SCHWEIZERISCHE NATIONALBANK
BANQUE NATIONALE SUISSE
BANCA NAZIONALE SVIZZERA
BANCA NAZIUNALA SVIZRA
SWISS NATIONAL BANK

utomated hort-\un conomic . orecasts (.)

ank of anada
ctober -, .

. icolas toffels
nicolas.stoffels snb.ch

ntroduction

- otivation
- lobal forecasts at the
- ramework
- pplication for growth
- ummary

. otivation

« …policymakers are well advised to follow two principles familiar to navigators throughout the ages: . irst, determine your position frequently. econd, use as many guides or landmarks as are available. »

. ernanke, . arch .

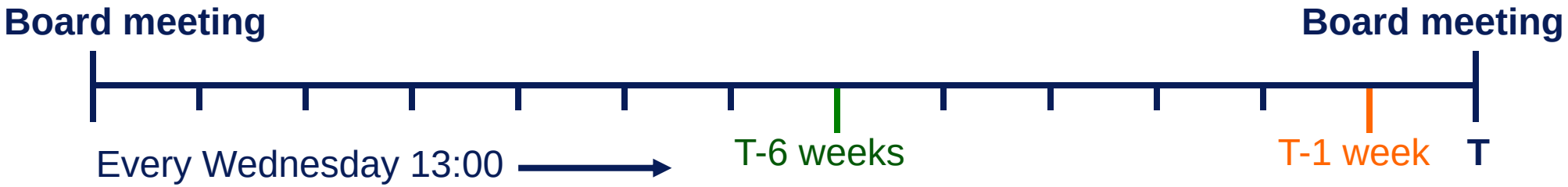
- \eleases of the official value of . . . and other national accounts data are published late
  → . lobal economic developments have to be assessed from numerous and more timely indicators
- .ncorporate higher-freqency indicators into statistical, quantitative forecasting models
  → **e.g. \ünstler and édillot (), .ngenito and rehan () …**
- wo main . oals:
  - . xploit the considerable amount of conjunctural information available before release of official national accounts data
  - . uild an automated process for an efficient day-to-day use

→ . . roject:

utomated procedure to select and run optimal, indicator models for short-term forecasting of the international economy

.'s global forecasts cycle

Quarterly cycle: 13 weeks



Weekly review of incoming indicators

Defining mid-term scenarios for the global economy: Base scenario & 2-3 risk scenarios (requiring Board approval)

Interim assessment of Base scenario

Update of short-term forecasts

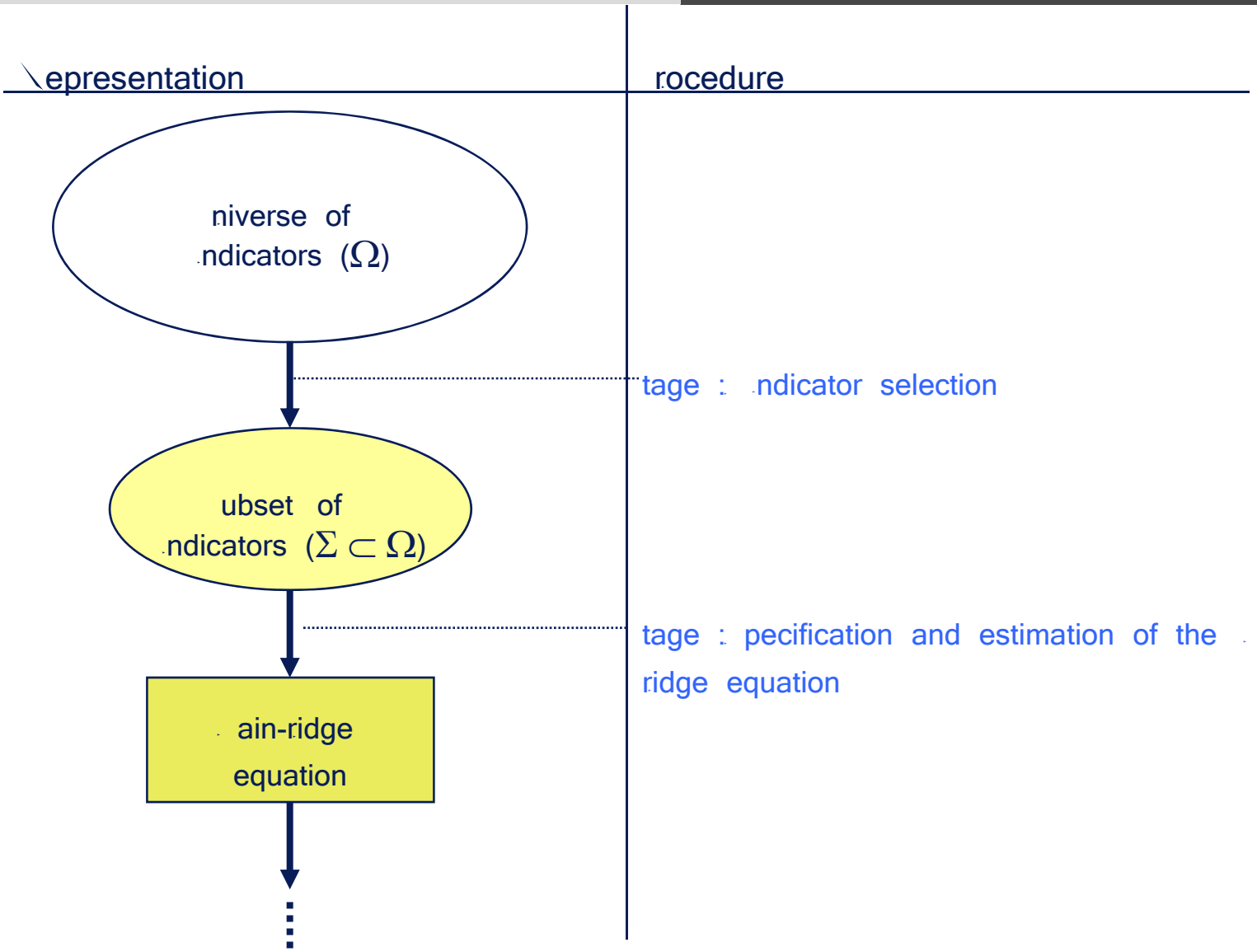
Update of short and medium-term forecasts

