The Abdus Salam
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SMR.1676 - 18

8th Workshop on Non-Linear Dynamics and Earthquake Prediction

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Socio - Economic Predictions
Parts I

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INTRODUCTION

In the general scheme of things our course belongs to *predictive understanding of non-linear systems, a.k.a. complex or chaotic systems*.

Such systems persistently selforganize into abrupt overall changes, generally called *critical phenomena* or *extreme events*. In applications we call them *crises, catastrophes,* or *disasters*; in non-linear dynamics - *bifurcations*; in statistical physics - *critical transitions*.

Examples: the *Earth's lithosphere*, generating catastrophic earthquakes, volcanic eruptions, and landslides; *economy*, generating recessions; *megacities*, generating outbursts of violence; *ecological* systems, generating fast deterioration of environment; etc.

Prediction of extreme events is necessary for:

- *Development of their fundamental theory.* This is a current frontier of the basic research ("finding order in chaos"),

and

- *Protection of population, economy, and environment.* Due to proliferation of high risk objects and rising socio-economic volatility of our world, such disasters became *"a threat to civilization survival, as great as was ever posed by Hitler, Stalin or the atom bomb"* /J. Wisner/. Prediction opens a possibility to reduce the damage by escalation of disaster preparedness.

INSTITUTIONS INVOLVED

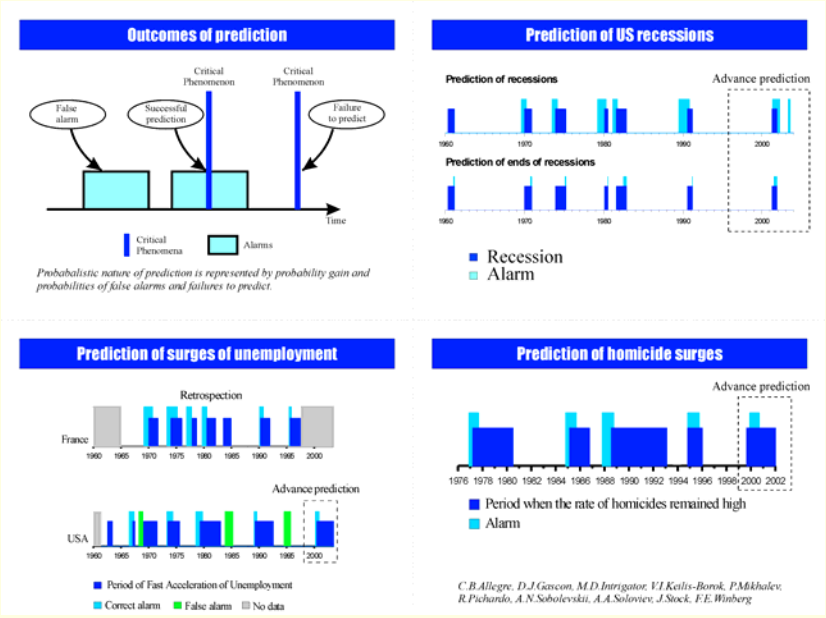
- MITPAN (Moscow)
- Moscow U
- Institute of Mathematics & Mechanics (Ekaterinburg)
- UCLA
- MIT
- Caltech
- UC Davis
- Cornell U
- Purdue U
- American U
- Harvard U
- USGS
- Los Alamos National Laboratory
- LAPD
- Abdus Salam Int. Centre for Theoretical Physics (Trieste)
- U of Rome (La Sapienza)
- International Center for Study of Economics and Poverty, Luxembourg
- Institut de Physique du Globe de Paris
- University of Paris-Sorbonne
- Ecole Normale Supérieure (Paris)
- Observatoire de la Côte d'Azur
- Geophysical Institute of Israel

Intermittent interaction with disaster management organizations in Russia, Italy, US; and reinsurance companies in Russia, Switzerland, and Spain.

RELEVANT FIELDS

- ***Pattern recognition of infrequent events***
- ***Mathematical Statistics***
- ***"Universal" models of complex systems***
- ***Models of the specific system considered***
- ***Error diagram techniques*** **(for evaluation of prediction quality)**
- ***Optimal control theory*** **(for optimization of disaster preparedness)**

SOCIO-ECONOMIC PREDICTIONS



RECESSIONS

PREDICTION OF AMERICAN ECONOMIC RECESSIONS

Pre-recession pattern of six USA economic indicators
V. Keilis-Borok, J. Stock, A. Soloviev, and P. Mikhalev
Journ. of Forecasting, ***19****(1), 65-80, (2000).*
http://dx.doi.org/10.1002/(SICI)1099-131X(200001)19:1<65::AID-FOR730>3.0.CO;2-U

Raw data:

- **Past recessions (beginning and end, officially defined), and**
- **Time series of the monthly economic indicators.**

Problem: **To recognise the months preceding a recession. The lead time should be not too large, not too small.**

INDICATORS CONSIDERED

They were selected among a multitude of known "leading" indicators.

1. Difference between interest rate on 10 year U.S. Treasury bond, and federal funds short-term interest rate; both on annual basis (G10FF)

2. Stock-Watson index of overall monthly economic activity.
   It is a weighted average of four measures, depicting employment, manufacturing output, and retail sales which emphasise services (XCI)
   Close equivalent is industrial production.

3. Index of "help wanted" advertising.
   This is put together by a private publishing company that measures the amount of job advertising (column-inches) in a number of major newspapers (LHELL)

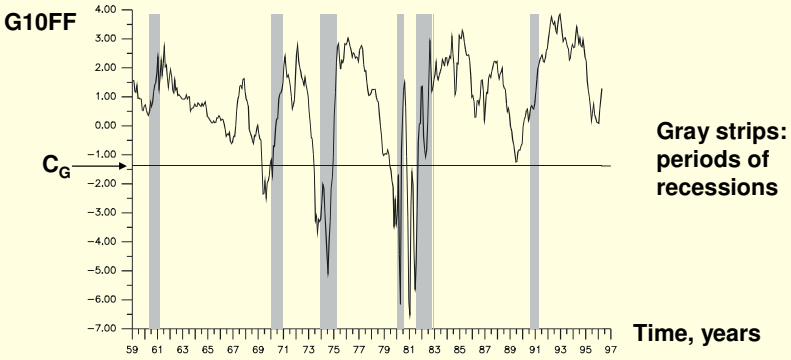
4. Average weekly number of people claiming unemployment insurance (LUINC)

5. Total inventories in manufacturing and trade, in real dollars.
   Includes intermediate inventories (for example held by manufacturers, ready to be sent to retailers) and final goods inventories (goods on shelves in stores) (INVMTQ)

6. Interest rate on 90 day U.S. treasury bills at an annual rate, in percent (FYGM3)

HYPOTHETICAL PRECURSORS: TYPICAL BEHAVIOUR OF AN INDICATOR I AS A RECESSION APPROACHES

Difference between long-term and short-term rates (G10FF)



Observation: G10FF becomes low before a recession
Discretization: Indicator is replaced by binary signal S_G

- If G10FF $\leq C_G$, $S_G = 1$
- If G10FF $> C_G$, $S_G = 0$

For convenience, all "premonitory" values are coded as 1

OTHER INDICATORS

Their premonitory behaviour is better seen in their linear trends, which have been estimated by a linear least square approximation:

$$l(\,i/n\,) = a + bi,$$

i is the time, counted in months; *b* is determined in the sliding time window *(i-n,* i *)*; note, that it is attributed to the end of the window.

