
DIRECCIÓN GENERAL DE ANÁLISIS MACROECONÓMICO
Y ECONOMÍA INTERNACIONAL
S.G. ANÁLISIS Y MODELIZACIÓN MACROECONÓMICA

# Business cycle indicators. Methods, applications, and limits.

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- Any views expressed herein are my own and not necessarily those of the Spanish Ministry of Economy and Finance.
- I owe Ana Abad and Juan Bógalo thanks for their help.

# OVERVIEW

- General objective of a system of cyclical indicators.
- A methodological proposal.
- Case study: Stock Index as leading indicator of Industrial Production.

# GENERAL OBJECTIVE
# What is the business cycle?

- Burns and Mitchell (1946):

  *Business cycles are a type of **fluctuation** found in the aggregate economic activity of nations that organize their work mainly in business enterprises: a cycle consists of **expansions** occurring at about the same time in **many economic activities**, followed by similarly general **recessions**, contractions, and revivals which merge into the expansion phase of the next cycle; in duration, business cycles **vary** from **more than one year to ten or twelve years**; they are not divisible into shorter cycles of similar characteristics with amplitudes approximating their own.*

# GENERAL OBJECTIVE
# Measuring the business cycle

- Amplitude: size of the fluctuations.
- Persistence: speed of mean-reversion.
- Diffusion: linkages across a vector of time series, static as well as dynamic.
- Others: asymmetry, specific role of turning points, second order turning points, etc. ➔ full anatomy of the business cycle, see Camacho et al. (2005).

# GENERAL OBJECTIVE

## What is not business cycle measurement:

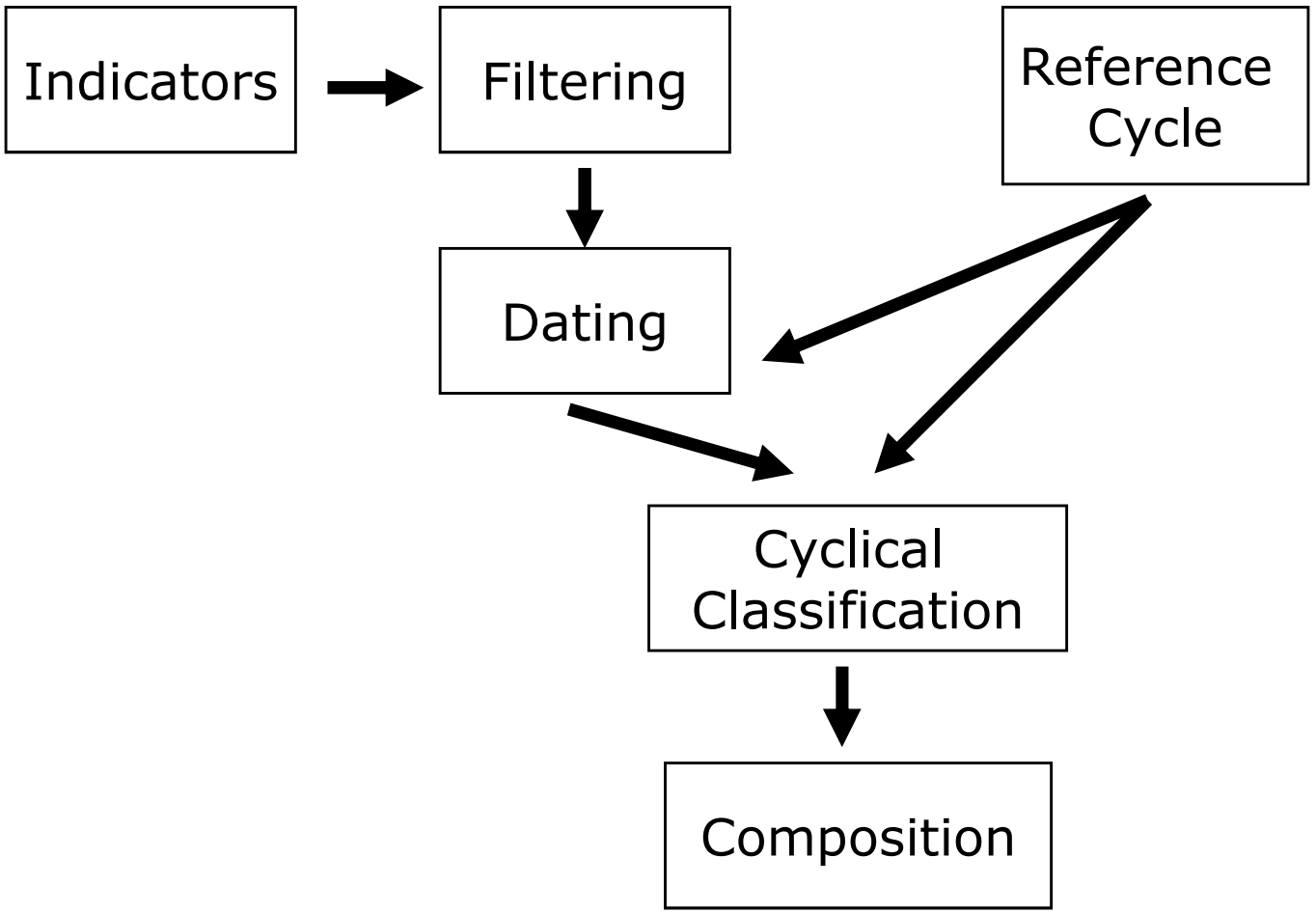
- Business cycle measurement is different from the measurement of the **levels** of economic activity according to a theoretical model (e.g., National Accounts).
- Business cycle measurement is not directly related to the quantification of the **growth** patterns of main economic aggregates (e.g., short-term economic activity indexes).
- Business cycle measurement is not **econometric** modeling (e.g., VAR or DSGE models).

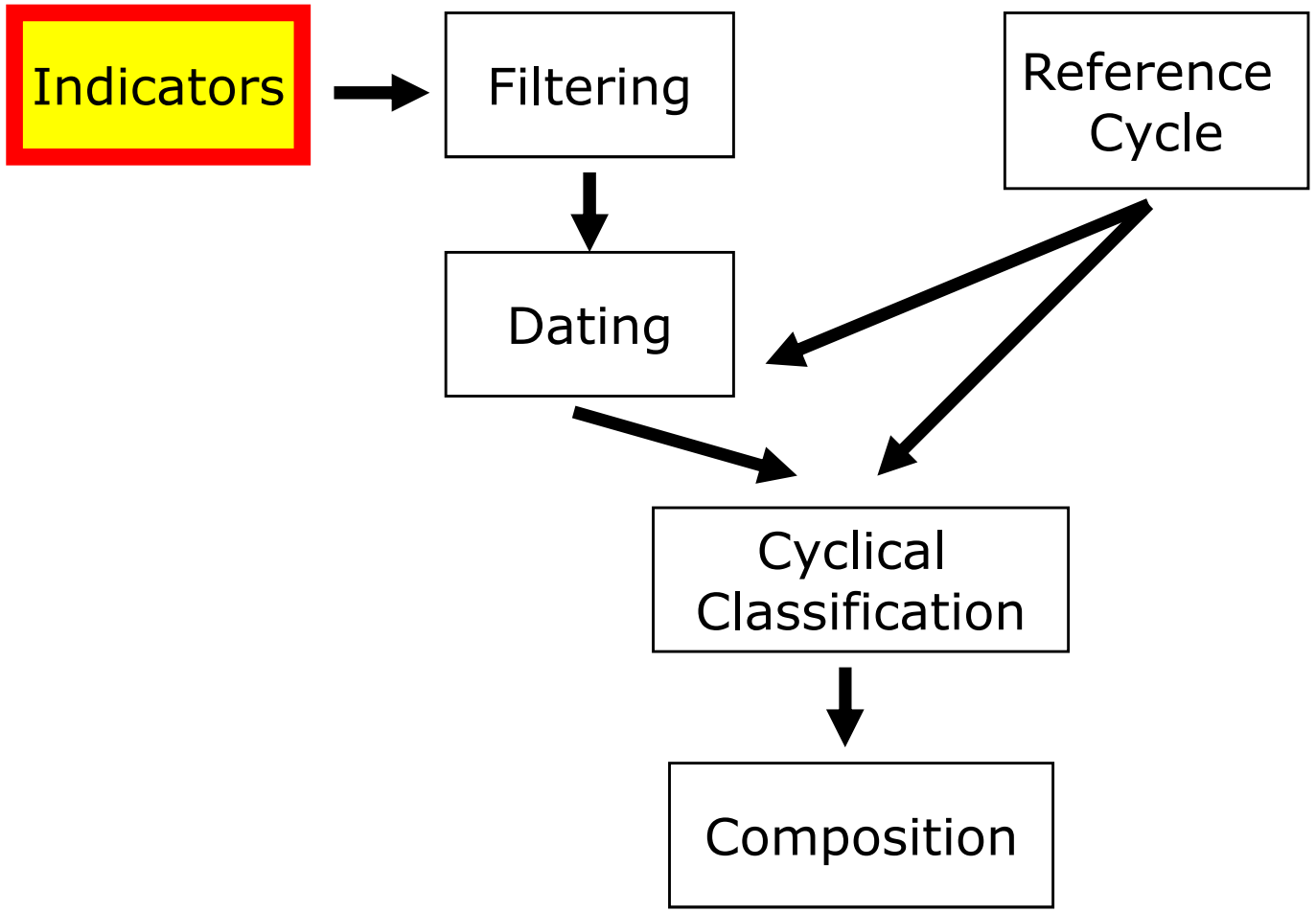
# GENERAL OBJECTIVE

## What is not business cycle measurement:

- But… take it easy:
  - National Accounts may play a role in a system of cyclical indicators, although the overlap should be small if we want to design truly independent measurement devices.
  - Growth filters (rates of growth) have some common features with cyclical filters (e.g., detrending).
  - Econometric techniques, specially dynamic factor models and BVAR models, have a clear quantitative function in business cycle analysis.