Update of short and medium-term forecasts

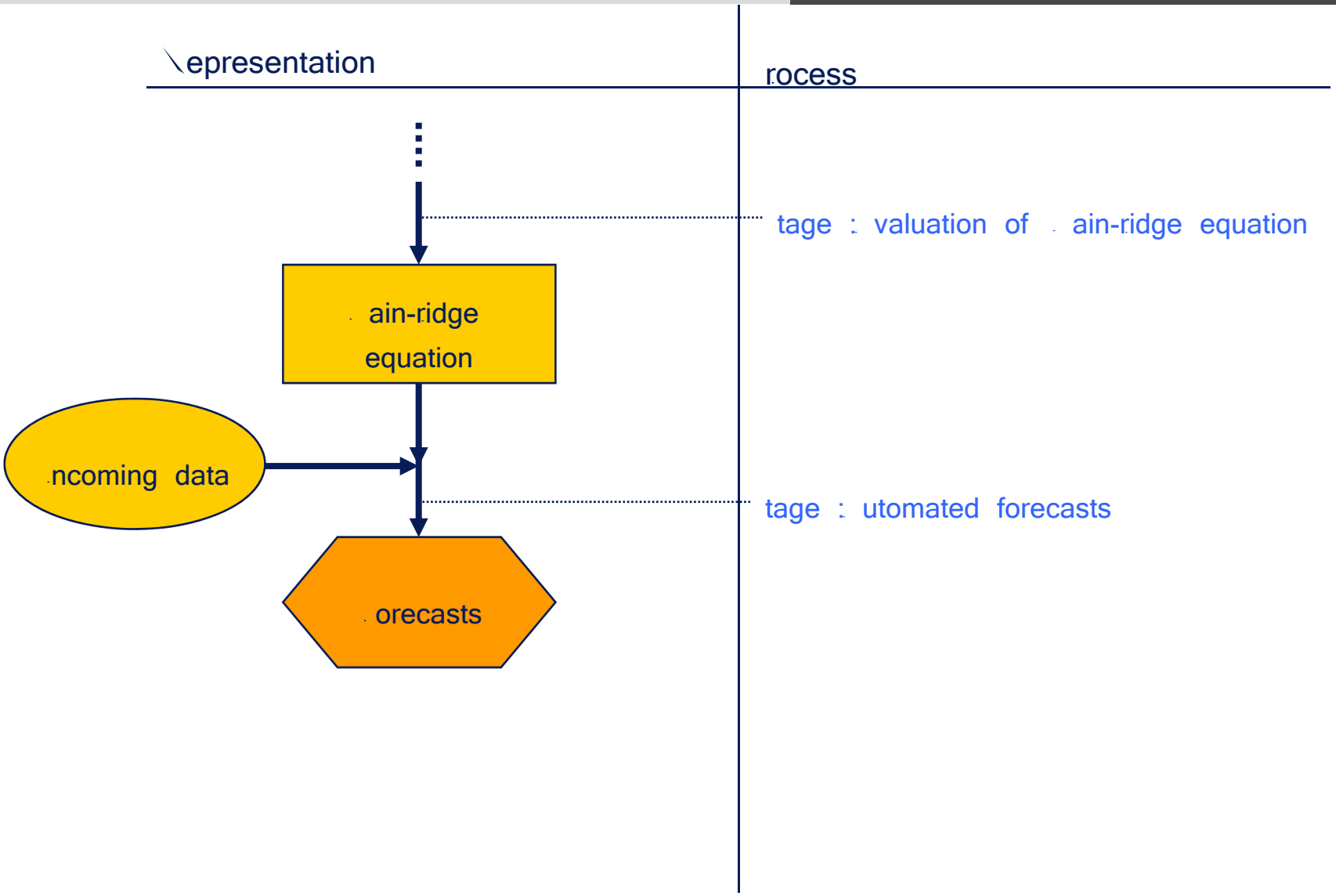
SCHWEIZERISCHE NATIONALBANK
BANQUE NATIONALE SUISSE
BANCA NAZIONALE SVIZZERA
BANCA NAZIUNALA SVIZRA
SWISS NATIONAL BANK

. exicon

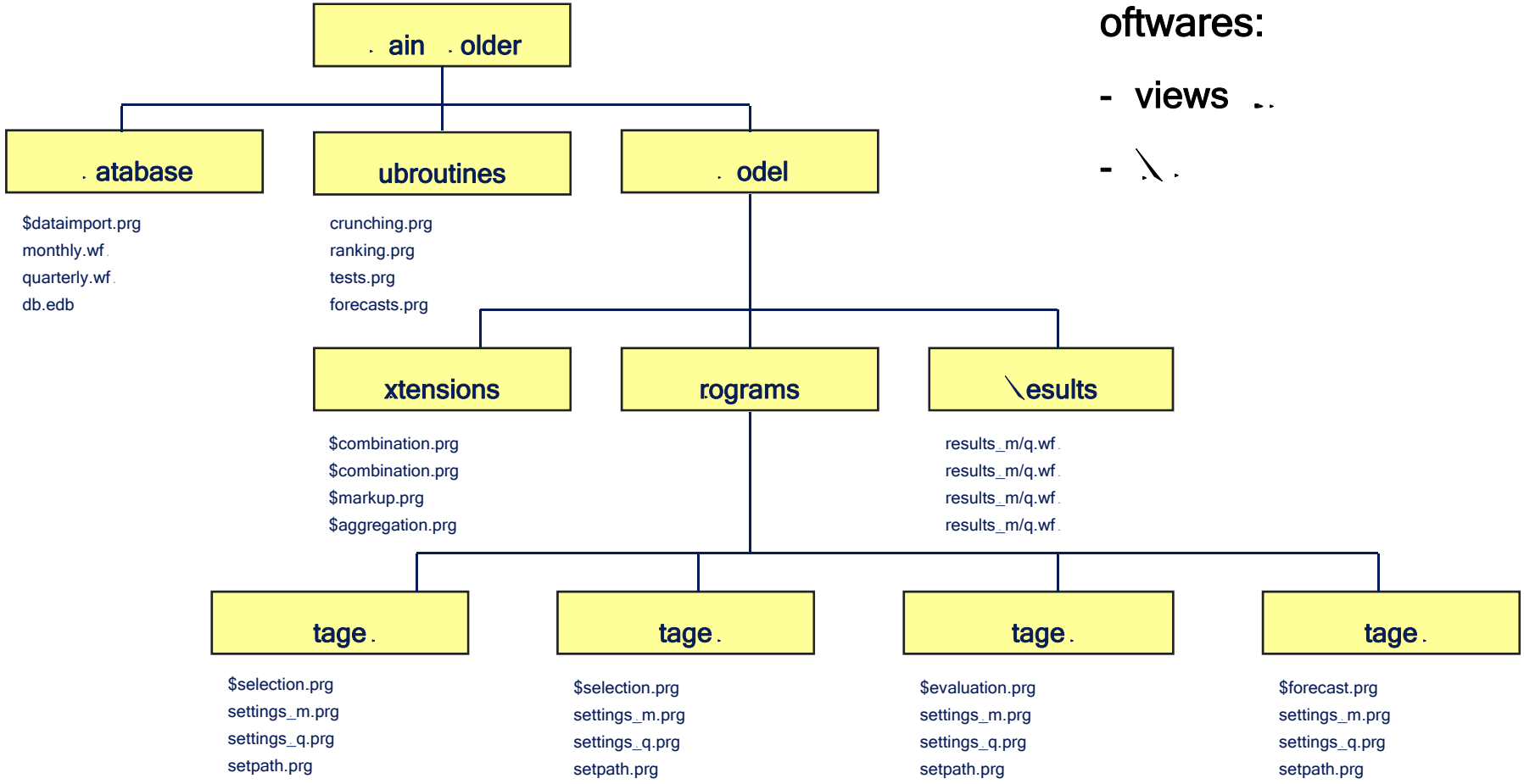
- . ain-ridge equation:
  . orecast equation for the target variable (quarterly frequency)
- . ini-ridge equation:
  . orecast equation for monthly indicators used as regressors in the . ain-ridge equation
- uxiliary variables:
  . onthly indicators that appear in the . ini-ridge equations but not in the . ain-ridge equation
- ard indicators:
  . **uantitative data (e.g. industrial production, retail sales …)**
- oft indicators:
  . **ualitative data (e.g. usiness / consumer surveys…)**