PREMONITORY BEHAVIOUR:

- **Low short-term trend *b* for help wanted advertising**
- **High short-term trend *b* for unemployment claims**

For three remaining indicators premonitory behaviour is better seen as deviation from the long-term trend:

$$R(\,i/g\,) = G(\,i\,) - l(\,i\,)$$

Here $G(\,i\,)$ is determined on a time interval $(\,j,\ i\text{-}1\,)$, j being the first month after the end of the previous recession.

- **Low deviation is premonitory for the Stock-Watson index of overall monthly economic activity and for total inventories in manufacturing and trade.**
- **High deviation is premonitory for the interest rate on 90 day U.S. treasury bills at an annual rate.**

Dynamics of economy is now described by a binary vector, determined at the end of each month.

#	Month	Binary vector: XCIR	INVR	G10F	LHK5F	LUK10R	FYG3R	Δ
1	1961:08	0	1	0	0	0	0	5
2	1961:09	0	1	0	0	0	0	5
3	1961:10	0	1	0	0	0	0	5
4	1961:11	0	1	0	0	0	0	5
5	1961:12	0	1	0	0	0	0	5
6	1962:01	0	1	0	0	0	0	5
7	1962:02	0	1	0	0	0	0	5
8	1962:03	0	1	0	0	0	0	5
9	1962:04	0	1	0	0	0	0	5
10	1962:05	0	1	0	0	0	0	5
11	1962:06	0	1	0	1	0	0	4
12	1962:07	0	1	0	1	0	0	4
13	1962:08	0	1	0	1	0	0	4
14	1962:09	0	1	0	1	0	0	4
15	1962:10	0	1	0	1	0	0	4
16	1962:11	0	1	0	1	0	0	4
17	1962:12	0	1	0	1	0	0	4
18	1963:01	0	1	0	1	0	0	4
19	1963:02	0	1	0	1	0	0	4
20	1963:03	0	1	0	0	0	0	5
21	1963:04	0	1	0	0	0	0	5
22	1963:05	0	1	0	1	0	0	4
23	1963:06	0	1	0	1	0	0	4
24	1963:07	0	1	0	1	0	0	4
25	1963:08	0	1	0	1	0	0	4
26	1963:09	0	1	0	1	0	0	4
27	1963:10	0	1	0	0	0	0	5
28	1963:11	0	1	0	0	0	0	5
29	1963:12	0	1	0	0	0	0	5
30	1964:01	0	1	0	0	0	0	5
30	1964:01	0	1	0	0	0	0	5
31	1964:02	0	1	0	0	0	0	5
32	1964:03	0	1	0	0	0	0	5
33	1964:04	0	1	0	0	0	0	5
34	1964:05	0	1	0	0	0	0	5
35	1964:06	0	1	0	0	0	0	5
36	1964:07	0	1	0	0	0	0	5
37	1964:08	0	1	0	0	0	0	5
38	1964:09	0	1	0	0	0	0	5
39	1964:10	0	1	0	0	0	0	5
40	1964:11	0	1	0	0	0	0	5
41	1964:12	0	1	0	0	0	0	5
42	1965:01	0	1	0	0	0	0	5
43	1965:02	0	1	0	0	0	0	5
44	1965:03	0	1	0	0	0	0	5
45	1965:04	0	1	0	0	0	0	5
46	1965:05	0	1	0	0	0	0	5
47	1965:06	0	1	0	0	0	0	5
48	1965:07	0	1	0	0	0	0	5
49	1965:08	0	0	0	0	0	0	6
50	1965:09	0	1	0	0	0	0	5
51	1965:10	0	1	0	0	0	0	5
52	1965:11	0	1	0	0	0	0	5
53	1965:12	0	1	0	0	0	0	5
54	1966:01	0	1	0	0	0	0	5
55	1966:02	0	0	0	0	0	0	6
56	1966:03	0	0	0	0	0	0	6
57	1966:04	0	0	0	0	0	0	6
58	1966:05	0	0	0	0	0	0	6
59	1966:06	0	0	0	0	0	0	6
60	1966:07	0	0	0	0	0	0	6
61	1966:08	0	0	0	1	0	0	5
62	1966:09	0	0	0	1	0	0	5
63	1966:10	0	0	0	1	0	0	5
64	1966:11	0	0	0	1	0	0	5
65	1966:12	0	0	0	1	0	0	5
66	1967:01	0	0	0	1	1	0	4
67	1967:02	0	0	0	1	1	0	4
68	1967:03	0	0	0	1	1	0	4
69	1967:04	0	0	0	1	1	0	4
70	1967:05	1	0	0	1	1	0	3
71	1967:06	1	0	0	1	1	0	3
72	1967:07	1	0	0	1	1	0	3
73	1967:08	0	0	0	1	1	0	4
74	1967:09	1	0	0	1	0	0	4
75	1967:10	1	0	0	0	0	0	5
76	1967:11	0	0	0	0	0	0	6
77	1967:12	0	0	0	0	0	0	6
78	1968:01	0	0	0	0	0	0	6
79	1968:02	0	0	0	0	0	0	6
80	1968:03	0	0	0	0	0	0	6
81	1968:04	0	0	0	0	0	0	6
82	1968:05	0	0	0	0	0	0	6
83	1968:06	0	0	0	0	0	0	6
84	1968:07	0	0	0	0	0	0	6
85	1968:08	0	0	0	0	0	0	6
86	1968:09	0	0	0	0	0	0	6
87	1968:10	0	0	0	0	0	0	6
88	1968:11	0	0	0	0	0	0	6
89	1968:12	0	0	0	0	0	0	6
90	1969:01	0	0	0	0	0	0	6
91	1969:02	0	0	0	0	0	0	6
92	1969:03	0	1	0	0	0	0	5
93	1969:04	0	1	0	0	0	0	5
94	1969:05	0	1	1	0	0	0	4
95	1969:06	0	1	1	1	0	0	3
96	1969:07	0	1	1	1	0	1	2 +
97	1969:08	0	1	1	1	0	1	2 +
98	1969:09	0	1	1	1	0	1	2 +
99	1969:10	0	1	1	1	0	0	3
100	1969:11	1	1	1	1	1	0	+
101	*1969:12*	*1*	*1*	*0*	*1*	*1*	*1*	*1 +*
...								
102	1971:05	0	1	0	1	0	1	3
103	1971:06	0	1	0	0	0	1	4
104	1971:07	0	1	0	0	0	1	4
105	1971:08	0	1	0	0	0	0	5
106	1971:09	0	1	0	0	0	0	5
107	1971:10	0	1	0	0	0	0	5
108	1971:11	0	1	0	0	0	0	5
109	1971:12	0	1	0	0	0	0	5
110	1972:01	0	1	0	0	0	0	5
111	1972:02	0	1	0	0	0	0	5
112	1972:03	0	1	0	0	0	0	5
113	1972:04	0	1	0	0	0	0	5
114	1972:05	0	1	0	0	0	0	5
115	1972:06	0	1	0	0	0	0	5
116	1972:07	0	1	0	0	0	0	5
117	1972:08	0	1	0	0	0	0	5
118	1972:09	0	1	0	0	0	0	5
119	1972:10	0	1	0	0	0	0	5
120	1972:11	0	1	0	0	0	0	5
121	1972:12	0	1	0	0	0	1	4
122	1973:01	0	1	0	0	0	1	4
123	1973:02	0	1	0	0	0	1	4
124	1973:03	0	1	0	0	0	1	4
125	1973:04	0	1	0	0	0	1	4
126	1973:05	0	1	0	0	0	1	4
127	1973:06	0	1	1	1	0	1	2 +
128	1973:07	0	1	1	1	0	0	3
129	1973:08	0	1	1	0	0	1	3
130	1973:09	0	1	1	1	0	1	2 +
131	1973:10	0	1	1	1	0	0	3
132	*1973:11*	*0*	*1*	*1*	*1*	*1*	*1*	*1 +*

