Nowcasting

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Federal Reserve Bank of New York and CEPR

ERNSI Workshop
European Research Network System Identification

University of Padova, September 2016

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Nowcasting

Contraction of the terms *Now* and *Forecasting*

Meteorology Nowcasting

forecasting up to 6-12 hours ahead (long tradition, since 1860)

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- Example, US GDP: Advanced estimate 4 weeks after end of the reference quarter
- Example, EA GDP: Flash estimate 6 weeks after end of the reference quarter

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Economic Nowcasting:

Forecasting the near future, the present and even recent past.

This Presentation

1. **Nowcasting and the Real-Time Data-Flow**
   with M. Bańbura, M. Modugno and L. Reichlin
   Handbook of Economic Forecasting, Volume 2, Elsevier-North Holland

2. **Introducing the FRBNY Staff Nowcast**
   Liberty Economics Blog, Federal Reserve Bank of New York

Macroeconomic Forecasting and Conjuctural Analysis

- predicting the future: formal economic modeling of the relations among key macroeconomic aggregates
- predicting the present: simplified heuristic scrutiny of a variety of conjunctural data
- forecasts are updated infrequently disregarding the high-frequency flow of conjectural information

  quarterly updates (SPF and Central Banks), bi-annual updates (OECD, IMF)

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- How important is nowcasting relative to longer horizon forecasting?

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- How relevant is the conjectural information? How often should we update the predictions?

How important is nowcasting relative to longer horizon forecasting?

Very !!!!

Forecasting GDP in real time
MSFE relative to constant growth

Horizon	0	1	2	3	4
GB	0.87	1.03	1.16	1.23	1.29
SPF	0.85	1.03	1.00	1.06	1.06

Evaluation sample 1992Q1 through 2001Q4

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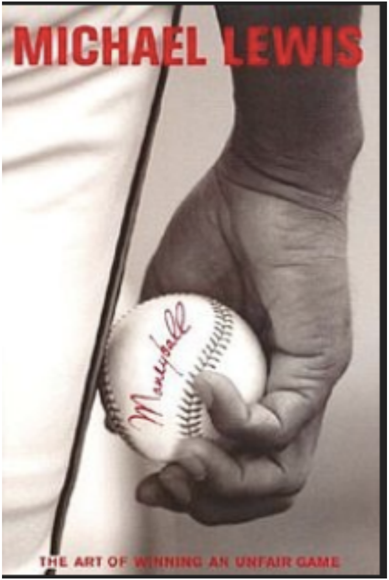
How can we predict the present?
Can a machine replicate expert judgement?

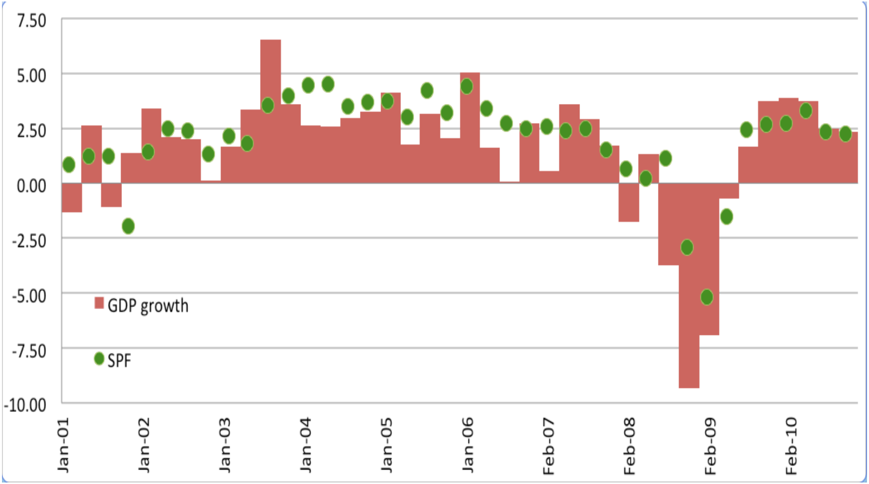
How important is expert Judgement?