\epresentation
rocedure
niverse of
ndicators (Ω)
tage : ndicator selection
ubset of
ndicators ($\Sigma \subset \Omega$)
tage : pecification and estimation of the ain-ridge equation
ain-ridge
equation

SCHWEIZERISCHE NATIONALBANK
BANQUE NATIONALE SUISSE
BANCA NAZIONALE SVIZZERA
BANCA NAZIUNALA SVIZRA
SWISS NATIONAL BANK



tructure



oftwares:

- views ..
- \ .

tage :

.ndicator selection

- \anks indicators according to their in-sample fit
- est for potentially useful combination of forecasts (encompassing). . odified . iebold- . ariano *t*-test.

tage :

.ndicator selection

. stimation of . bivariate distributed lag . . regressions with lagged dependent variable

$$A(L)\Delta y_t = \beta_0 + B_i(L)x_{i,t} + \varepsilon_t \qquad i = 1,2,\ldots,K$$

→ est lag specification for every stationary indicator $x_{i,t}$

. \anking of the . best models according to a specified criterion (., . . or adj. \)

. ncompassing bivariate tests (. odified . iebold-. ariano *t*-test (arvey, . eybourne and . ewbold,))
→ . -. variables that contain additional information to the best single variable equation

tage :

pplication

- arget variable: . uarterly . . . . growth (saar)
- . **ata set:** . **„hard“** indicators
- . ax # of lags: . (for exogenous); . (for target)
- **# of specifications:** ‘ . . (. x)
- riterion: adj. \ .
- omp. time: . sec.

. utput: tage .

EViews - [Table: SUMMARY1 Workfile: PROGRAMS1_Q::results\]

File Edit Object View Proc Quick Options Window Help

View | Proc | Object | Print | Name | Edit+/- | CellFmt | InsDel | Grid+/- | Title | Comments+/-

	A	B	C	D	E	F
1	Variable	@RBAR2	Encomp Coeff	H0: lambda=0 p (corr)	H0: 1-lambda=0 p (corr)	Sample Range
2						
3	@PCA(IPMAN)	0.47290	--	--	--	1987Q2 2007Q2
4	IPDIFF3	0.43998	0.30034	0.37785	0.04838	1987Q2 2007Q2
5	@PCA(IP)	0.42988	-0.22824	0.63938	0.01450	1987Q2 2007Q2
6	@PCA(INITCLAIMS)	0.40179	0.29671	0.11396	0.00114	1987Q2 2007Q2
7	IPDIFF1	0.39894	0.20959	0.36416	0.00095	1987Q2 2007Q2
8	@PCA(IPDURCG)	0.39005	0.22417	0.26534	0.00056	1987Q2 2007Q2
9	@PCA(PRIVCONST)	0.38824	0.37001	0.00637	0.00015	1987Q2 2007Q2
10	@PCA(SHIPDUR)	0.38393	0.57369	0.08371	0.23670	1992Q2 2007Q2
11	D(CAPUTIL)	0.38343	-0.02983	0.92081	0.00471	1987Q2 2007Q2
12	@PCA(TOTHOURS)	0.37513	0.26585	0.13856	0.00036	1987Q2 2007Q2
13	@PCA(EMP)	0.37351	0.30537	0.05424	0.00000	1987Q2 2007Q2
14	IPDIFF6	0.36897	0.02868	0.91340	0.00081	1987Q2 2007Q2
15	@PCA(TOTCONST)	0.36578	0.34430	0.00864	0.00007	1987Q2 2007Q2
16	@PCA(SHIPDUREX...	0.36297	0.50527	0.12517	0.17625	1992Q2 2007Q2
17	@PCA(PCE)	0.36091	0.35125	0.01550	0.00161	1987Q2 2007Q2
18	@PCA(EMPHELP)	0.33925	0.26546	0.11802	0.00169	1990Q2 2007Q2
19	@PCA(HOUSSTART)	0.33083	0.30889	0.01712	0.00021	1987Q2 2007Q2
20	@PCA(PCENDUR)	0.31442	0.33300	0.02098	0.00005	1987Q2 2007Q2
21	@PCA(START1)	0.31401	0.28032	0.02977	0.00013	1987Q2 2007Q2
22	D(ISTOT)	0.31229	0.42251	0.10730	0.03368	1992Q2 2007Q2
23	@PCA(EMPSER)	0.30967	0.23602	0.11427	0.00000	1987Q2 2007Q2
24	@PCA(SHIPTOT)	0.30761	0.38519	0.18962	0.02249	1992Q3 2007Q2
25	@PCA(EX)	0.30721	0.43053	0.05108	0.00707	1994Q4 2007Q2
26	@PCA(PCEDUR)	0.30298	0.28858	0.03849	0.00025	1987Q2 2007Q2
27	UNEMP	0.29985	0.24184	0.07671	0.00015	1987Q2 2007Q2
28	@PCA(TOTHOURMAN)	0.29227	-0.09556	0.64512	0.00136	1987Q2 2007Q2
29	@PCA(RESCONST)	0.28967	0.36581	0.02779	0.00076	1993Q2 2007Q2
30	@PCA(TOTHOURC...	0.28412	0.23041	0.07010	0.00000	1987Q2 2007Q2
31	@PCA(IPCG)	0.27881	-0.11840	0.56268	0.00000	1987Q2 2007Q2
32	@PCA(SHIPEXDEF)	0.27667	0.25796	0.36057	0.00842	1992Q2 2007Q2
33	@PCA(TOTHOURSE...	0.27623	0.10699	0.50416	0.00001	1987Q2 2007Q2
34	@PCA(HELPWANT)	0.27401	0.19153	0.21275	0.00005	1987Q2 2007Q2
35	@PCA(SHIPCONDUR)	0.27272	0.33861	0.12831	0.00654	1992Q2 2007Q2
36	@PCA(IPBUSEQ)	0.27061	-0.20853	0.31031	0.00016	1987Q2 2007Q2
37	@PCA(NODUR)	0.26995	0.30254	0.17635	0.00591	1992Q2 2007Q2
38	@PCA(BUILDPERM)	0.26464	0.21509	0.08182	0.00008	1987Q2 2007Q2
39	D(BUSINVSAL)	0.26391	0.34622	0.11765	0.00917	1992Q2 2007Q2
40	@PCA(SHIPCAPEX...	0.25531	0.32109	0.10767	0.01392	1992Q2 2007Q2
41	@PCA(IM)	0.25429	0.36163	0.07177	0.01572	1994Q4 2007Q2
42	@PCA(NOCONST)	0.25414	0.24012	0.33641	0.00806	1992Q2 2007Q2
43	@PCA(NODUREXDEF)	0.25319	0.19308	0.44734	0.01097	1992Q2 2007Q2
44	@PCA(NOTOT)	0.25314	0.24492	0.28795	0.00412	1992Q2 2007Q2
45	@PCA(EMPMAN)	0.25181	-0.09317	0.62156	0.00024	1987Q2 2007Q2
46	D(INVSALRA)	0.24834	0.36527	0.01658	0.00136	1992Q3 2007Q2
47	@PCA(SHIPCAPEX...	0.24527	0.31498	0.13852	0.01343	1992Q2 2007Q2
48	@PCA(SHIPCAPEX...	0.24512	0.29946	0.17308	0.01493	1992Q2 2007Q2
49	@PCA(SHIPCONST)	0.24443	0.21774	0.34446	0.00246	1992Q2 2007Q2
50	@PCA(DEFNSA)	0.24413	0.20800	0.11722	0.00000	1987Q2 2007Q2
51	@PCA(EXPCAP)	0.24396	0.29355	0.13181	0.00847	1994Q2 2007Q2
52	@PCA(IPINDEQ)	0.24057	-0.04651	0.80163	0.00009	1987Q2 2007Q2
53	@PCA(DEFENSE)	0.23902	0.21064	0.09487	0.00000	1987Q2 2007Q2
54						