# GENERAL VIEW: Basic map



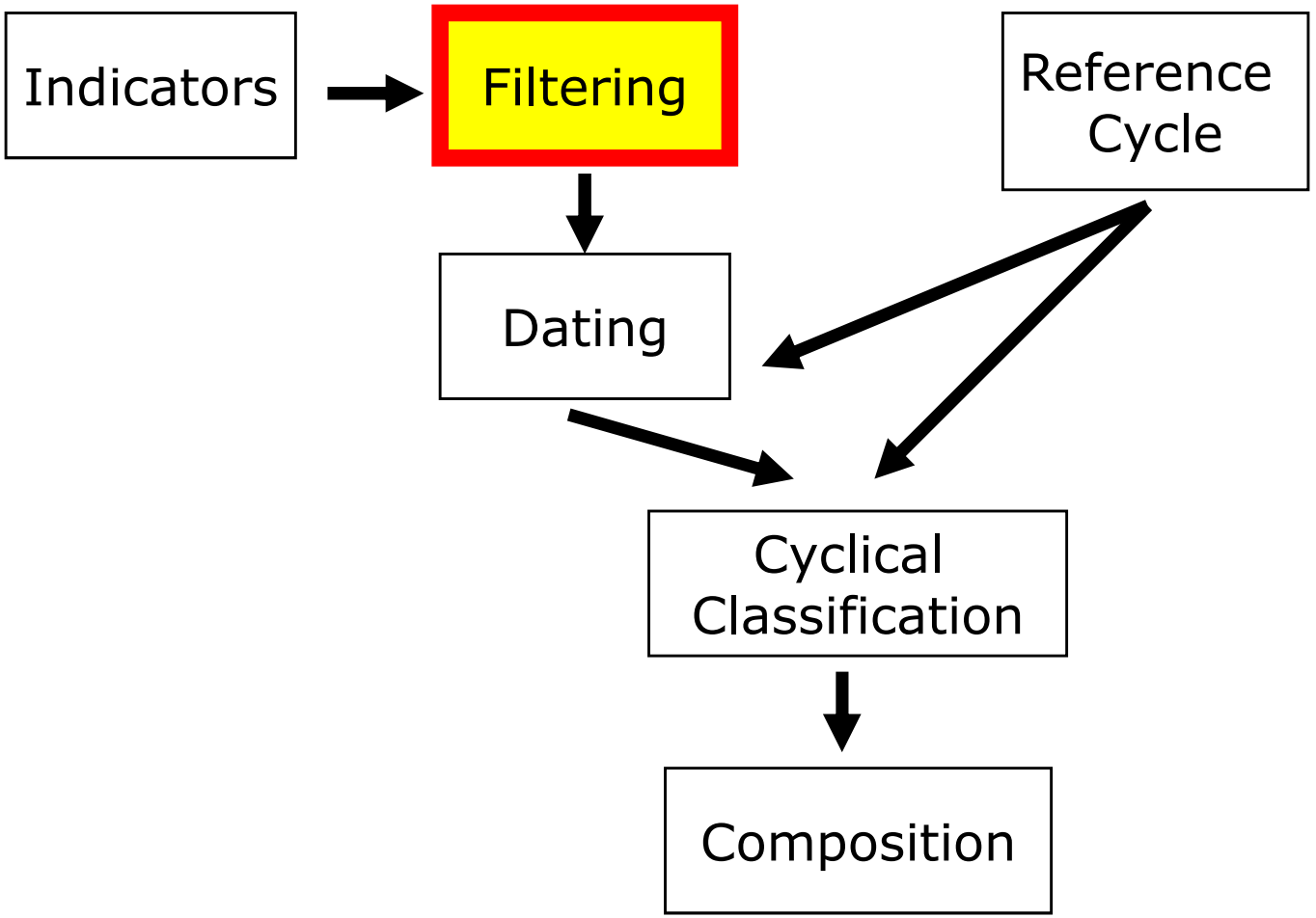

Indicators
Filtering
Reference Cycle
Dating
Cyclical Classification
Composition

# GENERAL RULES (Burns-Mitchell)

- Economic significance.
- Data quality.
- Timeliness.
- Cyclical stability.
- Small irregularity.
- Diversification of sources both across sectors (demand, supply, employment, etc.) and data suppliers.

# GENERAL RULES

- Use all the available information, from all available sources, and using all the available sample (data, data, and more data).
- Monthly data rather than quarterly data. Weekly or daily frequency even better.
- Do not impose a priori classifactions. Use loose definitions. Business cycle measurement is empirical by nature.
- Financial-monetary indicators should play an important role, due to their forward-looking nature. But do not overstate them (not all the cycles are linked to them!!).
- Administrative information (e.g., from the Tax Agency): cheap, timely, complete, reliable, and exhaustive, see Frutos (2007).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Overall strategy: see Kaiser & Maravall (2005)

STEP 1: $Z_t = P_t + S_t + I_t$

$P_t$: Trend-Cycle $S_t$: Seasonal $I_t$: Irregular

$$\hat{P}_t = V(B, F; \tilde{\phi}, \tilde{\theta}) Z_t$$

ARIMA Model Based filtering (TRAMO-SEATS):

- Data-driven decomposition.
- Allows forecasts to be used for signal stabilization purposes (at the end of the sample).

STEP 2:

$$P_t = T_t + C_t$$

$P_t$: Trend-Cycle $T_t$: Trend $C_t$: Cycle

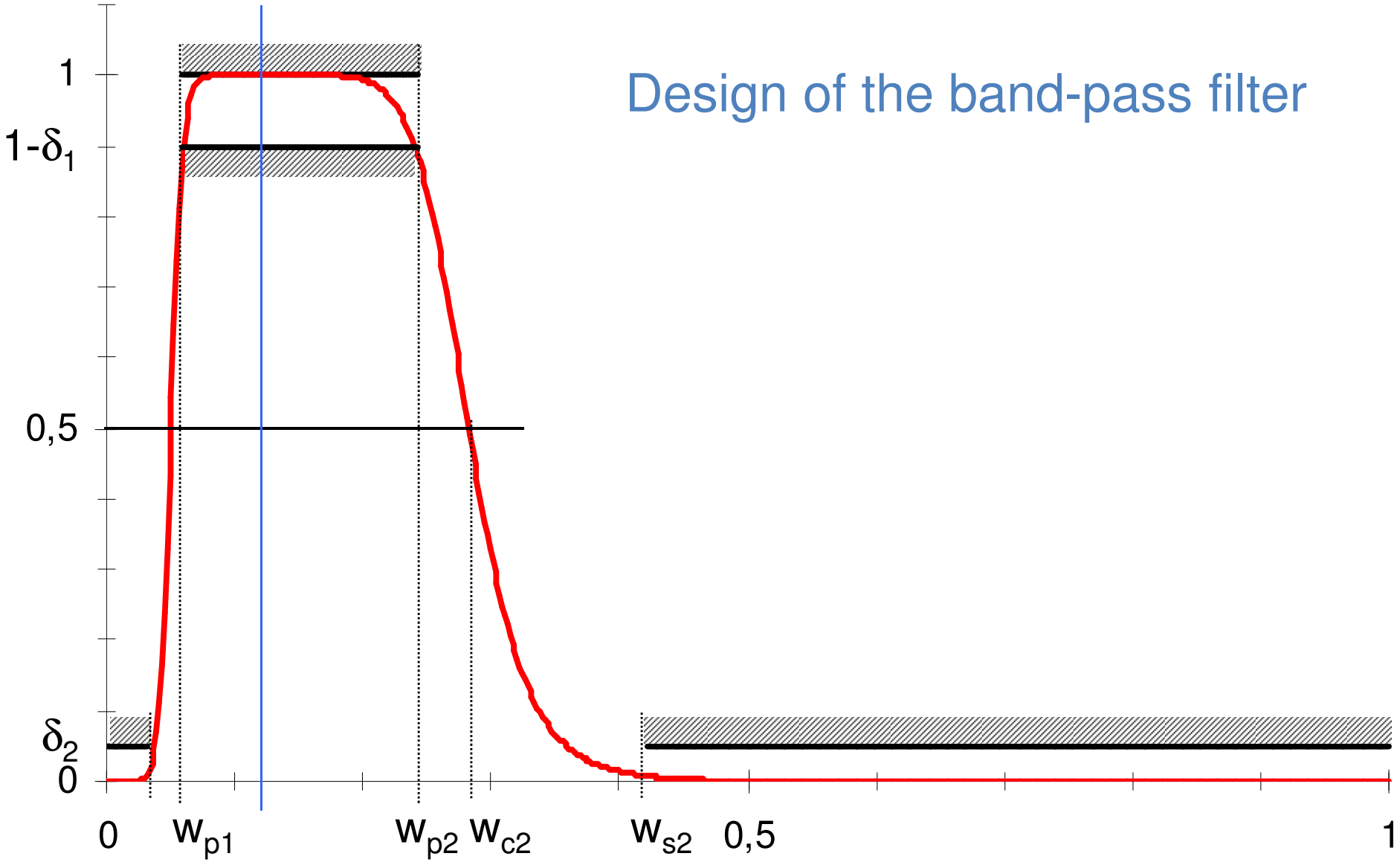
$$\hat{C}_t = H(B,F;\varphi)\hat{P}_t$$

- Band-pass filter, H(B,F) :
- Select information contained in a pre-specfied band.
- Derived from a low-pass, tangent-type Butterworth filter.