Red italics indicate start of a recession. Periods of recessions are not shown

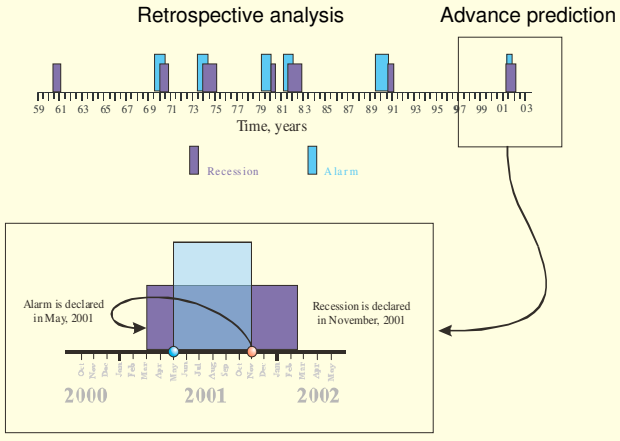
The type of a hypothetical precursor is indicated in italics.

1. **XCIR**: Deviation from long-term trend of Stock-Watson index of overall monthly economic activity. *Low value*.
2. **INVR**: Deviation from long-term trend of total inventories in manufacturing and trade, in real dollars. *Low value*.
3. **G10FF**: Difference between interest rate on 10 year U.S. Treasury bond, and federal funds interest rate, on annual basis. *Low value*.
4. **LHK5**: Growth rate (short-term trend) of index of "help wanted" advertising. *Low value*.
5. **LUK10**: Growth rate (short-term trend) of average weekly number of people claiming unemployment insurance. *Large value*.
6. **FYG3R**: Deviation from long-term trend of interest rate on 90 day U.S. treasury bills at an annual rate. *Large value*.

PREDICTION ALGORITHM

The table suggests prediction by simple voting

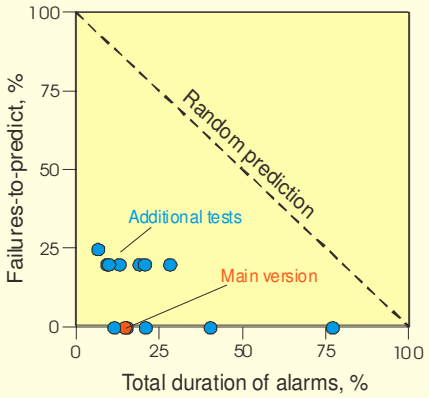
Let Δ be the number of "0"s in a code of a month; it shows how many indicators are not premonitory. If Δ ≤ 2, an alarm is declared for three subsequent months (regardless of whether this alarm overlaps with one already declared).



CONTROL EXPERIMENTS

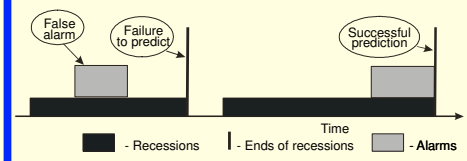
"With four parameters I can fit an elephant" E.Fermi / J. von Neumann

- *"Prediction history".* **We determined the thresholds for consecutively expanding time periods: 1961-1969, 1961-1973, 1961-1979, 1961-1981 and applied the prediction algorithm to the subsequent time period up to a next recession.**
- *"Reverse prediction history".* **We expanded the data set in the reverse order.**
- *Elimination of the functions.* **We eliminated from consideration each of the six indicators, one at a time.**
- *Prediction by a single function.* **In this experiment we used each of the function separately of others.**
- *Revised data.* **The indexes for the past years are retrospectively revised on a regular basis. In the main version we used the 1996 revision of the data base, and in this experiment - the 1994 revision.**
- *Change of the discretisation thresholds.*

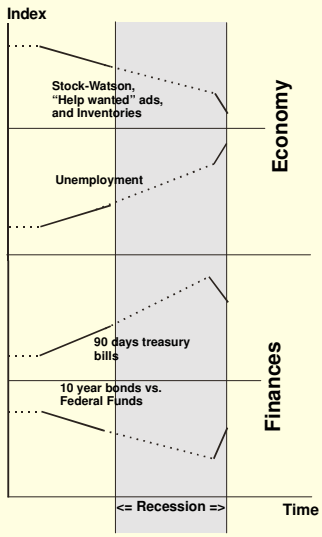


PREDICTION OF THE END OF A RECESSION

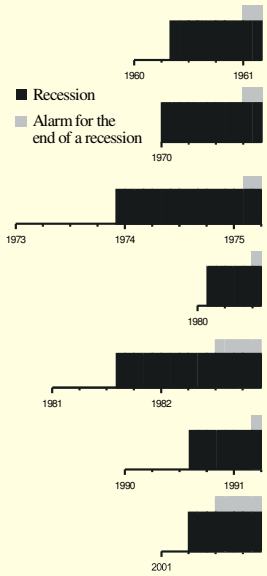
The problem

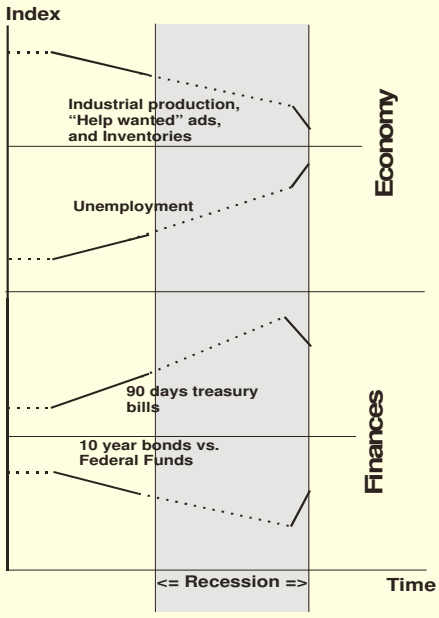


Premonitory changes of indicators before the start of a recession and before its end