@PCA(IPMAN)

tage :

dditional feature

- ossibility to use tage . also for a *monthly* target variable.

tage :

election of the ain-ridge equation

- ind the optimal specification regarding lags and variables (e.g. selected from tage)

- **he ranking is based on in-sample criteria (, ….)**

tage

ain-ridge equation

- ultivariate distributed lag regression with lagged dependent variable:

$$A(L)\Delta y_t = \beta_0 + \sum_{i=1}^{S} B_i(L)x_{i,t} + \varepsilon_t$$

→ est ain-ridge equation

where regressors $x_{i,t}$: a subset of indicators

tage :

pplication (contd)

- ndicators: manuf, and rivate constr.
- ample: q-q
- riterion:
- ax. # of lags: (exogenous); (target)
- # of specifications: ‘ ()
- omput. time: sec.

utput: tage

Table: SUMMARY3 Workfile: QUARTERL...

View | Proc | Object | Print | Name | Edit+/- | CellFmt | InsDel | Grid+/- | Title | Comments+/-

	A	B	C	D	E
1		@SCHWARZ	@SCHWARZ	@SCHWARZ	
2		1.	2.	3.	
3	Crit.	3.500750	3.508201	3.522736	
4	S.E.	1.240654	1.217204	1.224413	
5					
6	Models	@PCA(GDP)	@PCA(GDP)	@PCA(GDP)	
7		C	C	C	
8		@PCA(GDP(-1))	@PCA(GDP(-1))	@PCA(GDP(-1))	
9		@PCA(PCEM)	@PCA(PCEM)	@PCA(PCEM)	
10		@PCA(IPMAN)	@PCA(IPMAN)	@PCA(PCEM(-1))	
11		@PCA(PRIVCONST)	@PCA(PRIVCONST)	@PCA(IPMAN)	
12			@PCA(PRIVCONST(-2))	@PCA(PRIVCONST)	
13					
14					

tage :

dditional features

- ossibility to find equations for variables in *monthly* frequency

tage :

. ain-ridge evaluation

- valuate the forecast equation in pseudo out-of-sample exercises against . or . benchmarks
- .nput: . ain-ridge (e.g. from tage) and benchmark equations (e.g. univariate)
- utput: . tests of forecasts properties

tage :

ests

- *orecast accuracy*

  est of ean quared rrors equality. odified iebold- ariano *t*-test (arvey, eybourne and ewbold,)

- *irectional accuracy*

  ests if the direction forecast is significantly different from a random draw. ndependence *hi-quared*-test. (iebold and opez,)

- *orecast bias*

  ests the null of unbiased forecasts. *t*- and -test

- *ormality of residuals*

  arque-erra (hi-quared) -test

tage :

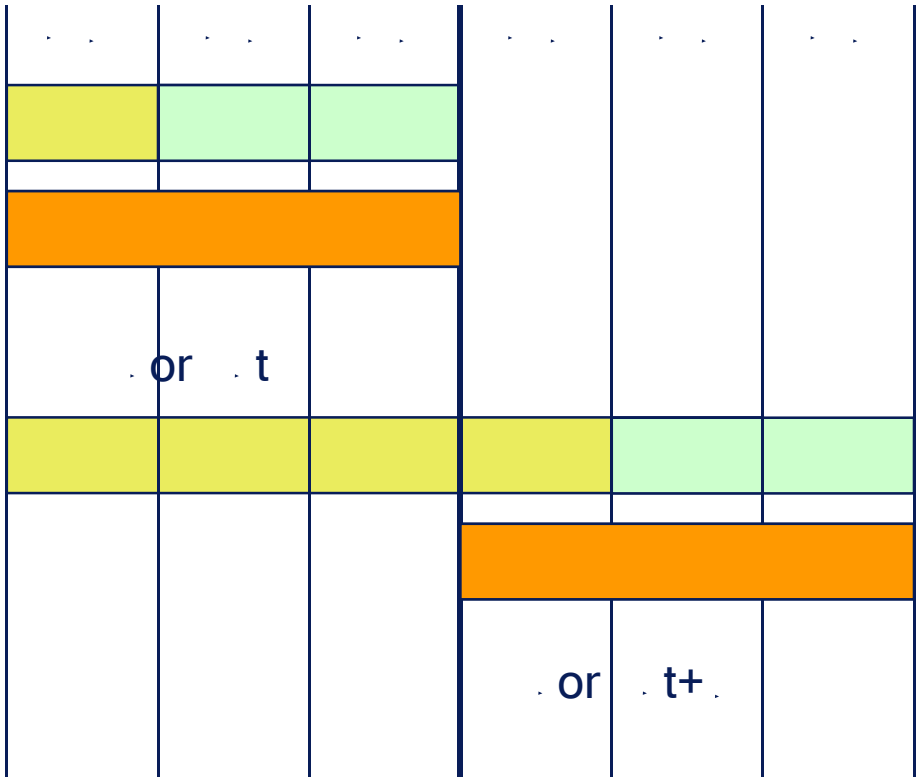
. ain features

- ossibility to simulate different degree of information inside the quarter (. month, . months, full quarter)
- alues of exogenous variables are forecasted with a \ or the mean of the previous month(s)

tage :

\olling forecast

(month of information)



\ estimation (monthly)

orecast (monthly)

ain-ridge forecast (quarterly)

tage :

pplication (contd)

- . ain-ridge (.): pcha(gdp) c pcha(gdp(-)) pcha(pce) pcha(ipman) pcha(privconst)
- enchmark . (. \ . - . odel, rehan,): pcha(gdp) c pcha(gdp(-)) pcha(gdp(-)) pcha(gdp(-)) pcha(pce) pcha(emp)
- enchmark : est univariate for pcha(gdp) (up to . lags)
- **stimation period:** **q . – q .**
- ut-of-ample . orecast: q-q . (. obs.)
- omputing time: . sec.