# CYCLICAL FILTERS

- Hodrick-Prescott (HP): implicit high-pass filter.
- Baxter-King: explicit band-pass filter, based on a moving average representation.
- Other: Christiano-Fitzgerald, Chebychev, etc.
- Our favorite filter: Butterworth:
  - Explicitly band-pass.
  - ARMA form: more parsimonious and simple than pure AR or MA filters.
  - Very flexible.
  - Include HP as a particular case.
  - Robust from input definition: applicable on trend-cycle signals or on seasonally adjusted data providing similar results.

# Design of the band-pass filter



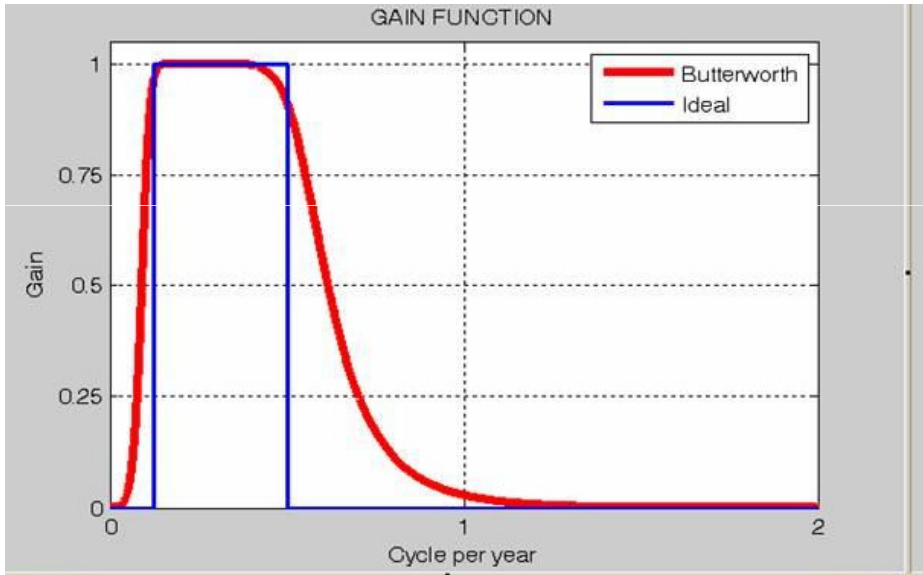
# Design of the band-pass filter

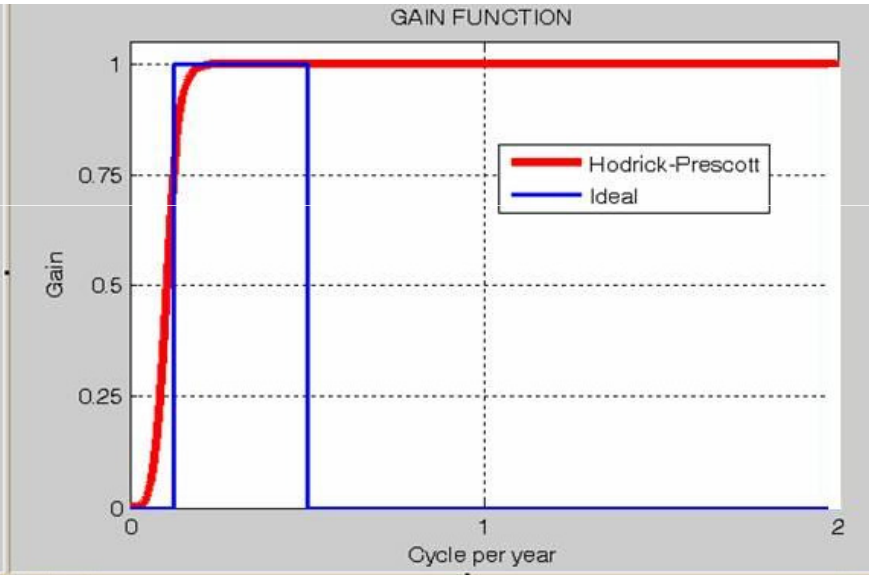
- Cyclical band: $[\mathbf{w_{p1}}, \mathbf{w_{p2}}]$ (2-8 years)
- Rejection band: $[0, w_{s1}] \cup [\mathbf{w_{s2}}, \pi]$
- $0 < w_{s1} < w_{p1} < w_{p2} < w_{s2} < \pi$
- Set: $w_p = w_{p2} - w_{p1}$ ; $w_s = w_{s2} - w_{p1}$
- Set tolerances $\delta_1$ and $\delta_2$.
- The band-pass filter is designed as a function of $\mathbf{w_p}$ , $\mathbf{w_s}$ , $\delta_1$ and $\delta_2$ ➔ $\varphi$ parameters.

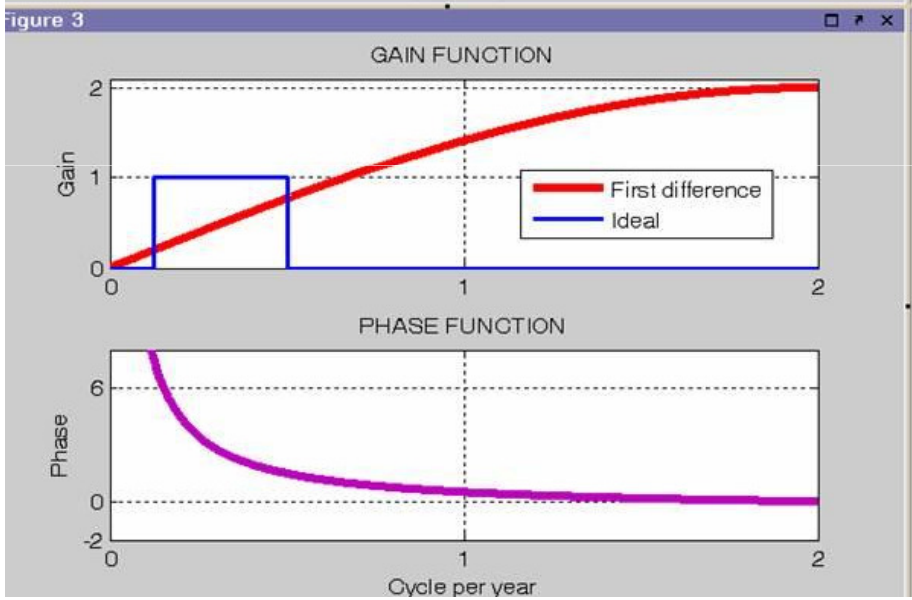
# Design of the band-pass filter: φ

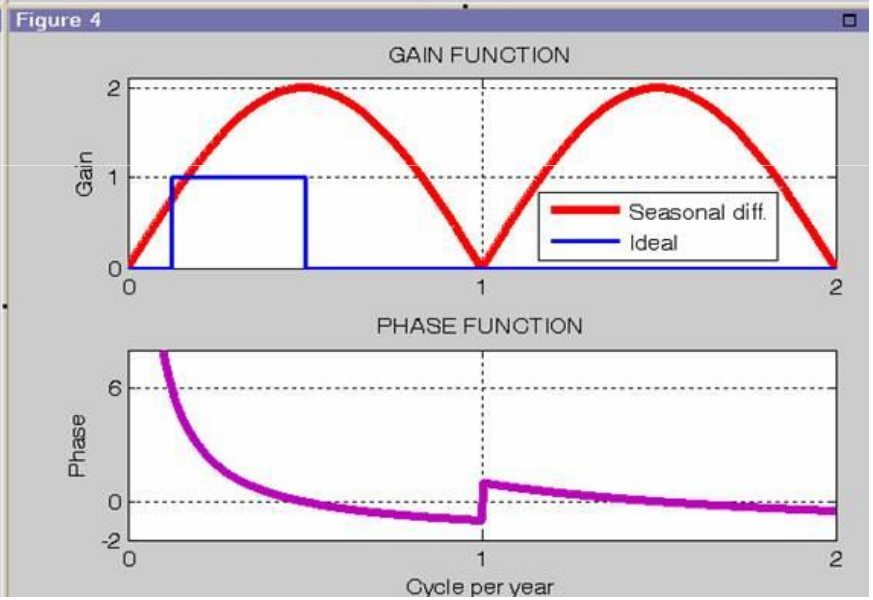
- Cyclical band: $[0.060\pi , 0.240\pi ]$ (2-8 years)
- Rejection band: $[0 , 0.034\pi ] \cup [0.420\pi , \pi ]$
- $\delta_1 = 0.10$
- $\delta_2 = 0.01$
- d = 5