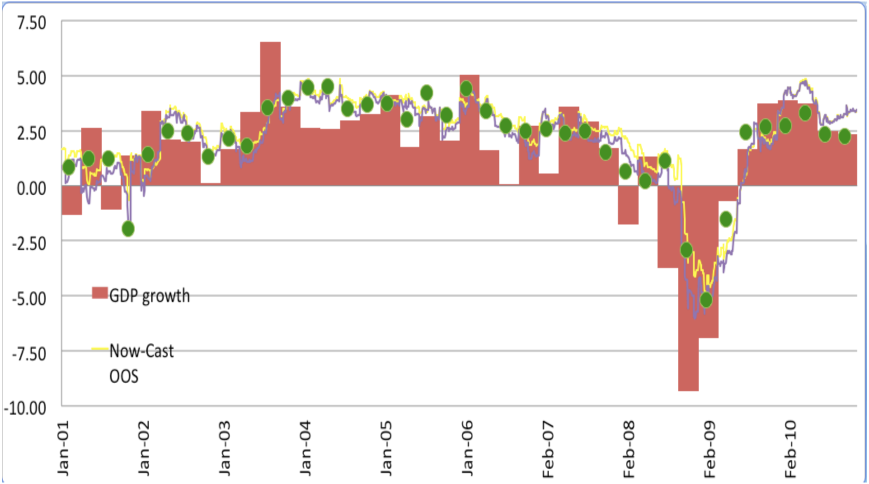
The Experts!

The Computer Nerde

Now-Casting US GDP: 10 years of Experience



Now-Casting US GDP: 10 years of Experience



Learning from the Markets

Market participants can be viewed as now-casters

$\Rightarrow$ they obsessively monitor all macroeconomic data to get a view on current and future fundamentals and their effects on policy

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- The relevant information on the state of the economy is conveyed to markets through the release of macroeconomic reports.
- Market expectation for the headlines of these reports are collected up to the day before the actual release of the indicator and distributed by data providers (i.e. Bloomberg).

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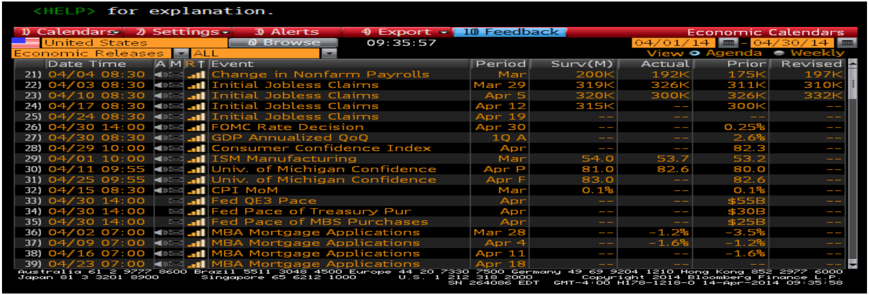
- The relevant information on the state of the economy is conveyed to markets through the release of macroeconomic reports.
- Market expectation for the headlines of these reports are collected up to the day before the actual release of the indicator and distributed by data providers (i.e. Bloomberg).
- When realizations are different than these expectations, that is when the news are sizeable, the view of the market changes and this leads to changes in asset prices

  see (Andersen et al., 200; Flannery and Protopapadakis, 2002)), Boyd, Hu, and Jagannathan, 2005;

The real-time data flow

The real-time data flow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1) Calendars 2) Settings 3) Alerts 4) Export 10) Feedback Economic Calendars

United States 6) Browse 09:35:57 04/01/14 - 04/30/14

Economic Releases ALL View Agenda Weekly

	Date Time	Event	Period	Surv(M)	Actual	Prior	Revised
21)	04/04 08:30	Change in Nonfarm Payrolls	Mar	200K	192K	175K	197K
22)	04/03 08:30	Initial Jobless Claims	Mar 29	319K	326K	311K	310K
23)	04/10 08:30	Initial Jobless Claims	Apr 5	320K	300K	326K	332K
24)	04/17 08:30	Initial Jobless Claims	Apr 12	315K	--	300K	--
25)	04/24 08:30	Initial Jobless Claims	Apr 19	--	--	--	--
26)	04/30 14:00	FOMC Rate Decision	Apr 30	--	--	0.25%	--
27)	04/30 08:30	GDP Annualized QoQ	1Q A	--	--	2.6%	--
28)	04/29 10:00	Consumer Confidence Index	Apr	--	--	82.3	--
29)	04/01 10:00	ISM Manufacturing	Mar	54.0	53.7	53.2	--
30)	04/11 09:55	Univ. of Michigan Confidence	Apr P	81.0	82.6	80.0	--
31)	04/25 09:55	Univ. of Michigan Confidence	Apr F	83.0	--	82.6	--
32)	04/15 08:30	CPI MoM	Mar	0.1%	--	0.1%	--
33)	04/30 14:00	Fed QE3 Pace	Apr	--	--	$55B	--
34)	04/30 14:00	Fed Pace of Treasury Pur	Apr	--	--	$30B	--
35)	04/30 14:00	Fed Pace of MBS Purchases	Apr	--	--	$25B	--
36)	04/02 07:00	MBA Mortgage Applications	Mar 28	--	-1.2%	-3.5%	--
37)	04/09 07:00	MBA Mortgage Applications	Apr 4	--	-1.6%	-1.2%	--
38)	04/16 07:00	MBA Mortgage Applications	Apr 11	--	--	-1.6%	--
39)	04/23 07:00	MBA Mortgage Applications	Apr 18	--	--	--	--