utput: tage

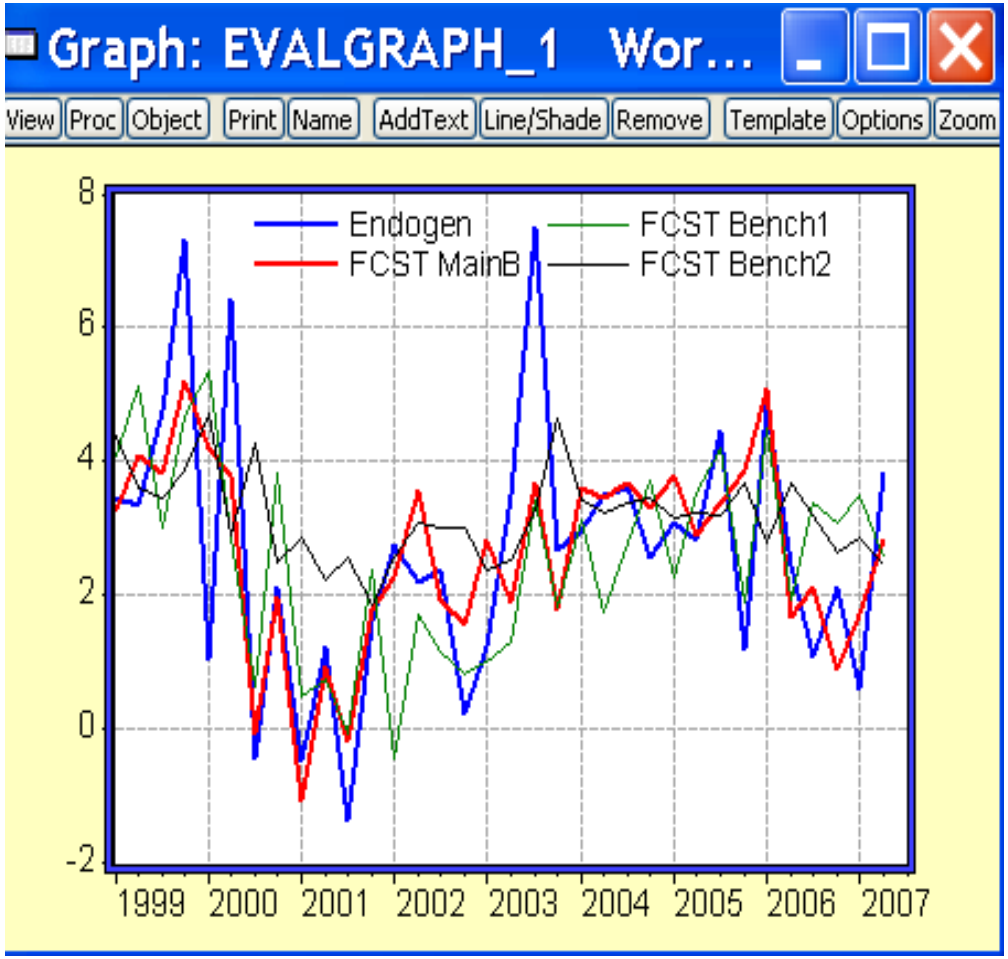


Table: SUMMARY_TESTS Workfile: PROGR...

View | Proc | Object | Print | Name | Edit+/- | CellFmt | InsDel | Grid+/- | Title | Comments+/-

	A	B	C	D
1		**Best Model**	**Benchmark 1**	**Benchmark 2**
2				
3	RMSE	1.37836	1.80367	2.10263
4	Theil's U	--	0.76419	0.65554
5				
6	**Diebold-Mariano Test**			
7	DM	--	-2.24536	-2.57067
8	P-value DM	--	0.03156	0.01485
9	modified DM	--	-2.31340	-2.64857
10	P-value modified DM	--	0.02707	0.01230
11				
12	**Chi^2 Independence**			
13	Matching quota	0.66667	0.54545	0.21212
14	Test statistic	3.47782	0.20263	11.38617
15	P-value	0.06220	0.65261	0.00074
16				
17	**Test for Forecast Bias**			
18	P-value a = 0	0.99388	0.07709	0.37020
19	P-value b = 1	0.91121	0.06200	0.20444
20	P-value joint	0.98810	0.14210	0.09640
21				
22	**Normal Distribution of Residuals**			
23	Jarque-Bera	1.068896	0.031138	0.365587
24	P-value	0.585993	0.984551	0.832940
25				
26				
27				

tage :

dditional features

- **. ag specification of \ is automatically chosen (., ., anna- . uinn…)** or can be imposed
- . ay also be used with equations containing quarterly regressors
- valuation of n-steps ahead forecasts
- est whether rolling optimization (for coefficients, variables and lags) improves forecasts
- ny time series can be used as a benchmark (e.g. from external sources/models)
- . orecasts of several equations can be computed and weighted (mean, median..) and then compared to a benchmark

SCHWEIZERISCHE NATIONALBANK
BANQUE NATIONALE SUISSE
BANCA NAZIONALE SVIZZERA
BANCA NAZIUNALA SVIZRA
SWISS NATIONAL BANK

tage :

utomated forecasts

- utomated forecasting tool for day-to-day use
- xploit as much information as possible by considering all monthly regressors available

tage :

utomated forecasts

- roblem: onthly regressors are often only partially available within a given quarter
- → ealing with staggerred data: ini-ridge equations to forecast missing data of monthly indicators
- z_h denote **auxiliary variables that won't** be used in the ain-ridge equation but are useful for forcasting the regressors x
- x_j are the variables to be forecasted:

$$A_j(L)x_{j,t} = \beta_{0,j} + \sum_{i \neq j} B_i(L)x_{i,t} + \sum_{h=1}^{H} C_h(L)z_{h,t} + \varepsilon_t \qquad j = 1,2,\ldots, P$$

tage :

utomated forecasts

- .n order to find good auxiliary variables, tage . can be used with monthly dependent variables
- o find the optimal . ini-ridge equation, tage . can also be used