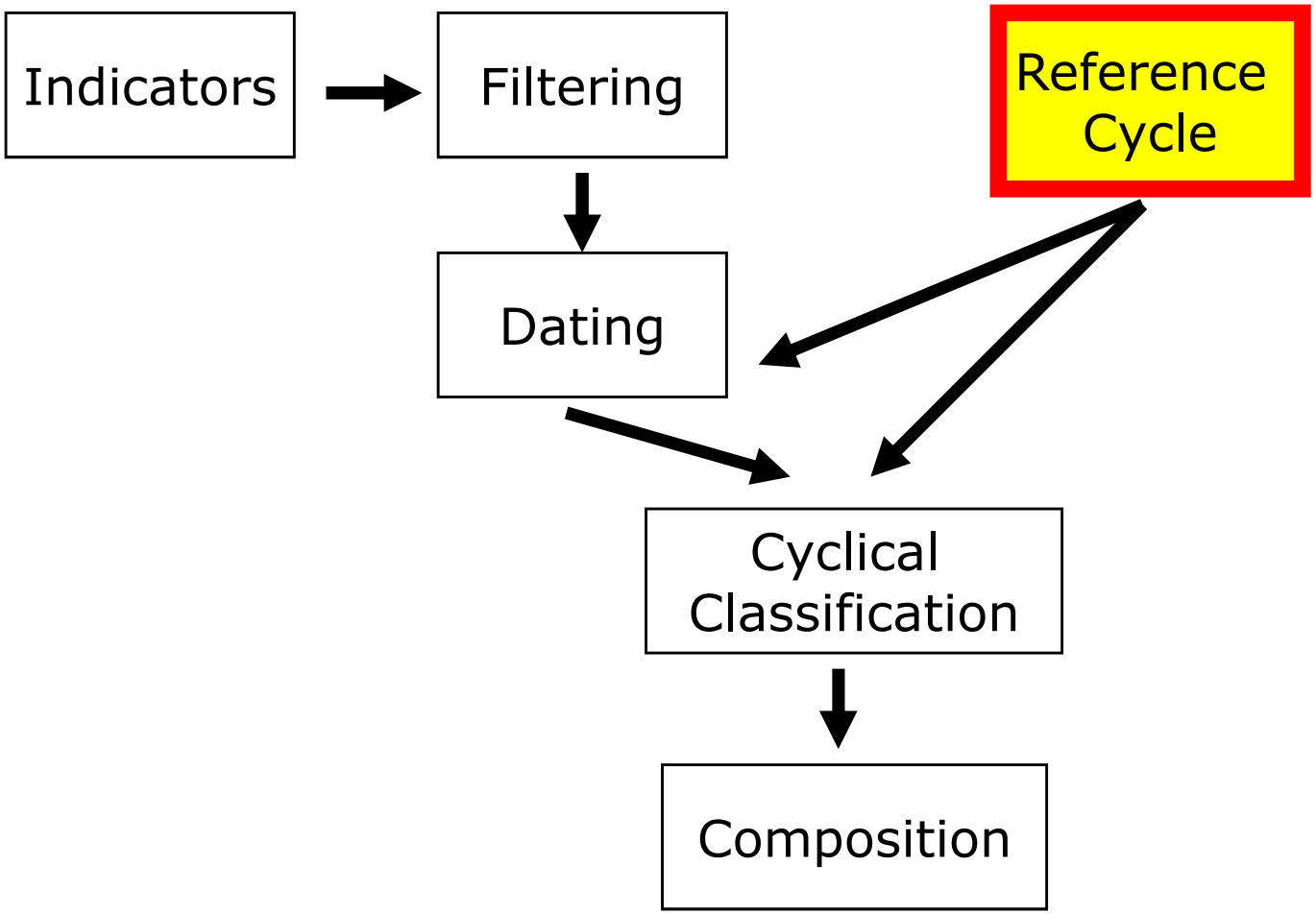
# Alternative filters




Indicators
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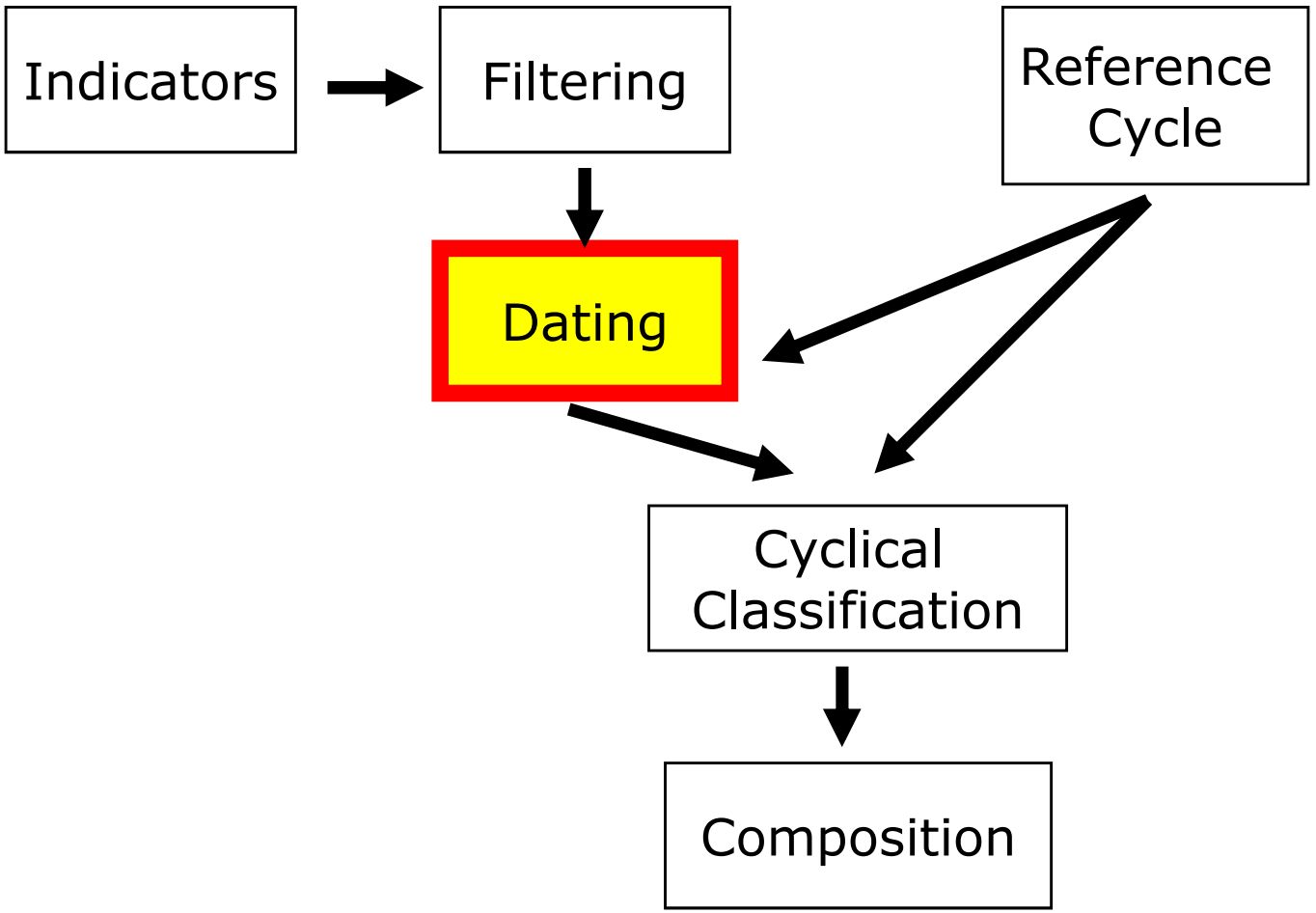
# REFERENCE CYCLE