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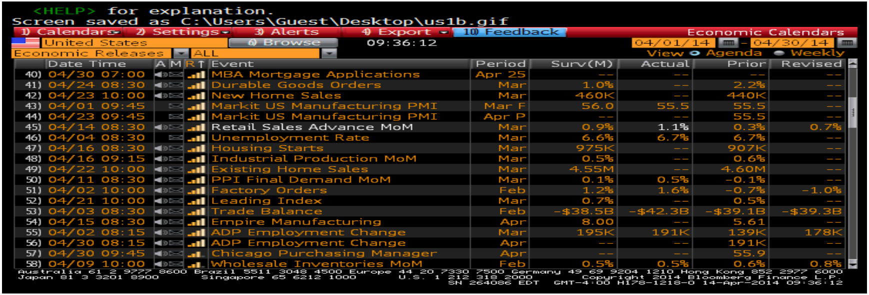
The real-time data flow



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Economic Releases ALL View Agenda Weekly

	Date Time	A M R ↑	Event	Period	Surv(M)	Actual	Prior	Revised
40)	04/30 07:00		MBA Mortgage Applications	Apr 25	--	--	--	--
41)	04/24 08:30		Durable Goods Orders	Mar	1.0%	--	2.2%	--
42)	04/23 10:00		New Home Sales	Mar	460K	--	440K	--
43)	04/01 09:45		Markit US Manufacturing PMI	Mar F	56.0	55.5	55.5	--
44)	04/23 09:45		Markit US Manufacturing PMI	Apr P	--	--	55.5	--
45)	04/14 08:30		Retail Sales Advance MoM	Mar	0.9%	1.1%	0.3%	0.7%
46)	04/04 08:30		Unemployment Rate	Mar	6.6%	6.7%	6.7%	--
47)	04/16 08:30		Housing Starts	Mar	975K	--	907K	--
48)	04/16 09:15		Industrial Production MoM	Mar	0.5%	--	0.6%	--
49)	04/22 10:00		Existing Home Sales	Mar	4.55M	--	4.60M	--
50)	04/11 08:30		PPI Final Demand MoM	Mar	0.1%	0.5%	-0.1%	--
51)	04/02 10:00		Factory Orders	Feb	1.2%	1.6%	-0.7%	-1.0%
52)	04/21 10:00		Leading Index	Mar	0.7%	--	0.5%	--
53)	04/03 08:30		Trade Balance	Feb	-$38.5B	-$42.3B	-$39.1B	-$39.3B
54)	04/15 08:30		Empire Manufacturing	Apr	8.00	--	5.61	--
55)	04/02 08:15		ADP Employment Change	Mar	195K	191K	139K	178K
56)	04/30 08:15		ADP Employment Change	Apr	--	--	191K	--
57)	04/30 09:45		Chicago Purchasing Manager	Apr	--	--	55.9	--
58)	04/09 10:00		Wholesale Inventories MoM	Feb	0.5%	0.5%	0.6%	0.8%

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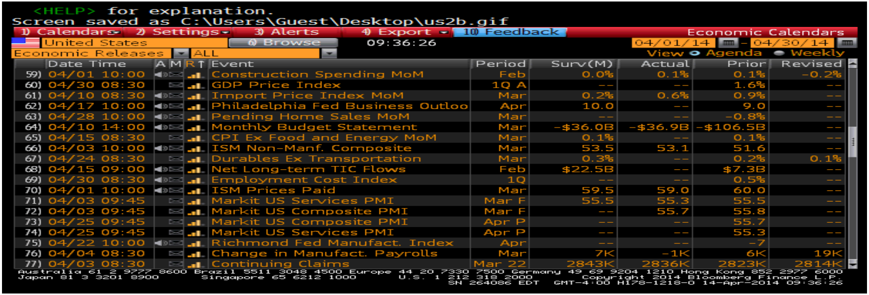

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United States 6) Browse 09:36:26 04/01/14 - 04/30/14