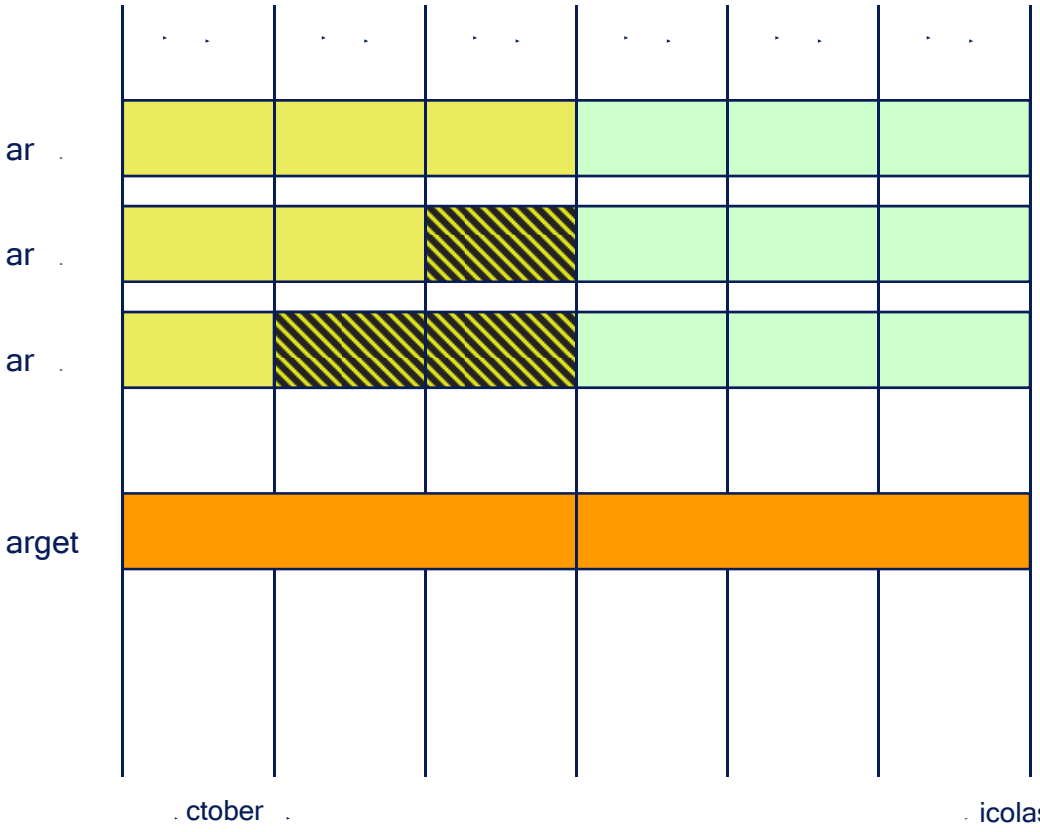
tage :

utomated forecasts

- nce all exogenous variables have the same end date, a \ is estimated to compute a forecast up to the specified horizon
- stimating then the best . ain-ridge equation and computing a forecast
- ptionally: kipping the . ini-ridge and \ forecasts and filling up the missing values with the mean of the previous month(s)

tage :

utomated forecasts



ini-ridge orecast (monthly)

\ orecast (monthly)

ain-ridge orecast (quarterly)

. utput: tage .

Table: SUMMARY Workfile: OVERALL::...

View | Proc | Object | Print | Name | Edit+/- | CellFmt | InsDel | Grid+/- | Title | Comments+/-

US GDP Growth Forecasts

	2007Q3	2007Q4	2008Q1	2008Q2	Last Update
@pca(gdp)	NA	NA	NA	NA	
Tracking_Mean	3.22	1.99	NA	NA	08/10/07 10:32
Tracking_VAR	3.58	3.74	3.40	3.50	08/10/07 10:33
Survey_Mean	2.46	2.75	2.54	2.92	08/10/07 10:32
Survey_Median	2.70	2.92	2.68	2.91	08/10/07 10:32
Harddata	2.58	3.21	3.04	3.10	08/10/07 10:33
Top_1q	1.82	-0.77	NA	NA	08/10/07 10:33
Leading_1q	2.29	2.72	1.99	2.88	08/10/07 10:34
Top_2q	2.43	0.20	-0.37	NA	08/10/07 10:33
Leading_2q	2.38	2.71	2.88	2.52	08/10/07 10:34

tage :

pplication

- . ain-ridge:
  pca(gdp) c pca(gdp(-)) pca(pce) pca(ipman) pca(privconst)
- . and construction data → . ini-ridge equations to forecast regressors
- uxiliary variables: \etail sales, ours worked in construction
- . **umber of tested . ini-ridge specifications: ‘ .**
- \ to forecast monthly data up to q .
- omputation time: . sec.

tage :

dditional features

- . orecasts with equations based on quarterly data
- . orecasts where missing monthly data is completed with the mean of the previous month(s)
- **ombination of forecasts: can run a large set of forecasting equations and weight the results (mean, median…);** useful assessment of the balance of risks

\esults

. igure :

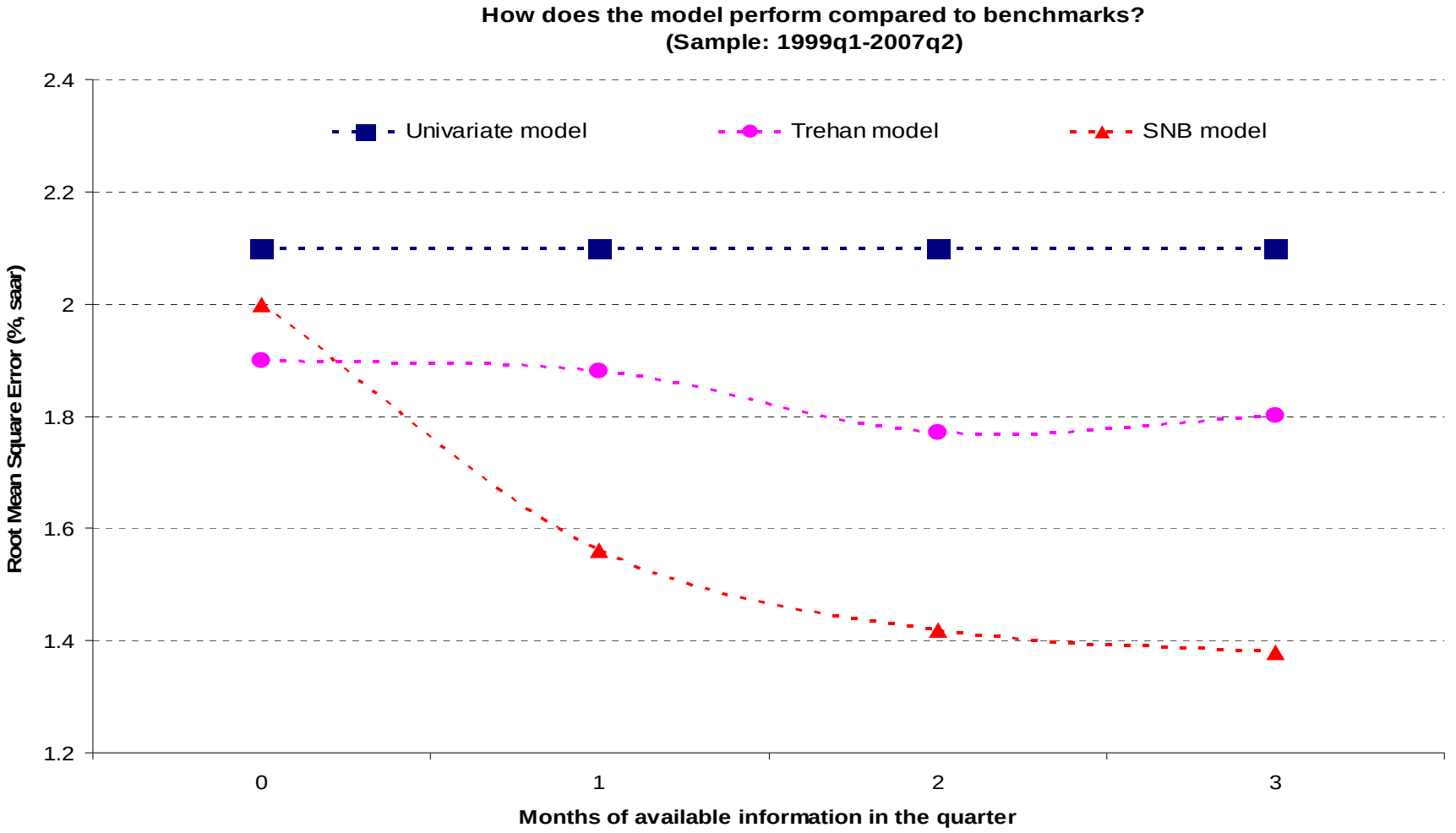
- . orecast accuracy significantly above benchmarks
- . irst month of data particularly important