- Usually: an exogenous indicator provided by the analyst and/or by substantive considerations.
- It should accomplish the general rules of the basis indicators plus a general economic significance.
- The natural choice: monthly indexes of economic activity, designed using dynamic factor analysis techniques.
- Careful use of QNA data: the unavoidable combination of chain-linking, seasonal adjustment, temporal constraints, and cross-section constraints has important dynamic effects on their own, which do not enhance business cycle analysis, Abad et al. (2009).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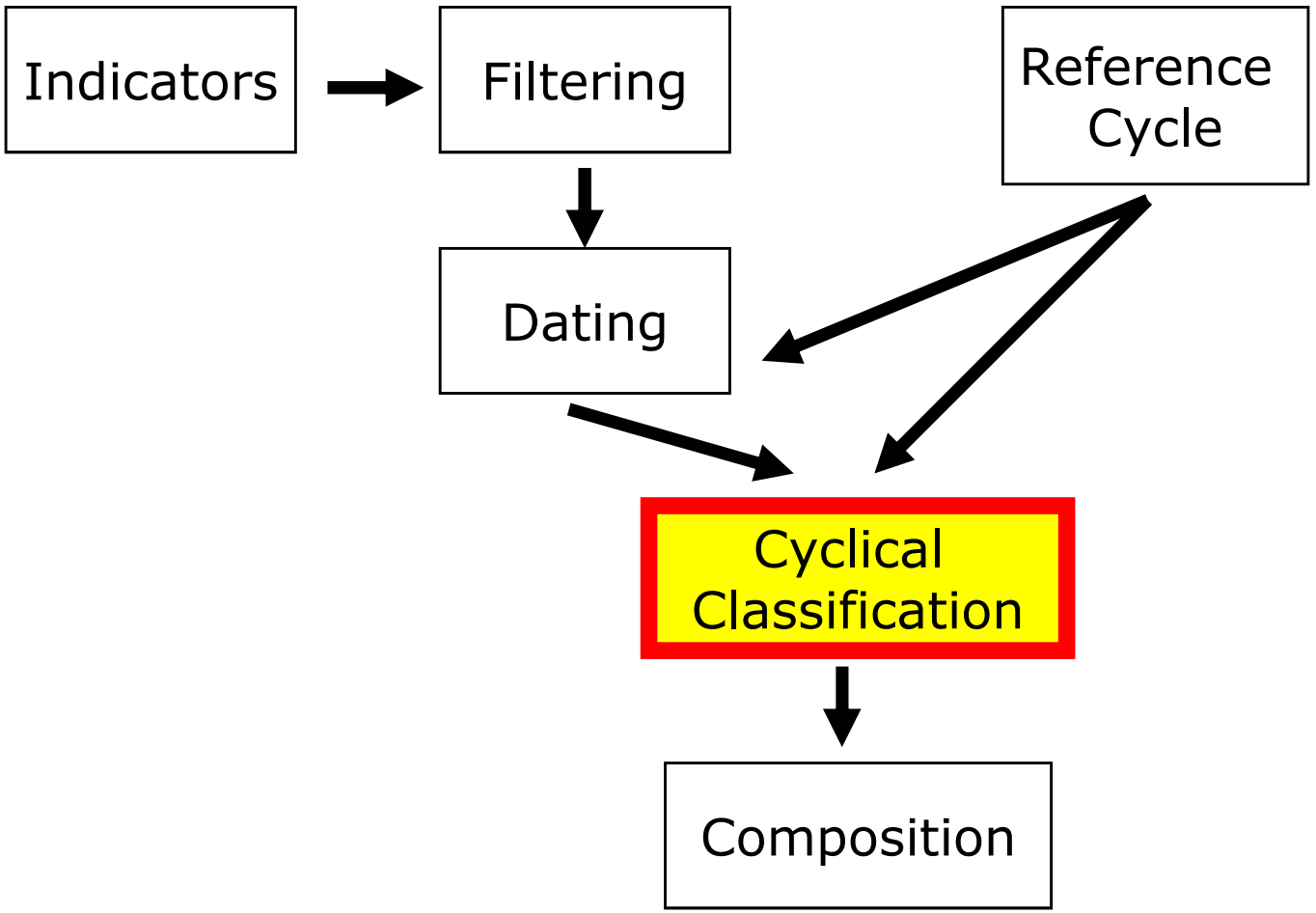
# DATING

- Identification of turning points: special observations chaterized by the transition from an upward phase to an downward phase (peaks) or viceversa (troughs).
- May be done by means of empiricist, non-parametric methods (e.g. Bry-Boschan approach) ➔ simple, robust, reasonable. Drawback: inference is almost impossible. Turning points are considered exogenous (a label).
- Model-based methods (e.g., MS-AR) are an interesting alternative than considers turning points as intrinsic features of the business cycle. Drawback: more complex procedures, not well suited to the filtered series provided by band-pass filters.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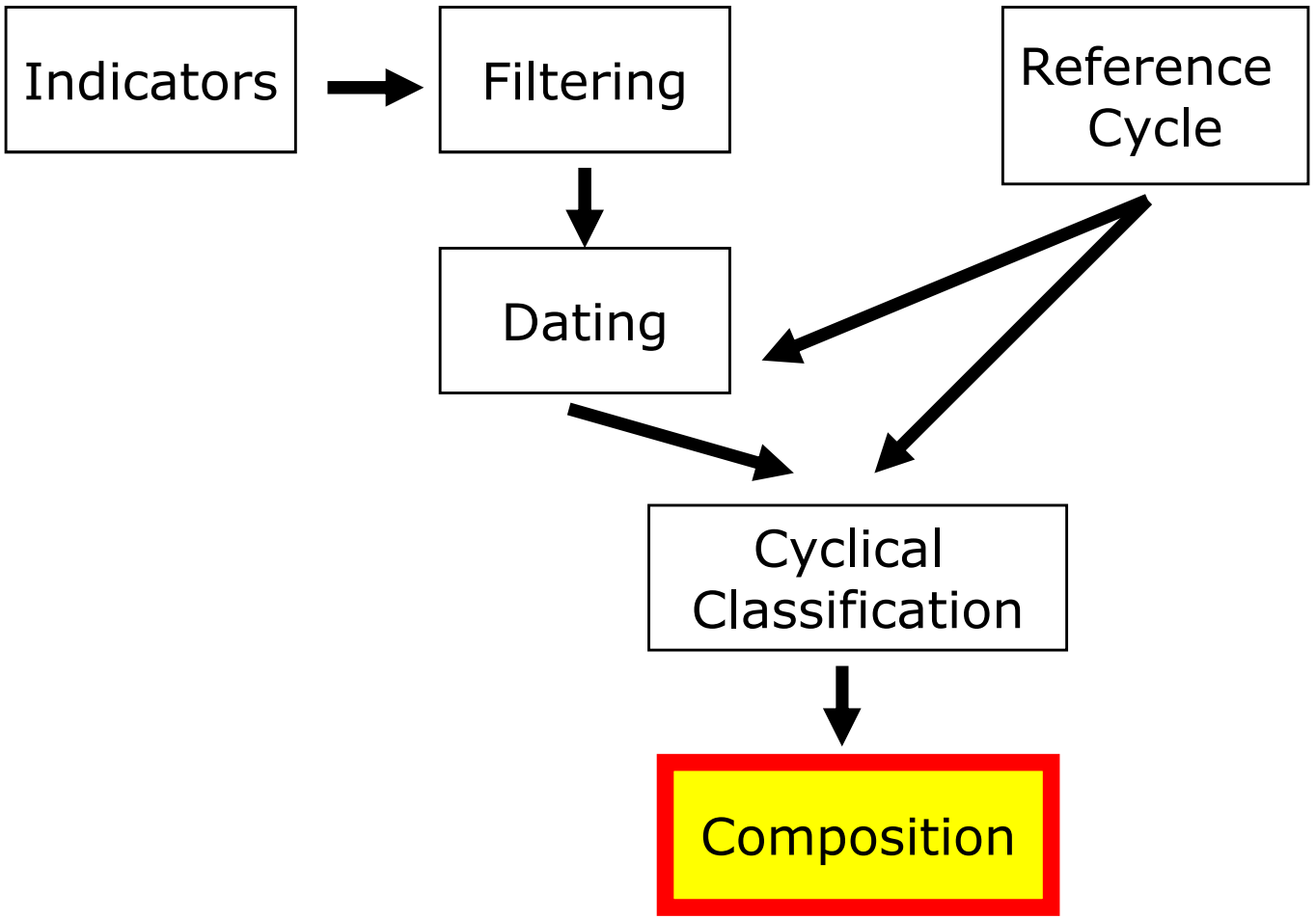
# CYCLICAL CLASSIFICATION

- Check lead/coincident/lagged or acyclical patterns by means of:
  - Cross correlation function.
  - Delays among turning points.
  - Spectral methods: coherence and phase.
  - Transfer function models.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# COMPOSITION

- Synthetic indexes can be built by means of:
  - Factor analysis.
  - Weigths proportional to correlation with the reference series.
  - Regression analysis.