Retrospective application
$\Delta \leq 3$

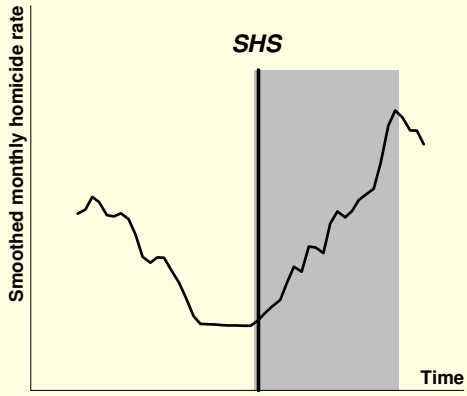




HOMICIDE SURGES

PREDICTION OF HOMICIDE SURGES IN LOS ANGELES

On predictability of homicide surges in megacities
V. I. Keilis-Borok, D. J. Gascon, A. A. Soloviev, M. D. Intriligator, R. Pichardo, and F. E. Winberg
In T. Beer and A. Ismail-Zadeh (eds.), Risk Science and Sustainability, Kluwer Academic Publishers, Dordrecht, pp. 91-110, (2003). http://www.bol.ucla.edu/~vkborok/papers/Homicide.pdf

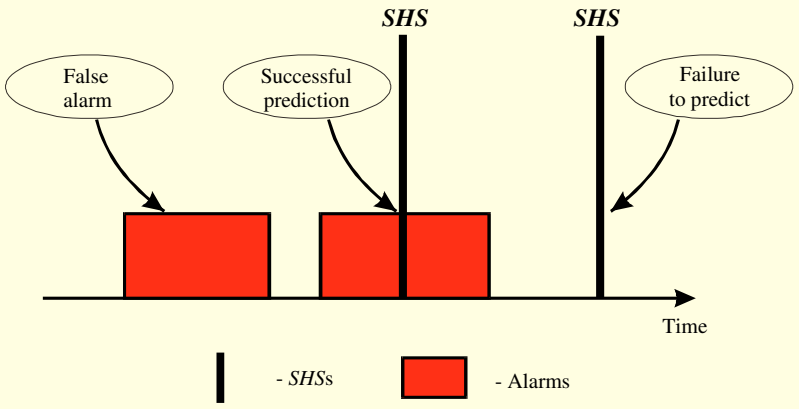


Target of prediction: the start of the homicide surge, "SHS"

Monthly homicide rate in Los Angeles with seasonal variations smoothed away per 3 million inhabitants

Gray bar marks the whole period of the homicide surge

POSSIBLE OUTCOMES OF PREDICTION

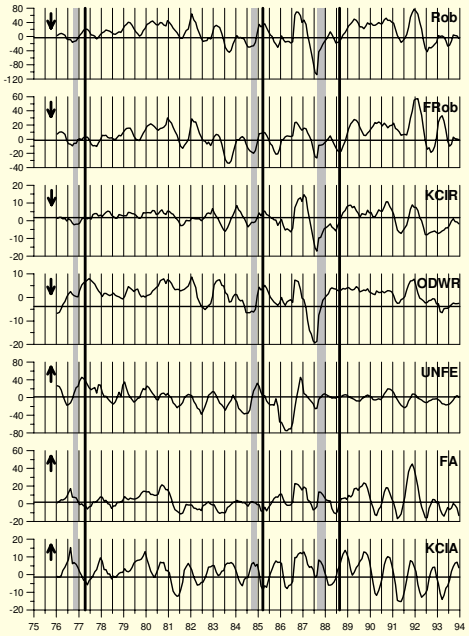


TYPES OF CRIMES (TIME SERIES) CONSIDERED

Note that other potentially relevant data might also be used for prediction.

Homicide	Robberies	Assaults	Burglaries
❖ All	❖ All ❖ With firearms ❖ With knife or cutting instrument ❖ With other dangerous weapon ❖ Strong-arm robberies*	❖ All* ❖ With firearms ❖ With knife or cutting instrument ❖ With other dangerous weapon* ❖ Aggravated injury assaults*	❖ Unlawful not forcible entry ❖ Attempted forcible entry*

*** Analysed in error diagrams only**



The regression coefficients *KC*(*m*-12, *m*) for seven crime types.

Horizontal lines and arrows show respectively discretization thresholds and directions of premonitory trends.

Vertical lines show episodes of *SHS*. Gray bars indicate months when 6 or all 7 trends are premonitory.