Economic Releases ALL View Agenda Weekly

	Date Time	A M R	Event	Period	Surv(M)	Actual	Prior	Revised
59)	04/01 10:00		Construction Spending MoM	Feb	0.0%	0.1%	0.1%	-0.2%
60)	04/30 08:30		GDP Price Index	1Q A	--	--	1.6%	--
61)	04/10 08:30		Import Price Index MoM	Mar	0.2%	0.6%	0.9%	--
62)	04/17 10:00		Philadelphia Fed Business Outloo	Apr	10.0	--	9.0	--
63)	04/28 10:00		Pending Home Sales MoM	Mar	--	--	-0.8%	--
64)	04/10 14:00		Monthly Budget Statement	Mar	-$36.0B	-$36.9B	-$106.5B	--
65)	04/15 08:30		CPI Ex Food and Energy MoM	Mar	0.1%	--	0.1%	--
66)	04/03 10:00		ISM Non-Manf. Composite	Mar	53.5	53.1	51.6	--
67)	04/24 08:30		Durables Ex Transportation	Mar	0.3%	--	0.2%	0.1%
68)	04/15 09:00		Net Long-term TIC Flows	Feb	$22.5B	--	$7.3B	--
69)	04/30 08:30		Employment Cost Index	1Q	--	--	0.5%	--
70)	04/01 10:00		ISM Prices Paid	Mar	59.5	59.0	60.0	--
71)	04/03 09:45		Markit US Services PMI	Mar F	55.5	55.3	55.5	--
72)	04/03 09:45		Markit US Composite PMI	Mar F	--	55.7	55.8	--
73)	04/25 09:45		Markit US Composite PMI	Apr P	--	--	55.7	--
74)	04/25 09:45		Markit US Services PMI	Apr P	--	--	55.3	--
75)	04/22 10:00		Richmond Fed Manufact. Index	Apr	--	--	-7	--
76)	04/04 08:30		Change in Manufact. Payrolls	Mar	7K	-1K	6K	19K
77)	04/03 08:30		Continuing Claims	Mar 22	2843K	2836K	2823K	2814K

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The real-time data flow

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United States 6) Browse 09:36:56 04/01/14 - 04/30/14

Economic Releases ALL View Agenda Weekly

	Date Time	A	M	R ↑	Event	Period	Surv(M)	Actual	Prior	Revised
78)	04/10 08:30				Continuing Claims	Mar 29	2835K	2776K	2836K	2838K
79)	04/17 08:30				Continuing Claims	Apr 5	2778K	--	2776K	--
80)	04/24 08:30				Continuing Claims	Apr 12	--	--	--	--
81)	04/11 08:30				PPI Final Demand YoY	Mar	1.1%	1.4%	0.9%	--
82)	04/30 08:30				Personal Consumption	1Q A	--	--	3.3%	--
83)	04/30 08:30				Core PCE QoQ	1Q A	--	--	1.3%	--
84)	04/22 09:00				FHFA House Price Index MoM	Feb	--	--	0.5%	--
85)	04/11 08:30				PPI Ex Food and Energy MoM	Mar	0.2%	0.6%	-0.2%	--
86)	04/11 08:30				PPI Ex Food and Energy YoY	Mar	1.1%	1.4%	1.1%	--
87)	04/15 09:00				Total Net TIC Flows	Feb	--	--	$83.0B	--
88)	04/14 08:30				Retail Sales Ex Auto MoM	Mar	0.5%	0.7%	0.3%	--
89)	04/16 08:30				Building Permits	Mar	1010K	--	1018K	1014K
90)	04/03 09:45				Bloomberg Consumer Comfort	Mar 30	--	-30.0	-31.5	--
91)	04/10 09:45				Bloomberg Consumer Comfort	Apr 6	--	-31.9	-30.0	--
92)	04/17 09:45				Bloomberg Consumer Comfort	Apr 13	--	--	-31.9	--
93)	04/24 09:45				Bloomberg Consumer Comfort	Apr 20	--	--	--	--
94)	04/16 09:15				Capacity Utilization	Mar	78.7%	--	78.8%	78.4%
95)	04/28 10:30				Dallas Fed Manf. Activity	Apr	--	--	4.9	--
96)	04/21 08:30				Chicago Fed Nat Activity Index	Mar	--	--	0.14	--