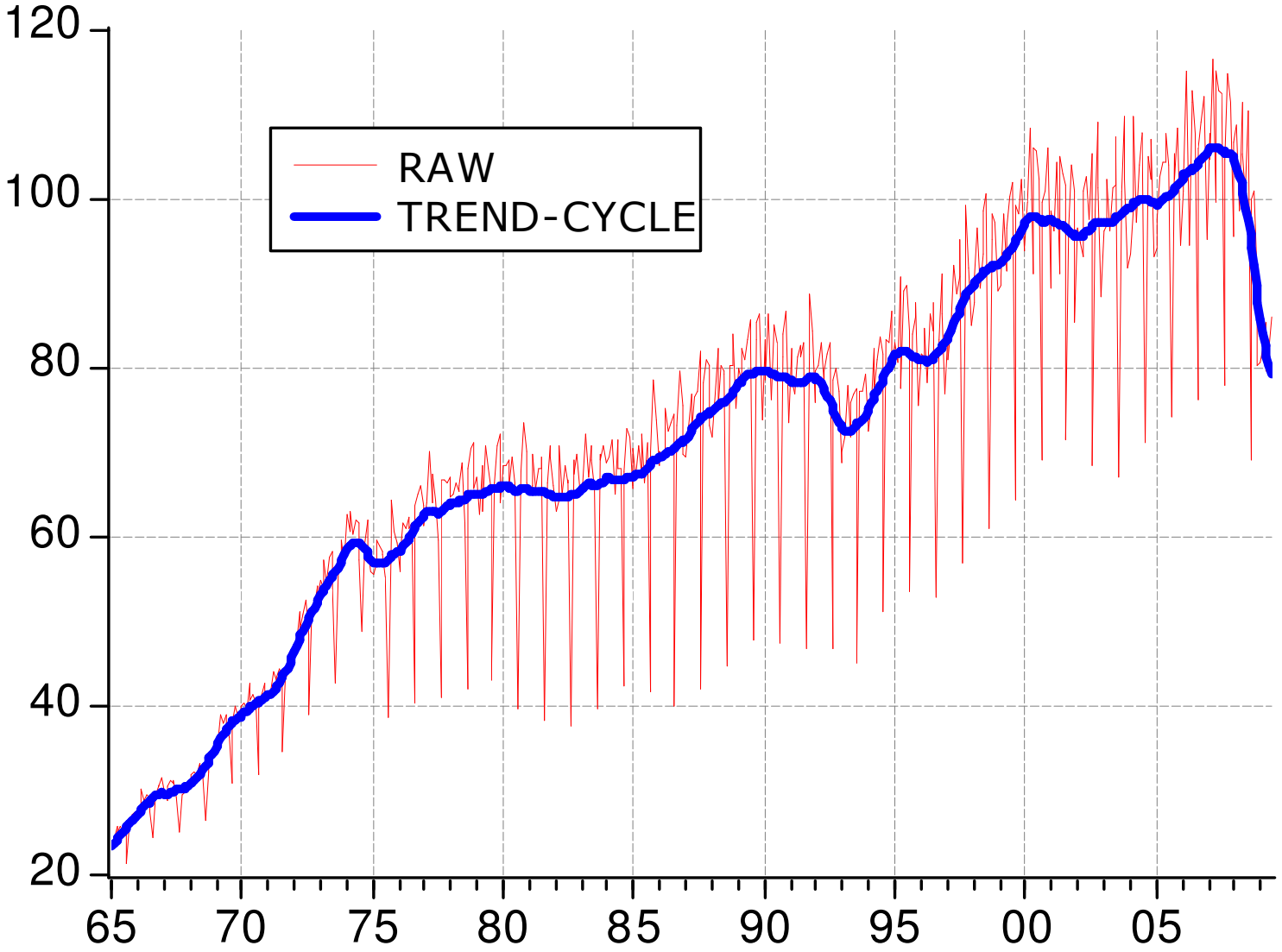
# APPLICATION

- Reference series: Spanish Index of Industrial Production ($IIP_t$).
- Indicator: Madrid Stock Exchange General Index ($Stock_t$).
- Sample: 1965.01 – 2009.06

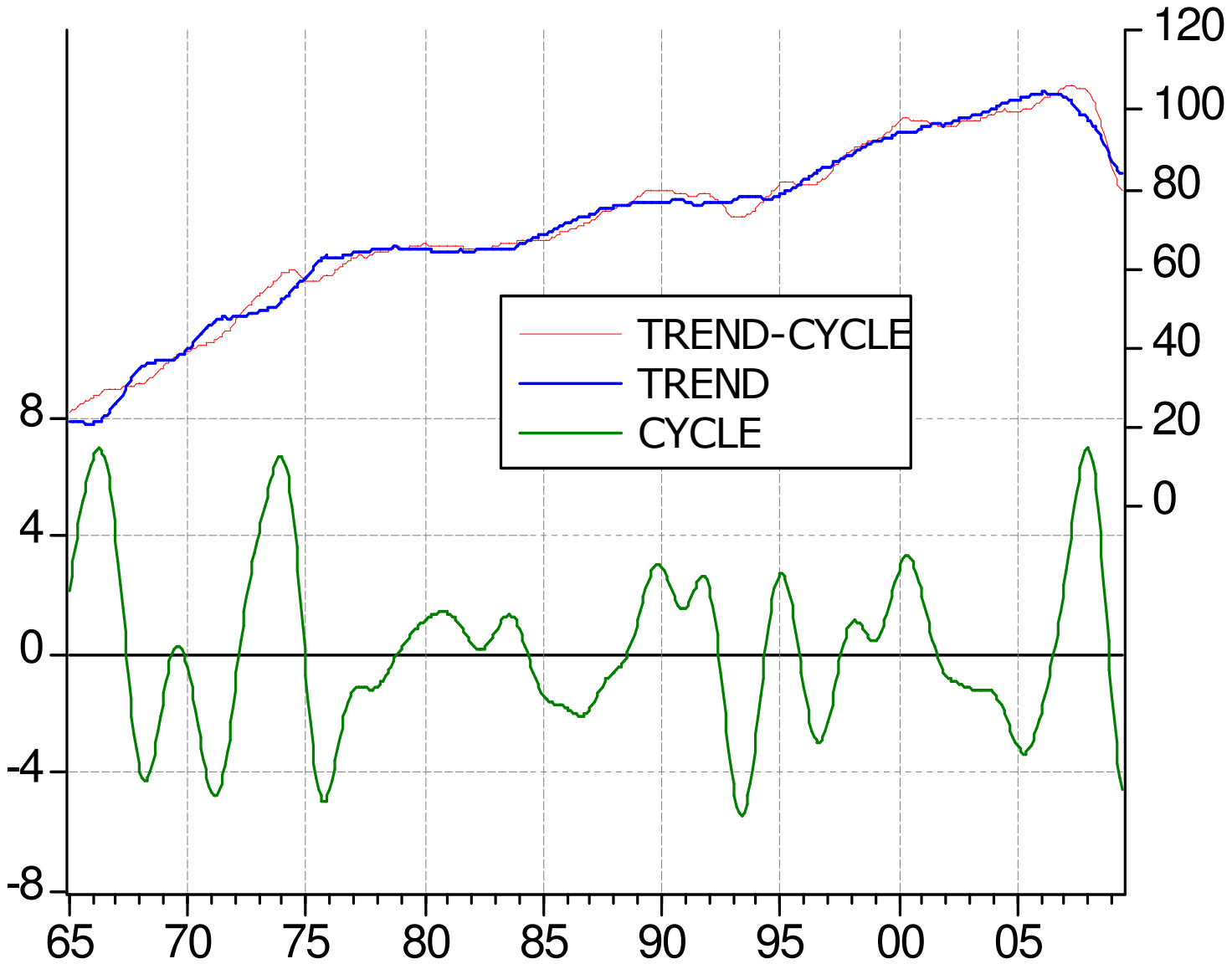
# APPLICATION: Software

- Seasonal adjustment: TRAMO-SEATS (TSW).
- Cycle estimation: MATLAB.
- Turning points dating and classification: <F> and <G>.
- Cross-correlation analysis and spectral analysis: SCA.