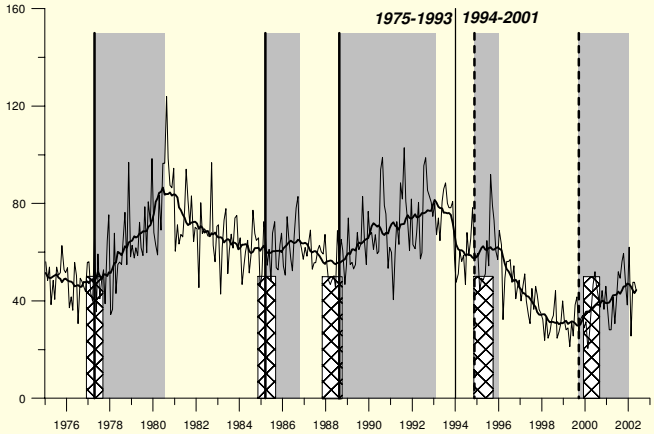
EMERGENCE OF PREMONITORY TRENDS

		Discretized trends								
		R	F	K	O	F	K	U		
		o	R	C	D	A	C	N		
		b	o	1	W		1	F		
#	Month		b	R	R		A	E	Δ	K^H
1	1976:01	1	0	0	1	0	1	0	4	0.44
2	1976:02	1	0	0	0	1	1	0	4	0.21
3	1976:03	1	0	0	0	1	1	0	4	-0.07
4	1976:04	0	0	0	1	1	1	1	3	-0.28
5	1976:05	0	0	0	1	1	0	1	4	-0.35
6	1976:06	0	1	1	1	1	0	1	2	-0.33
7	1976:07	0	1	1	1	1	0	1	2	-1.18
8	1976:08	0	1	1	1	1	0	1	2	-0.96
9	1976:09	0	1	1	1	1	0	1	2	-0.87
10	1976:10	0	1	1	1	1	1	1	**1**	+ -0.79
11	1976:11	0	1	1	1	1	1	1	**1**	+ -0.37
12	1976:12	0	0	1	1	1	1	1	2	0.16
13	1977:01	0	0	0	1	0	1	0	5	0.68
14	1977:02	0	0	0	1	0	1	0	5	0.84
15	1977:03	0	0	0	1	0	1	0	5	0.38
16	**1977:04**	0	0	0	0	0	1	0	6	0.85
17	1977:05	0	0	0	1	0	1	0	5	0.07
18	1977:06	0	0	0	1	0	1	0	5	0.71
19	1977:07	0	1	0	1	0	1	0	4	0.58
20	1977:08	0	1	0	0	0	1	0	5	0.03
21	1977:09	0	1	0	0	0	1	0	5	0.18
22	1977:10	0	1	1	0	1	1	1	2	-0.17
23	1977:11	0	1	0	0	1	1	1	3	0.24
24	1977:12	0	0	0	0	1	1	1	4	0.81
25	1978:01	0	0	0	0	1	1	1	4	0.38
26	1978:02	0	0	0	0	1	1	1	4	0.16
27	1978:03	0	0	0	0	1	1	1	4	0.53
28	1978:04	0	0	0	0	0	0	0	7	-0.09
29	1978:05	0	0	0	0	0	0	0	7	0.55
30	1978:06	0	0	0	0	0	0	0	7	0.2
31	1978:07	0	0	0	0	0	0	0	7	0.57
32	1978:08	0	0	0	1	0	0	0	6	0.66
33	1978:09	0	0	0	1	0	1	0	5	1.19
34	1978:10	0	0	0	0	0	1	0	6	1.07
35	1978:11	0	0	0	0	1	1	0	5	1.72
36	1978:12	0	0	0	0	1	1	0	5	1.81
37	1979:01	0	0	0	0	1	1	1	4	2.52
38	1979:02	0	0	0	0	1	1	0	5	1.66
39	1979:03	0	0	0	0	1	1	0	5	0.88
40	1979:04	0	0	0	0	1	1	1	4	0.98
41	1979:05	0	0	0	0	1	0	1	5	0.66
42	1979:06	0	0	0	0	1	0	1	5	0.27
43	1979:07	0	0	0	0	1	0	1	5	-0.21
44	1979:08	0	1	0	0	1	0	1	4	-0.14
45	1979:09	0	1	0	1	1	1	1	2	-0.36
46	1979:10	0	0	0	0	1	1	1	4	0.45
47	1979:11	0	0	0	0	1	1	1	4	0.19
48	1979:12	0	0	0	0	1	1	1	4	2.15
49	1980:01	0	0	0	0	1	1	1	4	1.82
50	1980:02	0	0	0	0	1	1	1	4	1.49
51	1980:03	0	0	0	0	1	1	0	5	0.82
52	1980:04	0	0	0	0	1	1	0	5	1.08
53	1980:05	0	0	0	0	1	1	0	5	0.63
54	1980:06	0	0	0	0	1	0	0	6	1.51
55	1980:07	0	0	0	0	1	0	1	5	1.86
56	1980:08	0	0	0	0	1	1	1	4	2.79
57	1980:09	0	0	0	0	1	1	1	4	3.26
58	1980:10	0	0	0	0	1	1	1	4	2.56
59	1980:11	0	0	0	0	1	1	1	4	2.43
60	1980:12	0	0	0	0	1	1	1	4	2.22
61	1981:01	0	0	0	0	1	1	0	5	1.78
62	1981:02	0	0	0	0	1	1	0	5	0.85
63	1981:03	0	0	0	0	0	0	0	7	-0.57
64	1981:04	0	0	0	0	0	0	0	7	-2.02
65	1981:05	0	0	0	1	0	0	0	6	-2.64
66	1981:06	0	1	0	1	0	0	0	5	-3.35
67	1981:07	0	1	1	1	0	0	0	4	-2.51
68	1981:08	0	1	1	1	0	0	0	4	-2.1
69	1981:09	0	1	0	1	0	1	1	3	-0.92
70	1981:10	0	1	0	1	0	1	1	3	-0.02
71	1981:11	0	0	0	1	0	1	1	4	-0.1
72	1981:12	0	0	0	1	0	1	1	4	0.09
73	1982:01	0	0	0	1	0	1	1	4	0.7
74	1982:02	0	0	0	1	0	0	0	6	-0.63
75	1982:03	0	0	0	1	0	0	0	6	-0.27
76	1982:04	0	0	0	1	0	0	0	6	-0.71
77	1982:05	0	0	0	1	0	0	0	6	-0.97
78	1982:06	0	0	1	1	0	0	0	5	-1.31
79	1982:07	1	1	1	1	0	0	0	3	-1.32
80	1982:08	1	1	1	0	0	0	0	4	-0.63
81	1982:09	1	1	1	0	0	0	0	4	0.73
82	1982:10	0	1	0	0	0	1	1	4	0.45
83	1982:11	0	1	1	0	0	1	1	3	0.43
84	1982:12	0	1	0	0	0	1	1	4	0.33
85	1983:01	0	0	0	0	0	1	1	5	0.48
86	1983:02	0	0	0	0	0	1	0	6	-0.35
87	1983:03	0	0	0	1	0	0	0	6	-1.32
88	1983:04	0	0	0	1	0	0	0	6	-0.62
89	1983:05	0	1	0	1	0	0	1	4	-0.22
90	1983:06	0	1	1	1	0	0	1	3	-0.73
91	1983:07	0	1	1	1	0	0	1	3	-0.85
92	1983:08	0	1	1	1	0	0	1	3	-0.78
93	1983:09	0	1	1	1	0	0	1	3	-0.92
94	1983:10	0	1	1	1	0	0	1	3	0.59
95	1983:11	0	1	1	0	0	1	1	3	0.9
96	1983:12	0	1	1	0	1	0	1	3	0.41
97	1984:01	0	0	0	0	1	0	0	6	0.58
98	1984:02	0	1	0	0	1	0	0	5	0.2
99	1984:03	0	0	0	0	1	0	0	6	-0.93
100	1984:04	0	0	1	0	0	0	0	6	-1.16
101	1984:05	0	0	1	1	0	0	0	5	-0.76
102	1984:06	1	1	1	1	0	0	0	3	-0.57
103	1984:07	1	1	1	1	0	0	0	3	-1.04
104	1984:08	1	1	1	1	0	0	1	2	-0.55
105	1984:09	1	1	1	1	0	1	1	**1**	+ -0.21
106	1984:10	1	1	1	1	0	1	1	**1**	+ -0.2

Hypothetical prediction algorithm: An alarm is declared for 9 months each time when $\Delta(m) \leq D$ for two consecutive months (regardless of whether these two months belong or not to an already declared alarm).