. igure :

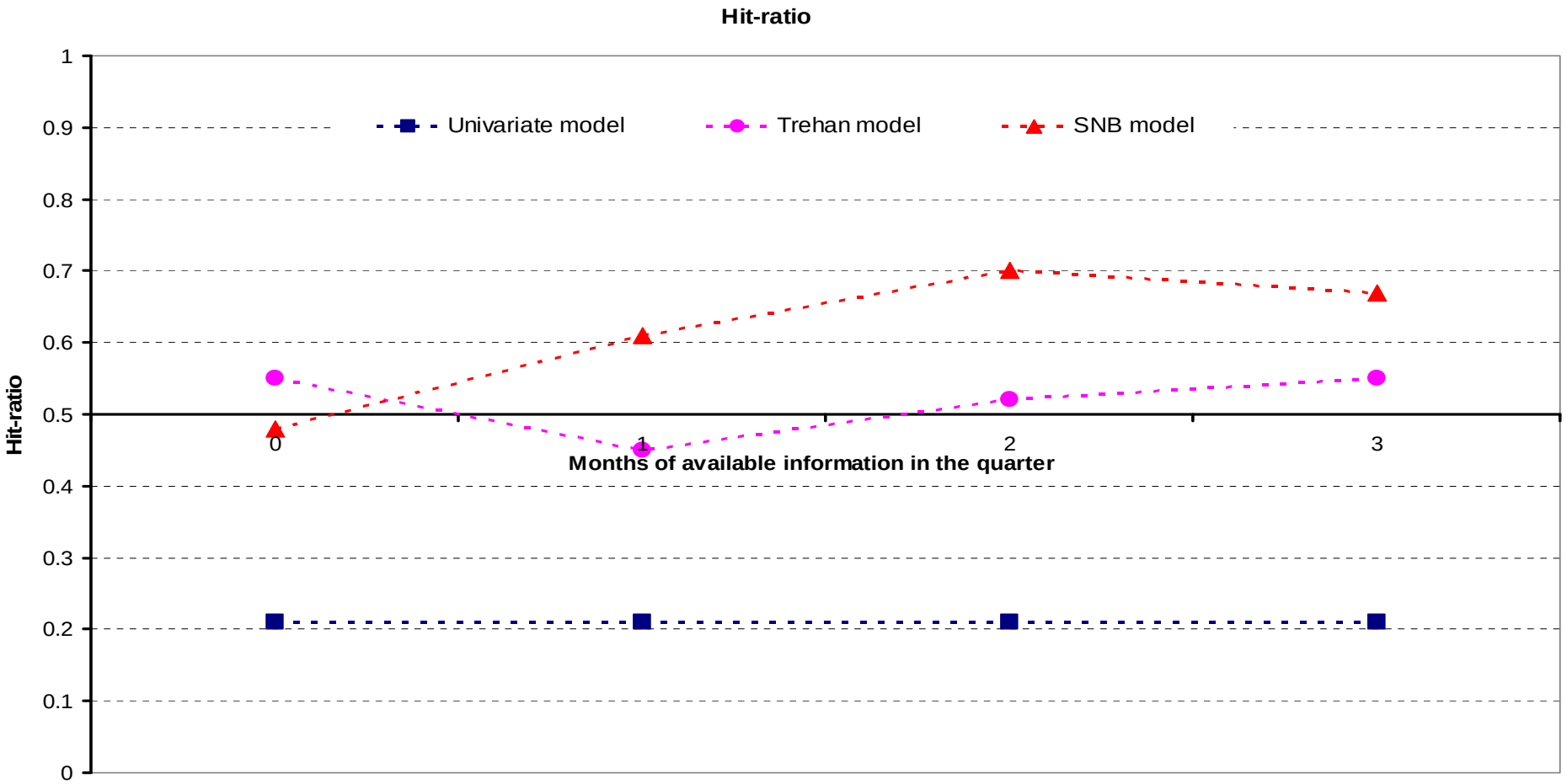
- it-ratio above %; much higher than the univariate forecast
- it-ratio *not* monotonously increasing with the information available

SCHWEIZERISCHE NATIONALBANK
BANQUE NATIONALE SUISSE
BANCA NAZIONALE SVIZZERA
BANCA NAZIUNALA SVIZRA
SWISS NATIONAL BANK

. igure .



. igure .


Hit-ratio
Univariate model
Trehan model
SNB model
Hit-ratio
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
Months of available information in the quarter

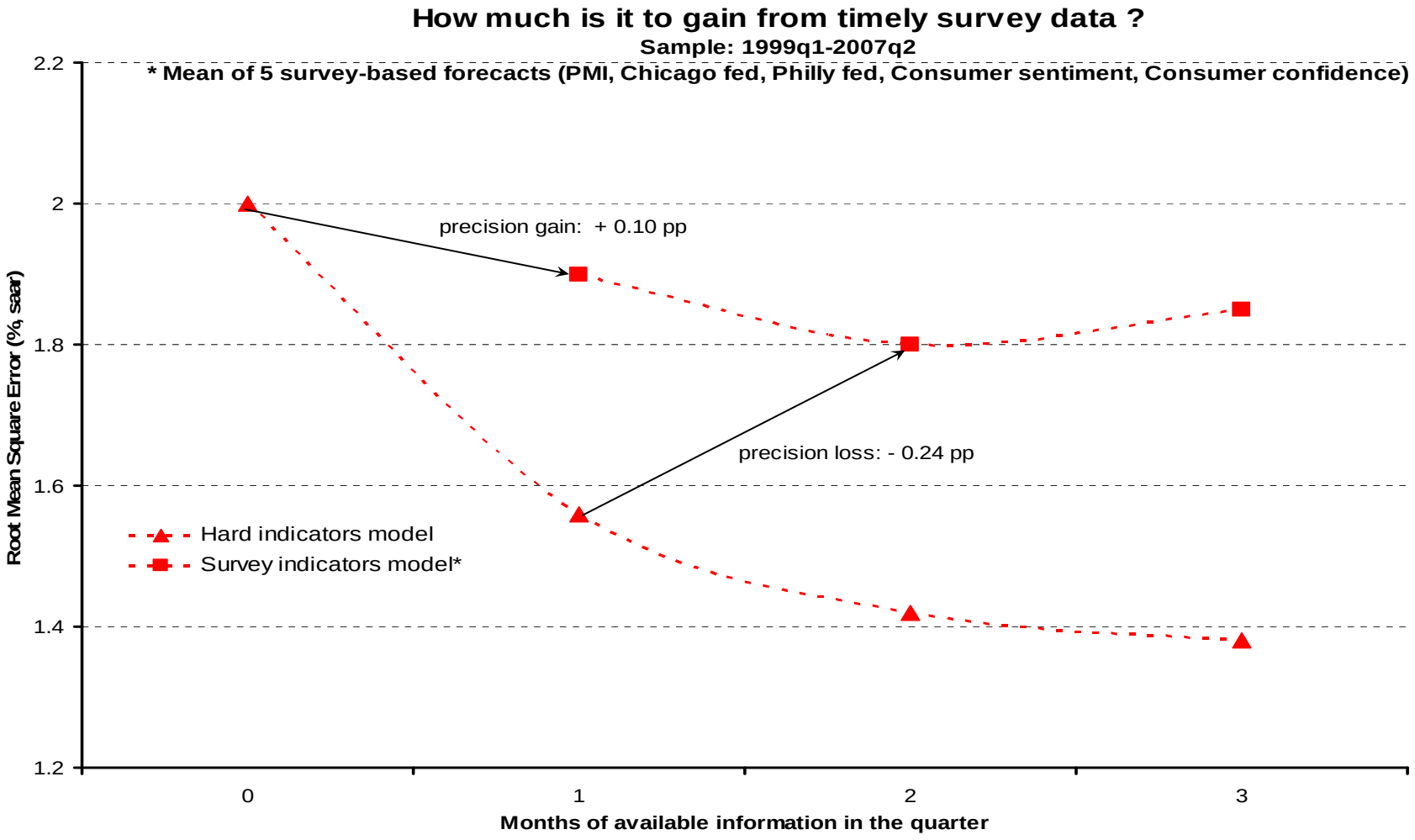
\esults (contd)