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The markets

Data offer mixed economic picture
Fresh statistics raise concerns over triple-dip recession
Manufacturing stable but outlook remains poor
Employment increases despite
Weak output raises growth fears
Manufacturing data worse than forecast
Record trade deficit fuels debate
ECB cuts eurozone economic outlook
New car sales reach highest level in four
US data brighten gloomy output trends
Brazilian employment soars despite 'sudden stop' in growth
US consumer incomes rise by the most in eight years
'Disappointing' output data add to economic gloom
GDP rises 0.6% in third quarter
Jobs market growth at its strongest in three years
Fiscal watchdog cuts growth forecast
Rise in inventories leads
Manufacturing output drops 2.1%
gloomy exporters belie upbeat data

Mimicking Market behavior and Beyond

Nowcasting: Monitoring current economic conditions in real time

- **Model-based** counterpart to conjuctural analysis
- **Real-time** reading of the newsflow
- **Continuously** updated nowcast of GDP growth

Nowcasting

A Big Data Analytics Framework

- High-dimensional data

  Includes the **large** and **complex** data monitored by economists at central banks, trading desks, and in the media

- Entirely automated

  Mimics **best practice** without relying on any judgment or subjective prior information (free of judgement, mood, heading)

- Real-time

  Digests new information within minutes of the releases

Digesting the Newsflow

Coherent analysis of the link between macro news and cyclical developments

- **Extract** the news/surprise component from data
  - Actual data minus model-based forecasts
- **Translate** the news in a common unit
  - What's the impact of news on GDP growth?

A model of Now-Casting

- y_t^Q: GDP at time t.
- Ω_v: vintage of data (quarterly, monthly, possibly daily) available at time v (date of a particular data release)

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Nowcasting of y_t^Q: orthogonal projection of y_t^Q on the available information:

$$\mathbb{E}\left[y_t^Q | \Omega_v\right],$$

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Nowcasting of y_t^Q: orthogonal projection of y_t^Q on the available information:

$$\mathbb{E}\left[y_t^Q | \Omega_v\right],$$

The information set Ω_v has particular characteristics:

1. it has a “ragged” or “jagged edge” [publication lags differing across series]
2. it contains mixed frequency series, in our case monthly and quarterly
3. it could be large

Spreadsheets in Real Time

-1.04	-9.75	-5.78	0.89	NaN	NaN	NaN	NaN	NaN
-0.28	-7.79	-1.54	-0.70	NaN	NaN	NaN	NaN	NaN
0.10	-0.05	0.57	0.47	0.54	-0.96	-0.10	0.32	-0.08
3.12	4.22	-0.93	1.45	-0.15	0.19	NaN	NaN	NaN
-0.43	0.43	-2.42	2.45	-0.22	0.80	NaN	NaN	NaN
0.06	-13.71	0.33	3.13	0.57	0.09	1.20	0.57	0.96
0.09	2.34	0.51	3.05	0.32	0.04	NaN	NaN	NaN
0.12	-13.15	0.64	1.70	-0.07	-1.47	NaN	NaN	NaN
-0.53	-8.77	-2.92	1.03	0.28	-1.10	0.30	0.87	0.24
-1.27	-8.21	-7.04	0.38	0.25	-0.75	NaN	NaN	NaN
-1.53	-7.94	-8.52	1.36	0.29	-0.74	NaN	NaN	NaN
-1.10	-9.46	-6.12	2.13	-0.06	-1.23	0.50	0.70	0.4
-0.69	2.48	-3.82	NaN	-0.24	4.70	NaN	NaN	NaN
-0.93	NaN	-5.17	NaN	NaN	NaN	NaN	NaN	NaN
NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN

Further features

- Projections need to be updated regularly

$$\mathbb{E}\left[y_t^Q|\Omega_v\right], \ \ \mathbb{E}\left[y_t^Q|\Omega_{v+1}\right], \ldots$$

v, $v+1$, ..., consecutive data releases

Typically the intervals between two consecutive data releases are short (possible couple of days or less) and change over time. Consequently, v has high frequency and it is irregularly spaced.

News and nowcast revisions

- New release $\Rightarrow$ the information set expands (new releases): $\Omega_v \subseteq \Omega_{v+1}$ [we are abstracting from data revisions]

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- Decompose new forecast in two orthogonal components:

$$\underbrace{\mathbb{E}\left[y_t^Q|\Omega_{v+1}\right]}_{\text{new forecast}} = \underbrace{\mathbb{E}\left[y_t^Q|\Omega_v\right]}_{\text{old forecast}} + \underbrace{\mathbb{E}\left[y_t^Q|I_{v+1}\right]}_{\text{revision}},$$

I_{v+1} information in Ω_{v+1} "orthogonal" to Ω_v

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- If we have a model that can account for joint dynamics of all variables, we can express the forecast revision as a weighted sum of *news* from the released variables:

$$\underbrace{\mathbb{E}\left[y_t^Q|\Omega_{v+1}\right] - \mathbb{E}\left[y_t^Q|\Omega_v\right]}_{\text{forecast revision}} = \sum_{j \in J_{v+1}} b_{j,t,v+1} \underbrace{\left(x_{j,T_{j,v+1}} - \mathbb{E}\left[x_{j,T_{j,v+1}}|\Omega_v\right]\right)}_{\text{news}}.$$

For detailed derivation see Banubra and Modugno, 2008.