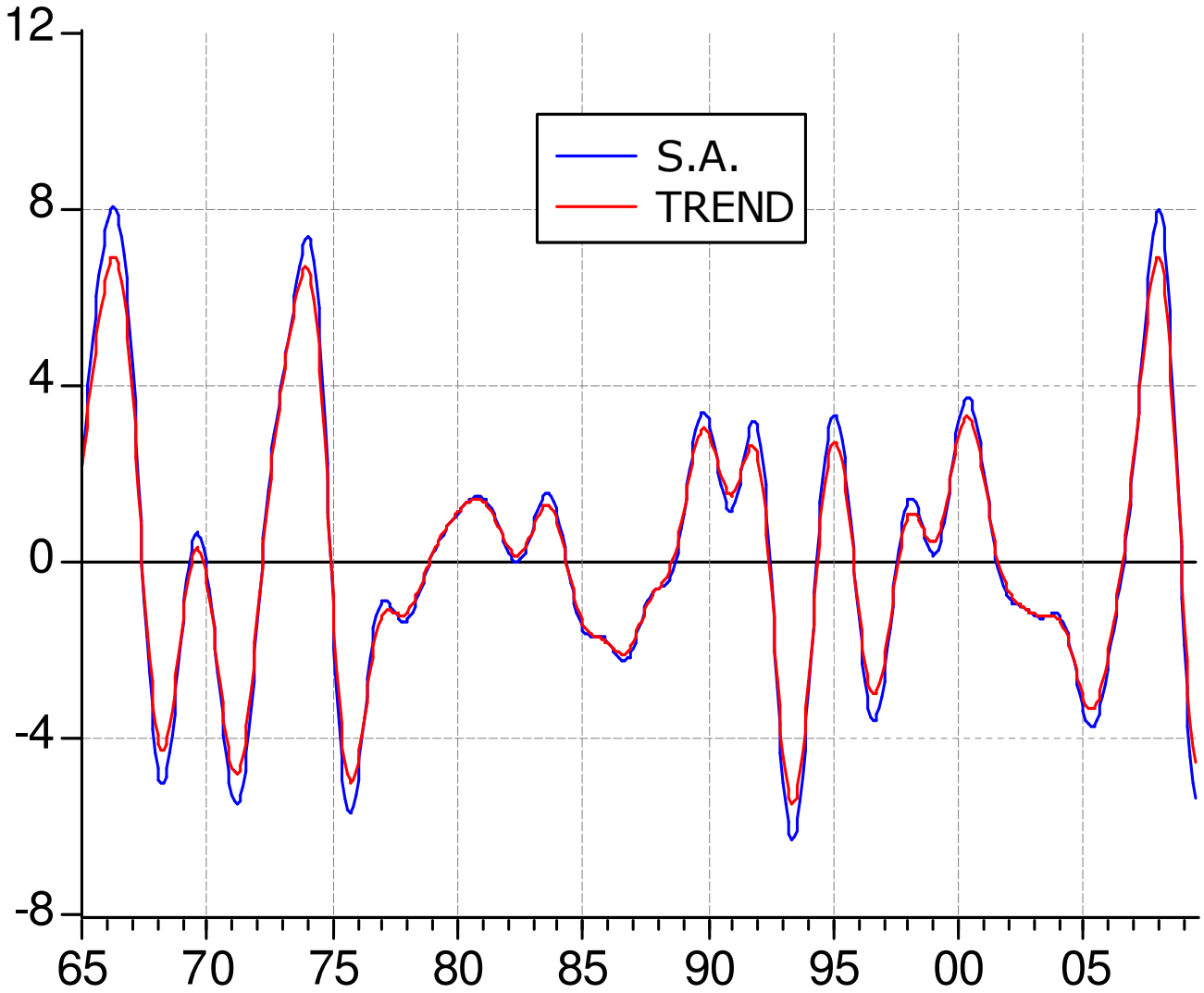
# IIP: First stage decomposition



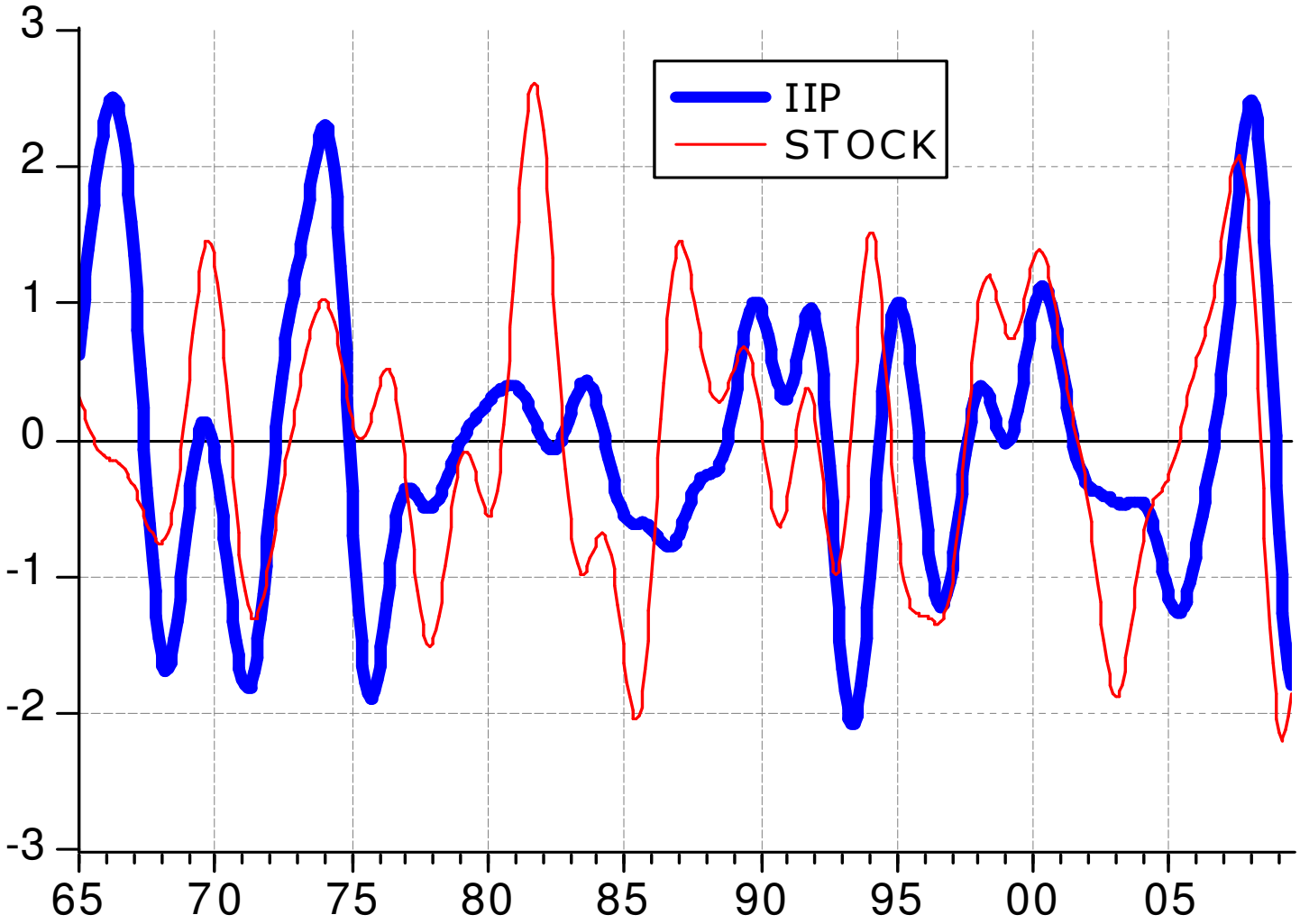
# IIP: Second stage decomposition



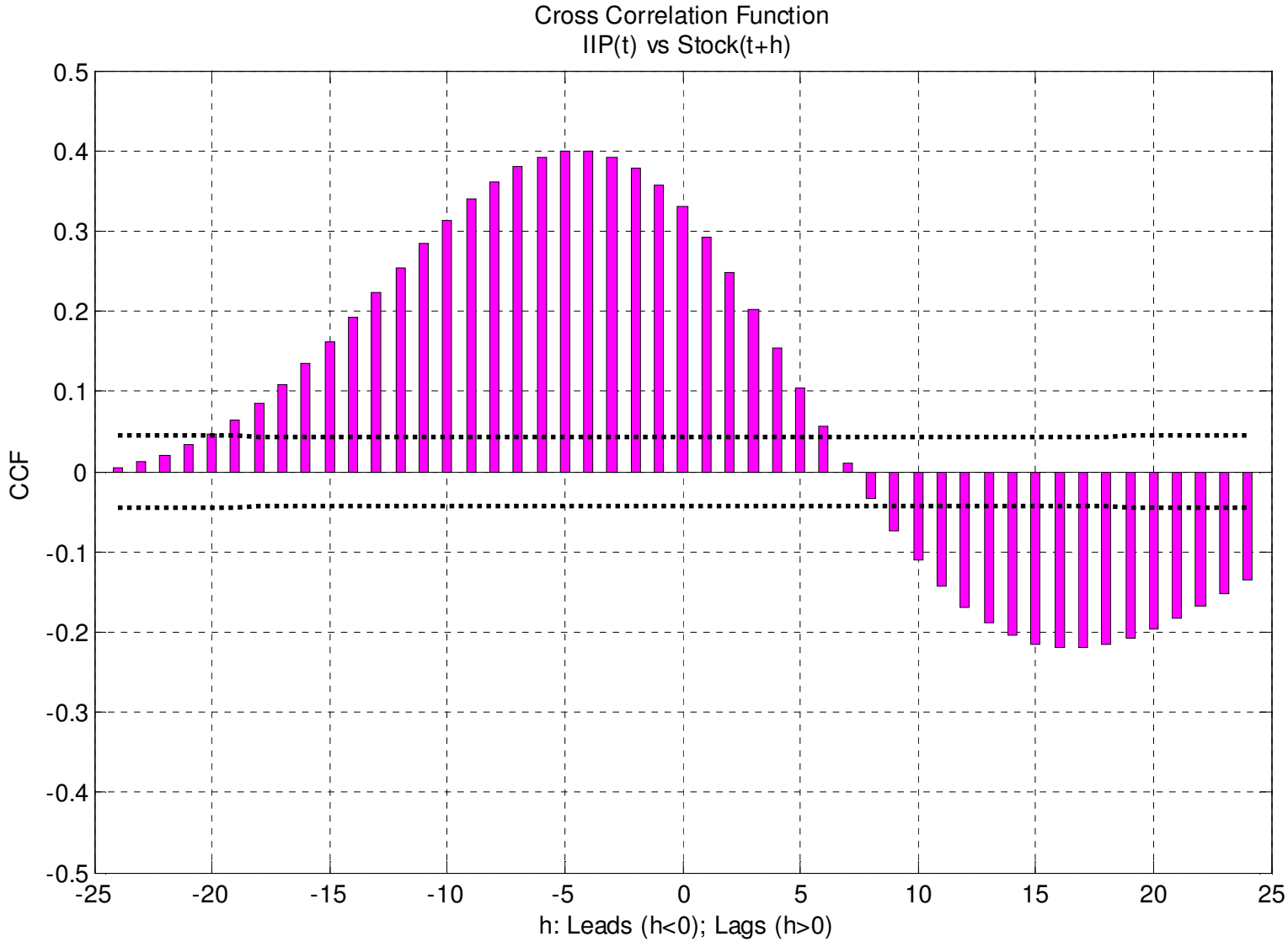
# IIP: Alternative cycle estimation



# IIP and STOCK (standardized)



# IIP and STOCK: CCF



# IIP and STOCK: CCF

- STOCK is weakly procyclical with respect to IIP.
- STOCK leads 5 months IIP.