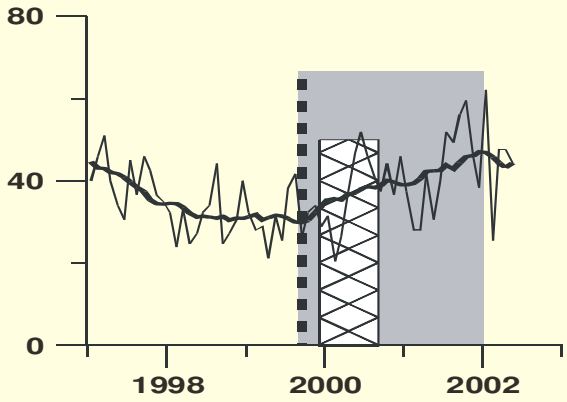
107	1984:11	1	1	1	1	0	1	1	**1** +	0.33
108	1984:12	0	1	0	1	0	1	1	3	0.25
109	1985:01	0	0	0	0	0	1	0	6	0.01
110	1985:02	0	0	0	0	0	1	0	6	0.73
111	**1985:03**	0	0	0	0	0	1	0	6	0.45
112	1985:04	0	0	0	0	0	1	0	6	-0.08
113	1985:05	0	0	0	0	0	0	0	7	-0.15
114	1985:06	0	0	0	0	0	0	0	7	-0.51
115	1985:07	0	1	0	0	0	0	0	6	-0.61
116	1985:08	0	1	0	1	1	0	1	3	-0.34
117	1985:09	0	1	1	1	1	0	1	2	-0.08
118	1985:10	0	1	1	1	1	0	1	2	-0.11
119	1985:11	0	1	1	1	1	0	1	2	0.19
120	1985:12	0	1	1	1	1	0	1	2	0.7
121	1986:01	0	1	0	1	1	0	1	3	-0.04
122	1986:02	0	0	1	1	1	0	0	4	-0.74
123	1986:03	0	0	1	1	0	0	0	5	0.29
124	1986:04	0	0	1	1	0	0	0	5	0.77
125	1986:05	0	0	1	1	0	0	0	5	0.42
126	1986:06	0	0	1	1	0	0	0	5	0.15
127	1986:07	0	0	1	1	1	0	0	4	-0.08
128	1986:08	0	0	0	0	1	0	1	5	0.76
129	1986:09	0	0	0	0	0	1	1	4	1.9
130	1986:10	0	0	0	0	1	1	1	4	1.56
131	1986:11	0	0	0	0	1	1	1	4	0.98
132	1986:12	0	0	0	0	1	1	1	4	0.59
133	1987:01	0	0	0	0	1	1	1	4	0.66
134	1987:02	1	0	0	0	0	1	1	3	0.11
135	1987:03	1	0	0	0	1	1	1	3	-0.43
136	1987:04	1	0	1	1	1	0	1	2	0.14
137	1987:05	1	1	1	1	0	0	1	2	-0.2
138	1987:06	1	1	1	1	0	0	1	2	-0.76
139	1987:07	1	1	1	1	0	0	0	3	-1.52
140	1987:08	1	1	1	1	0	0	0	3	-1.48
141	1987:09	1	1	1	1	1	0	1	**1** +	-0.9
142	1987:10	1	1	1	1	1	1	1	**0** +	-0.13
143	1987:11	0	1	1	1	1	1	1	**1** +	-0.01
144	1987:12	0	1	1	1	1	1	1	**1** +	0.29
145	1988:01	0	1	1	1	1	1	0	2	-0.01
146	1988:02	0	0	0	1	1	1	0	4	-0.35
147	1988:03	0	0	0	1	1	1	0	4	-0.84
148	1988:04	0	0	0	1	0	0	0	6	-0.96
149	1988:05	0	1	1	1	0	1	0	3	-0.69
150	1988:06	0	1	1	1	0	1	0	3	-1.21
151	1988:07	0	1	1	1	0	1	1	2	-0.68
152	**1988:08**	0	1	1	1	0	1	1	2	-0.66
153	1988:09	0	1	1	0	1	1	1	2	-0.13
154	1988:10	0	1	0	0	1	1	1	3	0.27
155	1988:11	0	1	0	0	1	1	1	3	0.04
156	1988:12	0	0	0	0	1	1	1	4	0.15
157	1989:01	0	0	0	0	1	1	1	4	1.38
158	1989:02	0	0	0	0	1	1	1	4	1.41
159	1989:03	0	0	0	0	1	0	0	6	1.13
160	1989:04	0	0	0	0	1	0	0	6	0.62
161	1989:05	0	0	0	0	0	1	0	5	0.21
162	1989:06	0	0	0	0	0	1	0	5	0.34
163	1989:07	0	0	0	0	0	1	0	5	-0.15
164	1989:08	0	0	0	0	0	1	0	5	0.39
165	1989:09	0	0	0	0	0	1	1	4	1.19
166	1989:10	0	0	0	0	0	1	1	4	1.47
167	1989:11	0	0	0	0	0	1	1	4	1.2
168	1989:12	0	0	0	0	0	1	1	4	1.18
169	1990:01	0	0	0	0	0	1	1	4	0.97
170	1990:02	0	0	0	0	0	0	0	7	1.6
171	1990:03	0	0	0	0	0	0	0	7	1.15
172	1990:04	0	0	0	0	0	0	0	7	0.92
173	1990:05	0	0	0	0	0	0	0	7	0.21
174	1990:06	0	0	0	0	0	0	0	7	-0.44
175	1990:07	0	0	0	0	1	1	0	5	0.74
176	1990:08	0	0	0	0	1	1	1	4	1.63
177	1990:09	0	0	0	0	1	1	1	4	1.64
178	1990:10	0	0	0	0	1	1	1	4	2.25
179	1990:11	0	0	0	0	1	1	1	4	1.24
180	1990:12	0	0	0	0	1	1	1	4	0.2
181	1991:01	0	0	0	0	0	1	0	6	0.04
182	1991:02	0	0	0	0	1	0	1	5	-1.16
183	1991:03	0	0	0	0	1	0	0	6	-1.38
184	1991:04	0	0	0	1	1	0	0	5	-1.4
185	1991:05	0	0	0	1	1	0	0	5	-1.6
186	1991:06	0	0	0	1	1	0	0	5	-1.14
187	1991:07	0	0	0	1	1	1	0	4	-1.1
188	1991:08	0	0	0	0	1	1	0	5	1.12
189	1991:09	0	0	0	0	1	1	0	5	2.63
190	1991:10	0	0	0	0	0	1	1	4	3.04
191	1991:11	0	0	0	0	0	1	1	4	2.86
192	1991:12	0	0	0	0	0	1	1	4	2.6
193	1992:01	0	0	0	0	0	1	1	4	1.84
194	1992:02	0	0	0	0	0	1	0	5	0.95
195	1992:03	0	0	0	0	0	1	0	5	-0.58
196	1992:04	0	0	0	0	1	0	0	5	-0.88
197	1992:05	0	0	0	1	1	0	0	5	-1.7
198	1992:06	0	0	1	1	1	0	0	5	-2.75
199	1992:07	0	1	1	1	0	0	0	5	-1.21
200	1992:08	0	1	1	1	0	0	0	5	0.1
201	1992:09	0	1	1	1	0	0	0	5	1.72
202	1992:10	0	1	1	1	1	0	1	4	2.35
203	1992:11	0	1	1	1	1	0	1	4	2.47
204	1992:12	0	0	1	1	0	0	0	5	1.76
205	1993:01	0	0	0	1	0	0	0	6	2.04
206	1993:02	1	0	0	1	0	0	0	5	1.04
207	1993:03	1	0	0	1	0	0	0	5	0.21
208	1993:04	1	0	0	1	0	0	0	5	-0.74
209	1993:05	1	0	1	1	0	0	0	4	-0.46
210	1993:06	1	1	1	1	0	0	0	3	-1.05
211	1993:07	1	1	1	1	0	0	0	3	-1.6
212	1993:08	0	1	1	1	0	0	0	4	-1
213	1993:09	0	0	0	1	0	0	1	5	-0.2
214	1993:10	0	0	0	1	0	1	1	4	0.14
215	1993:11	0	0	0	1	0	1	1	4	0.52
216	1993:12	0	0	1	1	0	1	1	3	-0.12