What kind of framework?

Three desiderata:

1. can capture joint dynamics of inputs and target
2. can be estimated on many series while retaining parsimony
3. can handle jagged edged data and mix frequency

Our approach:

- Dynamic factor model for large cross-section
  - Few factors capture the salient features of business cycle fluctuations
  - Flexibility, parsimony, robustness
- Filtering techniques
  - Efficient processing of real-time information
  - Mixed frequencies, jagged edges, missing data

Evans 2005 IJCB; Giannone, Reichlin and Small, 2008 JME

The dynamic factor model

$$x_t = \mu + \Lambda f_t + \varepsilon_t ,$$

- f_t: (unobserved) common factors; ε_t: idiosyncratic components
- Λ factor loadings
- Factors are modelled as a VAR process:

$$f_t = A_1 f_{t-1} + \cdots + A_p f_{t-p} + u_t$$

Parsimonious and robust model for Big Data

- Diebold, Reichlin and Watson, World Congress of the Econometric Society, 2000
- Forni et al. (2000), Stock and Watson (2002), Bernanke and Boivin (2002), Bai (2003) , Giannone et al (2005), Doz et al., (2011,2012)

Problems and solutions

- Missing data

  Naturally handled using Kalman filtering technique to obtain projections for any pattern of data availability in Ω_v as well as the *news* I_{v+1} and their impact $b_{j,t,v+1}$

- Mixed frequency

  Consider lower frequency variables as being periodically missing

- Estimation: Quasi Maximum likelihood:
  - robust and feasible Doz, Giannone and Reichlin., 2008 REStat
  - handling missing data Banbura and Modugno, 2010

A quasi maximum Likelihood approach Doz et al, 2012 (Restat)

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- Our Approach
  - Define a miss-specified (Quasi) Likelihood imposing ad hoc orthogonality restrictions (**exact** factor model)
  - Look at the approximation error when the model is approximate

...Maximum Likelihood Estimation: the main result

Define:
- $\hat{\theta}$ the maximum likelihood estimates under our approximating model...
- $\mathbf{F} = (\mathbf{f}_1, ..., \mathbf{f}_T)'$ true common factors
- $\mathbf{F}_{\hat{\theta}} = (\mathbf{f}_{\hat{\theta},1}, ..., \mathbf{f}_{\hat{\theta},T})'$ expected common factors estimated under $\hat{\theta}$

Proposition Under the assumption of an approximate factor structure

$$\frac{1}{T}\mathrm{Tr}(\mathbf{F} - \hat{H}\hat{\mathbf{F}}_{\hat{\theta}})'(\mathbf{F} - \hat{H}\hat{\mathbf{F}}_{\hat{\theta}}) = O_p\left(\frac{1}{\Delta(n,T)}\right) \text{ as } n, T \to \infty$$

where $\Delta_{nT} = \min\left\{\sqrt{T}, \frac{n}{\log(n)}\right\}$
and
$\hat{H} = \left(\hat{\mathbf{F}}'_{\hat{\theta}}\hat{\mathbf{F}}_{\hat{\theta}}\right)^{-1} \hat{\mathbf{F}}'_{\hat{\theta}}\mathbf{F}$ is the coefficient of the OLS projection of $\mathbf{F}$ on $\hat{\mathbf{F}}_{\hat{\theta}}$.

...Maximum Likelihood Estimation: the main result

Some comments...

- General maximum likelihood estimates are consistent to the common factors in a large cross-section and under an approximate factor structure...

- Consistency is achieved along any path $n, T \to \infty$
  $\Rightarrow$ suitable for large cross-section (even for $n >> T$)

Alternative models?

Vector Autoregression (VAR) instead of dynamic factor model

- Estimation: use Shrinkage (informative prior) to make it work with Big Data $\Rightarrow$ Large Bayesian VAR

  De Mol et al., 2008; Banbura et al,. 2010; Koop, 2013; Karlsson, 2102; Giannone et al, 2015

- Handling mixed frequencies: blocking, unobserved components
  - Theory: cross-fertilization between system identification and econometric

    Andersson, Deistler and co-authors
  - Applications

    Schorfheide and Song (2011), McCracken, Owyang, Sekhposyan (2013)

Bayesian Shrinkage and Comovement

- Homogenous shrinkage on observables implies less shrinkage on important common factors
- If few common factors dominate the induced by the prior becomes negligible for large models (double asymptotics)

  See Demol et al., 2008 (JoE).
- Intuition: comovement implies that sample informations in all variable massively points in the same direction against prior.

