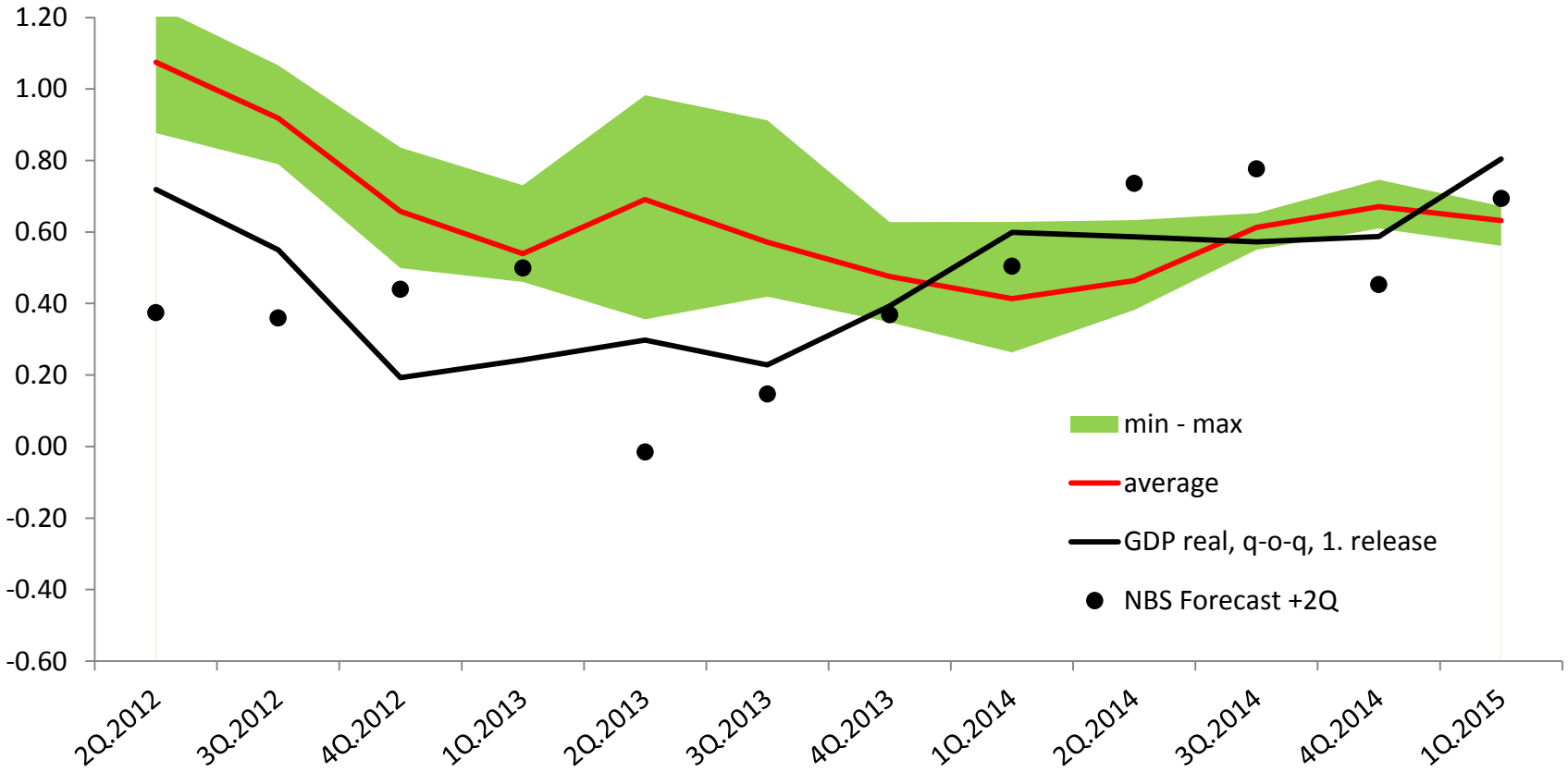
Nowcast - Signal approach



Forecast - Direct approach



Forecast - Signal approach



MSE – which model/approach is the best?

MSE (1Q12-4Q14)	Bridge (large-40)	Bridge (expert-11)	Bridge (statistic-11)	DFM (expert-11)	DFM (statistic-11)	NBS Forecast
NOWCAST	0.15	0.11	0.08	0.15	0.04	0.10
NOWCAST - Signal approach	0.01	0.02	0.03	0.07	0.03	
FORECAST	0.18	0.10	0.10	0.05	0.04	0.04
FORECAST - Signal approach	0.05	0.08	0.11	0.12	0.11	

Direction of GDP growth rate changes vs. models results

	2012				2013				2014			
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
GDP Q-o-Q	-	-	-	-	+	+	-	+	+	-	-	+
NBS Forecast +1Q		+	+	-	+	-	+	+	+	-	-	-
Q-o-Q NOWCAST												
DFM(expert-11)		+	-	-	+	+	+	+	+	-	+	+
DFM(statistic-11)		+	-	-	-	+	+	+	+	-	-	-
Bridge(large-40)		+	-	-	-	+	-	+	+	+	+	+
Bridge(expert-11)		+	-	-	-	+	-	+	+	-	-	+
Bridge(statistic-11)		+	-	-	-	+	-	+	+	-	+	-
Q-o-Q NOWCAST Signal approach												
DFM(expert-11)		+	-	-	+	+	-	+	-	+	+	-
DFM(statistic-11)		+	-	-	-	+	-	+	+	+	-	-
Bridge(large-40)		+	-	-	-	+	-	+	+	+	+	-
Bridge(expert-11)		+	-	-	+	+	-	+	+	+	+	-
Bridge(statistic-11)		-	-	-	-	+	-	+	+	+	+	-
NBS Forecast +2Q			+	+	-	+	-	+	+	+	-	-
Q-o-Q FORECAST												
DFM(expert-11)			+	-	-	+	+	+	+	+	-	+
DFM(statistic-11)			+	-	-	+	+	-	+	+	-	+
Bridge(large-40)			+	-	-	-	+	-	+	+	+	+
Bridge(expert-11)			+	-	-	+	+	+	-	+	-	-
Bridge(statistic-11)			-	-	+	-	-	+	-	+	-	+
Q-o-Q FORECAST Signal approach												
DFM(expert-11)			-	-	-	+	-	-	-	-	+	+
DFM(statistic-11)			-	-	-	+	+	-	+	+	-	+
Bridge(large-40)			-	-	-	-	+	-	-	+	+	-
Bridge(expert-11)			-	-	-	+	-	-	-	+	+	+
Bridge(statistic-11)			-	+	-	-	-	+	-	+	+	+

Conclusion

- We can’t say which model is the best for GDP short-term forecast
- It seems short term-models slightly outperform official NBS +1Q forecast (NOWCAST) - potential for improvement if new models are implemented in forecasting process
- NBS +2Q forecast outperform (in average) Bridge and Dynamic Factor models
- Suggestion: Extension of the available model range to include DFM models and some additional Bridge equations

Thank you for your attention