PERFORMANCE OF PREDICTION ALGORITHM THROUGH 1975-2002



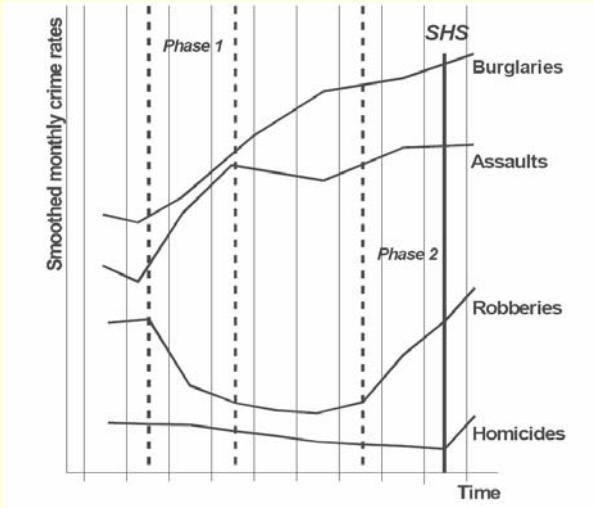
- The *thin curve* shows total monthly rates of homicides in Los Angeles city, per 3,000,000 inhabitants.
- The *thick curve* shows the same rates with seasonal variations smoothed away.
- The *vertical lines* show the targets of prediction - upward bends of the smoothed homicide rate while the solid and dashed lines show the turns that occurred before and after 1993.
- *Gray bars* are the periods when the rate of homicides remained high.
- *Checkered bars* show alarms – time intervals where these bends are predicted.

CASE HISTORY: ADVANCE PREDICTION OF THE LAST RISE OF HOMICIDES



- The *thin curve* shows total monthly rates of homicides in Los Angeles city, per 3,000,000 inhabitants.
- The *thick curve* shows the same rates with seasonal variations smoothed away.
- The *vertical line* shows the target of prediction - upward bend of the smoothed homicide rate.
- *Gray bar* shows the period when the rate of homicides remained high.
- *Checkered bar* shows the time interval where this bend is predicted

SCHEME OF PREMONITORY CHANGES IN CRIME STATISTICS



"BAROMETER" IN LAPD: *A POSSIBILITY*

R – Robberies: ***a*** - all; ***f*** - firearm; ***k*** - knife or cutting instrument; ***o*** - other dangerous weapon.
A – Assaults: ***f*** - firearm; ***k*** - knife or cutting instrument
B – Burglaries: ***u*** - unlawful not forcible entry

		Discretized trends							
#	Month	Ra	Rf	Rk	Ro	Af	Ak	Bu	Δ
1	1976:01	1	0	0	1	0	1	0	4
2	1976:02	1	0	0	0	1	1	0	4
3	1976:03	1	0	0	0	1	1	0	4
4	1976:04	0	0	0	1	1	1	1	3
5	1976:05	0	0	0	1	1	0	1	4
6	1976:06	0	1	1	1	1	0	1	2
7	1976:07	0	1	1	1	1	0	1	2
8	1976:08	0	1	1	1	1	0	1	2
9	1976:09	0	1	1	1	1	0	1	2
10	1976:10	0	1	1	1	1	1	1	1
11	1976:11	0	1	1	1	1	1	1	1
12	1976:12	0	0	1	1	1	1	1	2
13	1977:01	0	0	0	1	0	1	0	5
14	1977:02	0	0	0	1	0	1	0	5
15	1977:03	0	0	0	1	0	1	0	5
16	1977:04	0	0	0	0	0	1	0	6
17	1977:05	0	0	0	1	0	1	0	5
18	1977:06	0	0	0	1	0	1	0	5
19	1977:07	0	1	0	1	0	1	0	4

The program stores and regularly updates the monthly crime rates used in prediction.
For each consecutive month the program does the following:

1. Computes the trend of each crime rate during last 12 months.
2. Determines which of these trends are precursory to the homicide surge.
3. Counts the number of premonitory trends Δ. If Δ <= 1 for that and previous month, *algorithm predicts the homicide surge within next 9 months*.

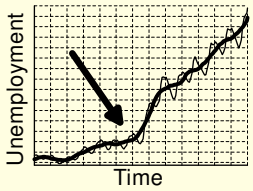
Whether to believe this – to undertake or not special preparedness/prevention measures – is decided *not* by computer, but by experts.

UNEMPLOIMENT

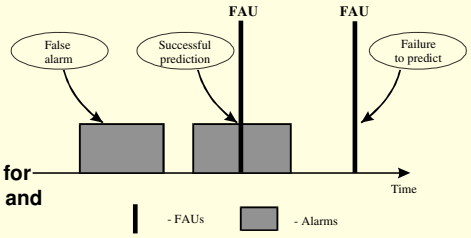
FAST ACCELERATION OF UNEMPLOYMENT ("FAU")

Patterns of macroeconomic indicators preceding the unemployment rise in Western Europe and the USA
V. I. Keilis-Borok, A. A. Soloviev, C. B. Allègre, A. N. Sobolevskii, and M. D. Intriligator
Pattern Recognition, ***38***(3), 423-435, (2005). http://dx.doi.org/10.1016/j.patcog.2004.08.005

Prediction target: moment of a sharp and lasting upward bend of monthly unemployment rate



Schematic definition of FAU. Thin line - monthly unemployment; note seasonal quasiperiodic variations. Thick line - monthly unemployment, with seasonal variations smoothed away. The arrow indicates a *FAU* - the sharp upward bend of the smoothed curve. The moment of a *FAU* is the target of prediction.



Formal definition:

- ***U(m) = a + bm*** **– linear least square regression of *U*, *m* – time in months.**
- ***b⁺(s)*** **and *b⁻(s)* – values of the slope *b* for regressions over *s* months preceding and following m respectively.**
- **FAU is defined by condition $b^+(s) - b^-(s) \geq F$.**

THE DATA

Composite characteristics of national economy

1. ***IP***: ***Industrial production index.***
2. ***L***: ***Long-term interest rate*** **on 10-year government bonds, in %.**
3. ***S***: ***Short-term interest rate*** **on 3-month bills, in %.**

Characteristics of more narrow areas of economy which are sensitive to its overall state

4. ***NC***: ***The number of new passenger car registrations***, **in thousands of units.**
5. ***EI***: **The experts' prospects for the national industrial sector.**
6. ***EP***: **The experts' prospects for selected manufacturers.**
7. ***EO***: **The estimated current volume of orders.**

The last three indicators are subjective estimates that distinguish "good" from "bad" situations.
They are obtained by a poll of a group of 2,500 manufacturers.

Two indicators related to the American economy

8. ***FF/$***: **Value of U.S. dollar in French francs.**
9. ***AR***: **The state of the American economy: is it close to a recession or not? These two states are distinguished by the pre-recession alarms determined for the United States economy (*Keilis-Borok et al., 2000*). A brief explanation of the *AR* indicator follows.**

AR INDICATOR

- All five U.S. economic recessions in 1962–2000 were preceded by a certain pattern of 6 leading macroeconomic indicators for the U.S. This pattern emerged 5 to 13 months before each recession and at no other time. On that basis, a prediction algorithm was suggested. The indicator *AR* (for "American Recession") shows whether an alarm is or is not determined by this algorithm.
- As a precursor to the American recessions this pattern was identified retrospectively. As a potential precursor to *FAU*s in France, however, *it was determined independently on the present study, and it includes no European indicators.*
- It is trivial, that these nine indicators are *relevant* to prediction of unemployment
- It is new, that they are *sufficient* for prediction of *FAU*s.