State space representation with mixed frequencies

Example: Let Y_t^Q denote the vector of (log of) the quarterly flow series.

We assume that Y_t^Q is the sum of daily contributions X_t

$$Y_t^Q = \sum_{s=t-k+1}^{t} X_s \,, \qquad t = k, 2k, \ldots .$$

Hence we will have that the stationary series $y_t^Q = Y_t^Q - Y_{t-k}^Q$ can be written as:

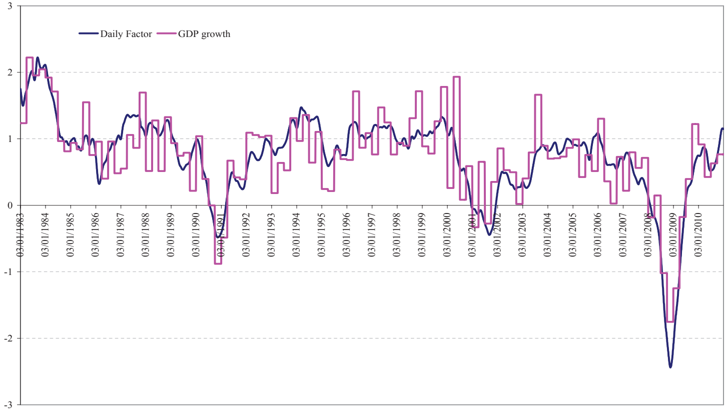
$$y_t^Q = k \left(\sum_{s=t-k+1}^{t} \frac{t+1-s}{k} x_s + \sum_{s=t-2*(k-1)}^{t-k} \frac{s-t+2*k-1}{k} x_s \right) , \qquad t = k, 2k,$$

where $x_s = X_s - X_{s-1}$ can be thought of as an unobserved daily growth rate (or difference).

The real-time data flow

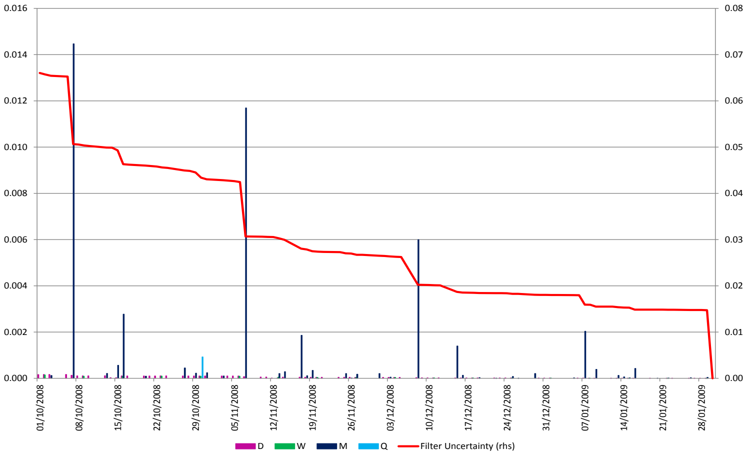
No	Name	Frequency	Publication delay (in days after reference period)
1	Real Gross Domestic Product	quarterly	28
2	Industrial Production Index	monthly	14
3	Purchasing Manager Index, Manufacturing	monthly	3
4	Real Disposable Personal Income	monthly	29
5	Unemployment Rate	monthly	7
6	Employment, Non-farm Payrolls	monthly	7
7	Personal Consumption Expenditure	monthly	29
8	Housing Starts	monthly	19
9	New Residential Sales	monthly	26
10	Manufacturers' New Orders, Durable Goods	monthly	27
11	Producer Price Index, Finished Goods	monthly	13
12	Consumer Price Index, All Urban Consumers	monthly	14
13	Imports	monthly	43
14	Exports	monthly	43
15	Philadelphia Fed Survey, General Business Conditions	monthly	-10
16	Retail and Food Services Sales	monthly	14
17	Conference Board Consumer Confidence	monthly	-5
18	Bloomberg Consumer Comfort Index	weekly	4
19	Initial Jobless Claims	weekly	4
20	S&P 500 Index	daily	1
21	Crude Oil, West Texas Intermediate (WTI)	daily	1
22	10-Year Treasury Constant Maturity Rate	daily	1
23	3-Month Treasury Bill, Secondary Market Rate	daily	1
24	Trade Weighted Exchange Index, Major Currencies	daily	1