igure :

- ain of using a survey-based model only until hard data arrive for the st month in the quarter

SCHWEIZERISCHE NATIONALBANK
BANQUE NATIONALE SUISSE
BANCA NAZIONALE SVIZZERA
BANCA NAZIUNALA SVIZRA
SWISS NATIONAL BANK

. igure .

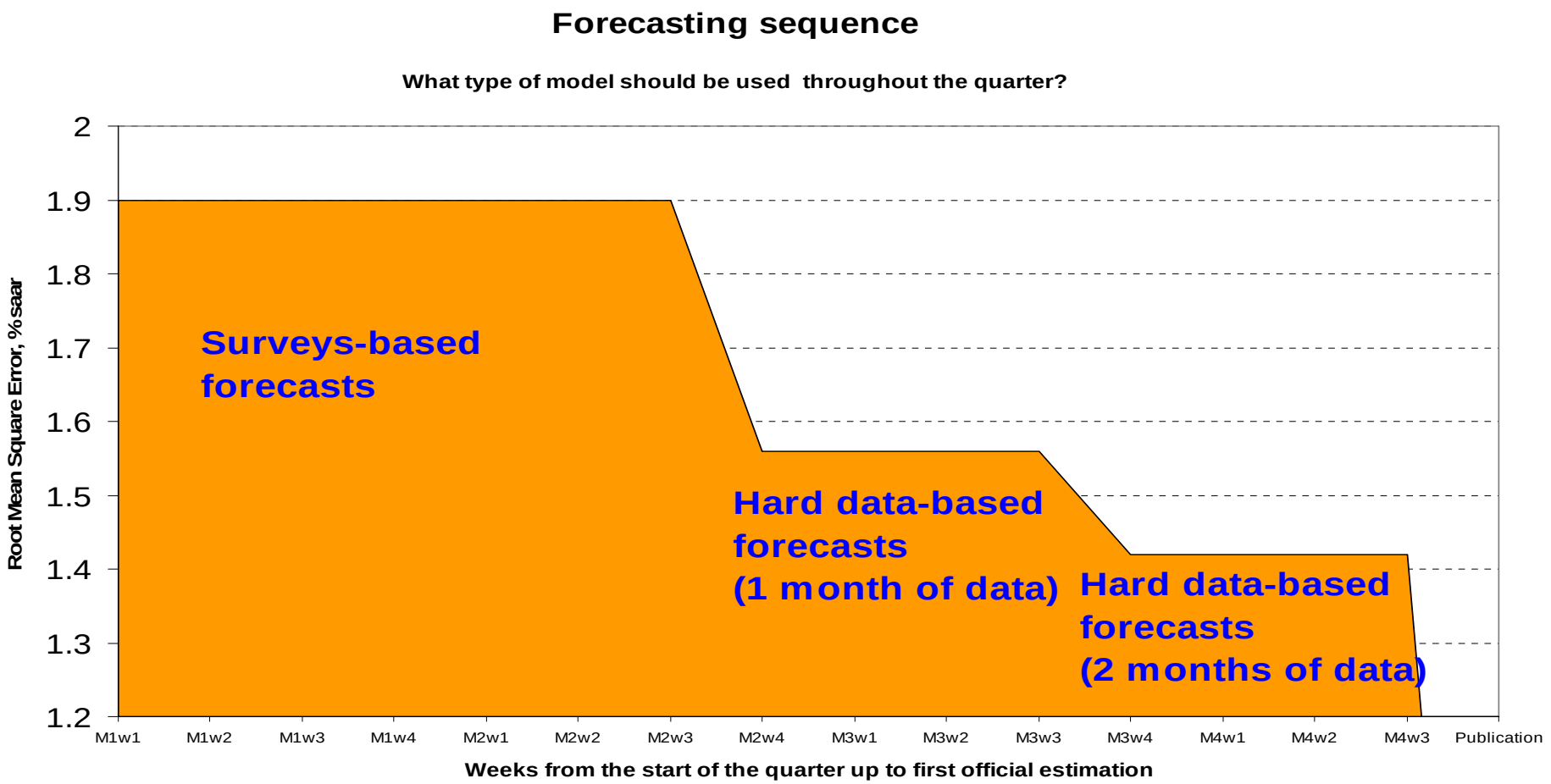


\esults (contd)

. igure :

- urvey-based forecasts useful during the first half of current quarter
- ferwards, better to incorporate information from the hard data
- ignificant jump in accuracy when hard data become available
- . agnitude of errors very similar to the ones reported in recent . interim forecasts document

igure


Forecasting sequence
What type of model should be used throughout the quarter?
Root Mean Square Error, %saar
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
Surveys-based forecasts
Hard data-based forecasts (1 month of data)
Hard data-based forecasts (2 months of data)
M1w1
M1w2
M1w3
M1w4
M2w1
M2w2
M2w3
M2w4
M3w1
M3w2
M3w3
M3w4
M4w1
M4w2
M4w3
Publication
Weeks from the start of the quarter up to first official estimation

ummary .

- otent tool to uncover variables with high informational content (tage . and)
- onvenient way to evaluate out-of-sample forecasts based on various informational assumptions (tage)
- . ast computing and summary of forecasts for daily use (tage)
- an compute and combine the results of a large set of forecasting equations