DISCRETIZATION

1. Indicators have been replaced by their *trends* – values of b in linear regression

$$I(m) = a_I + b_I(s_I)t, \quad m - s_I <= t <= m.$$

2. Comparison of the plots $b_I(m)$ with the moments of FAUs suggests a hypothesis on what trends are "premonitory" (occur more frequently in proximity of a FAU).
3. Discretization: Values of the trends b_I have been replaced by binary signals S_I. For first three indicators:

$$\text{If } b_I >= C_I, S_I = 1; \quad \text{If } b_I < C_I, S_I = 0$$

For other indicators inequalities are reversed.

The thresholds are determined as Q-level percentiles of the trend (for example with Q_L = 33%, one third of observed values of b_L is regarded as premonitory).

Trends and thresholds

Indicator	Premonitory trend	*s*	*Q*, %
IP: Industrial production index	Upward	12	50%
L: Interest rate, long-term bonds	Upward	12	33%
S: Interest rate, short-term bills	Upward	12	25%
NC: New passenger cars registrations	Downward	6	33%
EI: Prospects for industrial sector	Downward	6	33%
EP: Prospects for selected manufacturers	Downward	6	33%
EO: Orders	Downward	6	33%
FF/$: French francs per USD, exchange rate	Downward	6	33%
AR: Recession alarm in the U.S.	Is current		

CHRONOLOGY OF THE INDICATORS FOR FRANCE

- Columns 2 - 9 correspond to the single indicators. Headings show their symbols, as explained in Section 2 of the paper. Code "1" indicates the "premonitory" value, which appears more frequently in the proximity of a *FAU*.
- The last six columns correspond to the group of indicators indicated in caption to error diagram (slide 8). The number of a group in that table is given in the heading. Each column shows the number D of non-premonitory values, where "+" marks the months when D ≤ $\overline{D}$, that is, when the *FAU* alarm is diagnosed. Thresholds $\overline{D}$ are indicated in Table 3.
- Shaded lines show the moments of *FAU*s.

Dates	*IP*	*L*	*S*	1
'65:01	.	.	3	.
'65:02	.	.	3	.
'65:03	.	.	3	.
'65:04	.	.	3	.
'65:05	.	.	3	.
'65:06	.	.	3	.
'65:07	.	1	.	2	.
'65:08	.	.	3	.
'65:09	.	.	3	.
'65:10	.	.	3	.
'65:11	1	.	.	2	.
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'90:04	1	1	1	0	+
'90:05	**1**	**1**	**.**	**1**	**+**
'90:06	1	1	.	1	+
'90:07	1	1	.	1	+
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'90:09	1	1	.	1	+
'90:10	1	1	.	1	+
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'94:07	1	1	.	1	.
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'94:12	1	1	.	1	.
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'95:06	1	.	1	1	+
'95:07	.	.	1	2	+
'95:08	.	.	1	2	+
'95:09	**.**	**.**	**1**	**2**	**+**
'95:10	.	.	.	3	+
'95:11	.	.	.	3	+
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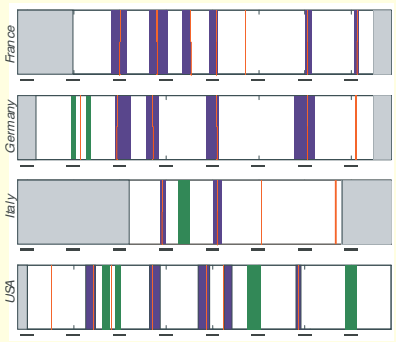
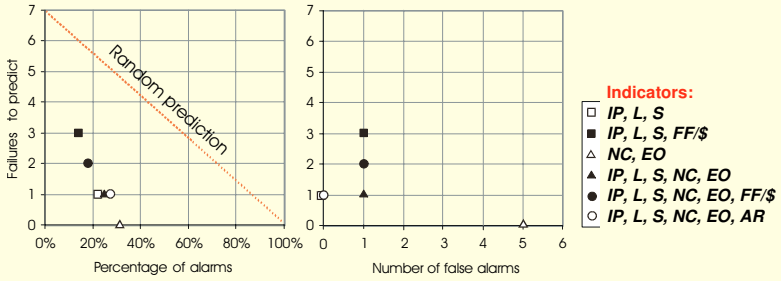
PREDICTION OF FAST ACCELERATION OF UNEMPLOYMENT ("FAU")



Precursor is the steep rise of three national macroeconomic indicators.
Red vertical lines - moments of FAU. Blue bars - periods of alarms.
Green bars - false alarms.
Gray areas on both sides - periods, for which the economic indicators were unavailable.



Error diagrams for predictions with various groups of indicators

WHAT IS THE PLACE OF OUR APPROACH IN RESEARCH IN THE PREDICTION OF UNEMPLOYMENT?

Our approach is complementary to *"cause and effect"* approach. The cause that triggered each *FAU* is usually known: a certain governmental decision, a change in international trade, rise of price of oil, etc. Accordingly, one might predict an imminent *FAU* when a triggering cause occurs.

That does not exclude predictability of *FAU*s with a longer lead time, as in this study. A *FAU* may be triggered only if and when the situation becomes "ripe" for a *FAU*; otherwise the government would not make that decision; unemployment would be less sensitive to international trade etc. If that conjecture is correct our approach can predict such a "ripe" situation.

DISCUSSION

1. We have found collective behavior patterns, transcending immense complexity of economy. They are applicable in very different conditions:
   (i) *Through the whole time period* considered (the last 40 yrs) despite extraordinary changes in labor market.
   (ii) *To the FAUs of different origin*. E.g., the *FAUs* in Europe reflect the cyclical fluctuations in the economy, in the U.S. they reflect the onset of a recession.
   (iii) *To different countries*: prediction algorithm, developed for France is applicable without readaptation to Germany, Italy, and the U.S.
2. *If* our results are correct, what do they tell us about the unemployment?
   (i) Heuristic constraints for macroeconomic models of unemployment.
   (ii) Diagnosis of situations, ripe for FAU. Only in such situations *FAU*s may be triggered in the short-term scale by usually known causes, such as the announcement of new economic regulations, an oil crisis, unfortunate decision, etc.
3. Unemployment has been traditionally associated with a decline in the economy. This relation becomes more complex and can even be reversed. A decrease of unemployment can be regarded as a threat of "inflation by wages". On the contrary, when a corporation announces massive layoffs of employees the price of its stock often increases, with the stock owners (especially the pension funds) considering the wage bill a fixed "cost".
   Small and medium businesses, by contrast, reduce unemployment.
4. Will our results become irrelevant due to some drastic change of the mechanisms controlling the fast acceleration of modern economy? Not necessarily, since the premonitory patterns considered here probably reflect some type of scenario of transition to critical phenomena

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