Daily factor, GDP and its common component

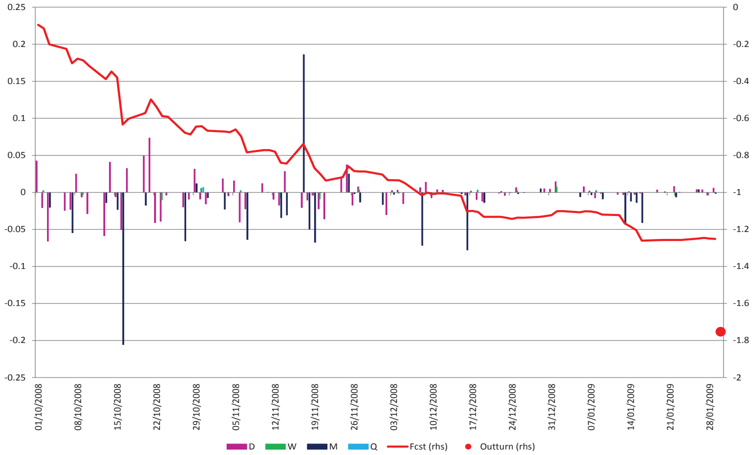


See also Stock and Watson, 1991; Aruoba, Diebold, Scotti, 2009

Filter uncertainty, GDP

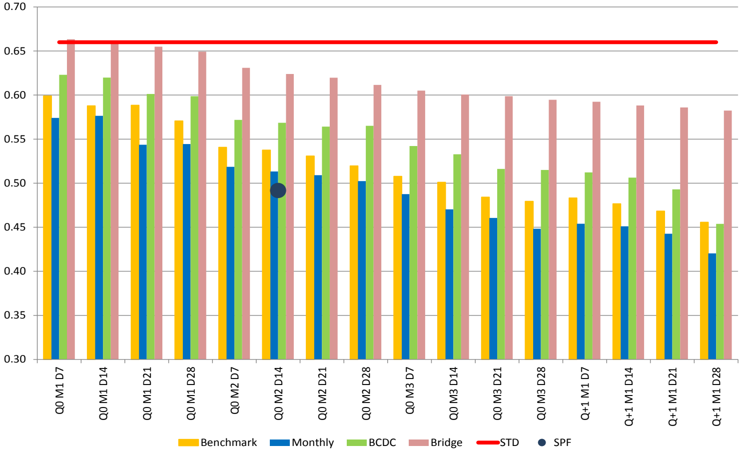


Forecasting the Great Recession

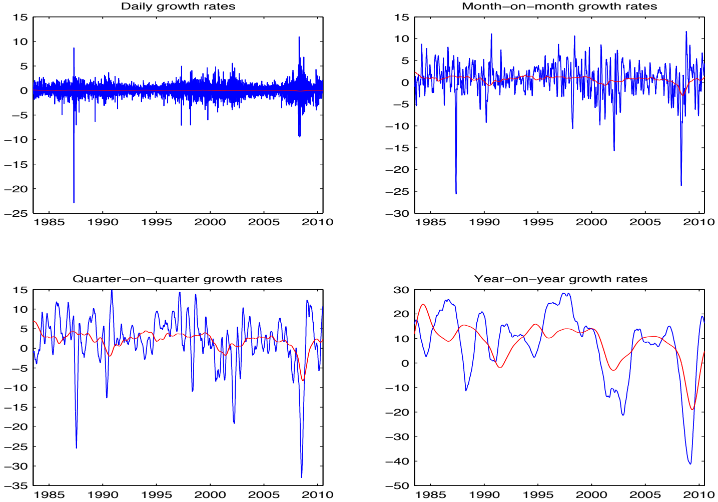


Does information help improving forecasting accuracy?

Root Mean Squared Forecast Error (RMSFE)



S&P 500 and its common component at different levels of time aggregation



Now-Casting and the Real-Time Data-Flow

Research questions

- How important is nowcasting relative to longer horizon forecasting?
- Can we predict the present? How relevant is informal judgement?
- How relevant is the conjectural information? How often should we update the predictions?

What have we learned

- ✓ Nowcasting is key! Little predictability beyond current quarter!
- ✓ We can predict the present without the need of informal judgement?.
- ✓ It is worth to obsessively monitor conjectural information! Accuracy improves significantly and continuously.