# IIP: Turning points

DATING OF THE SERIES ---> IIP Spain
FINAL TURNING POINTS

| OBS. | DATE | TYPE | CS |
|---|---|---|---|
| 16 | 1966. 4 | 1 | 8.0600 |
| 39 | 1968. 3 | -1 | -5.0300 |
| 56 | 1969. 8 | 1 | 0.6700 |
| 75 | 1971. 3 | -1 | -5.4500 |
| 109 | 1974. 1 | 1 | 7.4100 |
| 129 | 1975. 9 | -1 | -5.7000 |
| 190 | 1980.10 | 1 | 1.4800 |
| 209 | 1982. 5 | -1 | -0.0100 |
| 224 | 1983. 8 | 1 | 1.5900 |
| 260 | 1986. 8 | -1 | -2.2300 |
| 299 | 1989.11 | 1 | 3.4000 |
| 311 | 1990.11 | -1 | 1.1700 |
| 323 | 1991.11 | 1 | 3.2200 |
| 341 | 1993. 5 | -1 | -6.2600 |
| 361 | 1995. 1 | 1 | 3.3500 |
| 380 | 1996. 8 | -1 | -3.5700 |
| 398 | 1998. 2 | 1 | 1.4600 |
| 409 | 1999. 1 | -1 | 0.1700 |
| 425 | 2000. 5 | 1 | 3.7500 |
| 485 | 2005. 5 | -1 | -3.7400 |
| 517 | 2008. 1 | 1 | 7.9800 |

Final number of peaks = 11
Final number of troughs = 10
Time interval ---> 1965.01 - 2009.06
Number of observations ---> 534

# IIP: Turning points

ANALYSIS OF THE DATING OF ---> IIP Spain

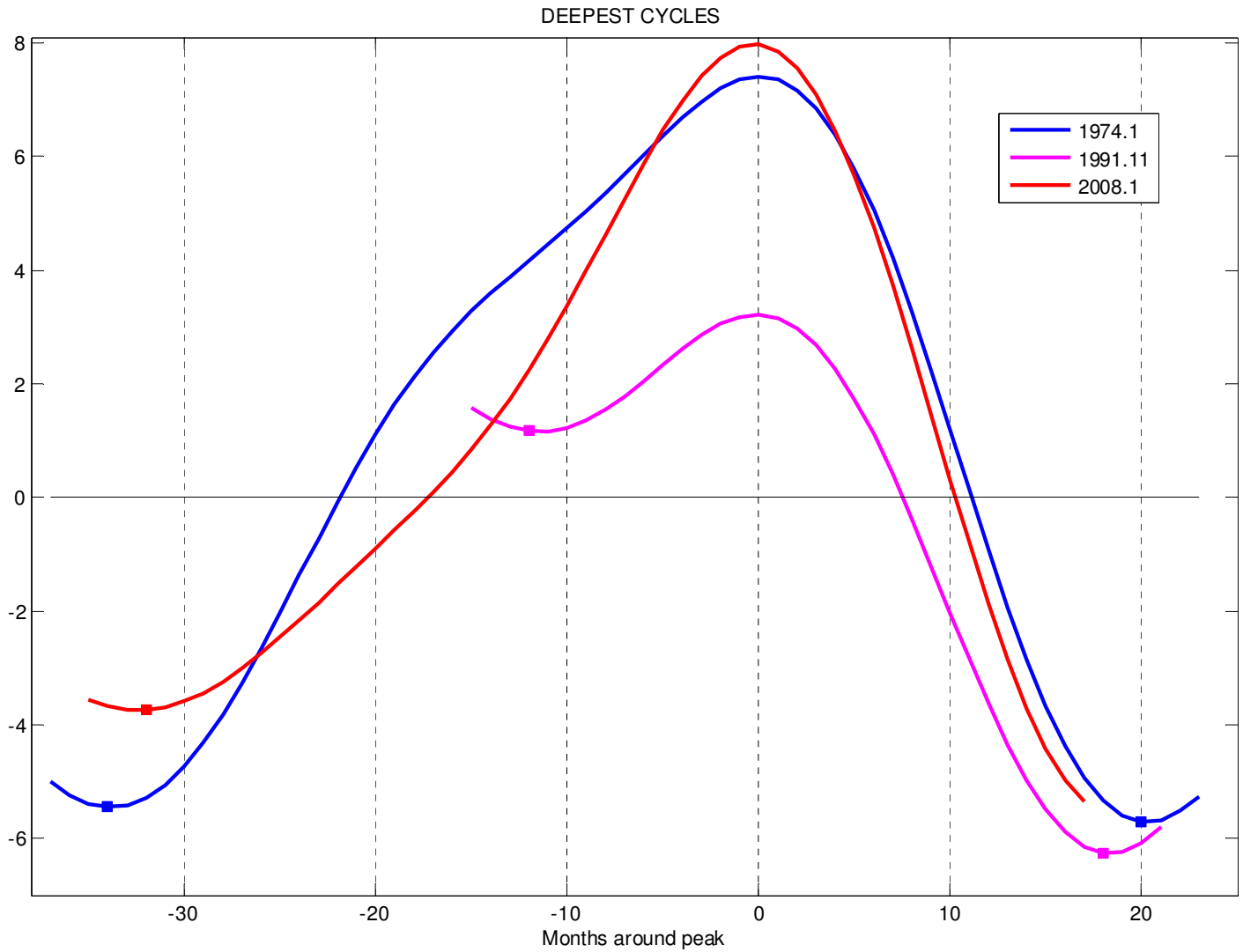
| DATE | | DURATION | | | AMPLITUDE | | STRENGTH | | ASYMMETRY | |
|---|---|---|---|---|---|---|---|---|---|---|
| PEAK | TROUGH | PEAK | TROUGH | CYCLE | PEAK | TROUGH | PEAK | TROUGH | DURATION | AMPLITUDE |
| 1966.04 | 1968.03 | - | 23.00 | - | - | 13.09 | - | 0.57 | - | - |
| 1969.08 | 1971.03 | 17.00 | 19.00 | 36.00 | 5.70 | 6.12 | 0.34 | 0.32 | 0.89 | 0.93 |
| 1974.01 | 1975.09 | 34.00 | 20.00 | 54.00 | 12.86 | 13.11 | 0.38 | 0.66 | 1.70 | 0.98 |
| 1980.10 | 1982.05 | 61.00 | 19.00 | 80.00 | 7.18 | 1.49 | 0.12 | 0.08 | 3.21 | 4.82 |
| 1983.08 | 1986.08 | 15.00 | 36.00 | 51.00 | 1.60 | 3.82 | 0.11 | 0.11 | 0.42 | 0.42 |
| 1989.11 | 1990.11 | 39.00 | 12.00 | 51.00 | 5.63 | 2.23 | 0.14 | 0.19 | 3.25 | 2.52 |
| 1991.11 | 1993.05 | 12.00 | 18.00 | 30.00 | 2.05 | 9.48 | 0.17 | 0.53 | 0.67 | 0.22 |
| 1995.01 | 1996.08 | 20.00 | 19.00 | 39.00 | 9.61 | 6.92 | 0.48 | 0.36 | 1.05 | 1.39 |
| 1998.02 | 1999.01 | 18.00 | 11.00 | 29.00 | 5.03 | 1.29 | 0.28 | 0.12 | 1.64 | 3.90 |
| 2000.05 | 2005.05 | 16.00 | 60.00 | 76.00 | 3.58 | 7.49 | 0.22 | 0.12 | 0.27 | 0.48 |
| 2008.01 | - | 32.00 | - | - | 11.72 | - | 0.37 | - | - | - |
| MEDIAN | | 19.00 | 19.00 | 51.00 | 5.66 | 6.52 | 0.25 | 0.25 | 1.05 | 0.98 |

Number of peaks ---> 11
Number of troughs ---> 10
Total number of turning points ---> 21

Smoothness index ---> 0.9545

Time interval ---> 1965.01 - 2009.06
Number of observations ---> 534

# IIP: Deepest cycles



# STOCK: Turning points

DATING OF THE SERIES ---> Stock Index
FINAL TURNING POINTS

| OBS. | DATE | TYPE | CS |
|---|---|---|---|
| 37 | 1968. 1 | -1 | -10.3600 |
| 58 | 1969.10 | 1 | 19.6300 |
| 78 | 1971. 6 | -1 | -18.0000 |
| 109 | 1974. 1 | 1 | 13.7300 |
| 125 | 1975. 5 | -1 | -0.1000 |
| 137 | 1976. 5 | 1 | 6.8800 |
| 155 | 1977.11 | -1 | -20.5300 |
| 171 | 1979. 3 | 1 | -1.2200 |
| 181 | 1980. 1 | -1 | -7.7000 |
| 201 | 1981. 9 | 1 | 35.2700 |
| 246 | 1985. 6 | -1 | -27.8400 |
| 266 | 1987. 2 | 1 | 19.5900 |
| 282 | 1988. 6 | -1 | 3.6500 |
| 294 | 1989. 6 | 1 | 9.0700 |
| 309 | 1990. 9 | -1 | -8.7900 |
| 321 | 1991. 9 | 1 | 5.0500 |
| 334 | 1992.10 | -1 | -13.5900 |
| 349 | 1994. 1 | 1 | 20.4800 |
| 379 | 1996. 7 | -1 | -18.3300 |
| 401 | 1998. 5 | 1 | 16.1700 |
| 411 | 1999. 3 | -1 | 9.8500 |
| 424 | 2000. 4 | 1 | 18.7300 |
| 457 | 2003. 1 | -1 | -25.6100 |
| 511 | 2007. 7 | 1 | 27.9900 |
| 530 | 2009. 2 | -1 | -29.8800 |

Final number of peaks = 12
Final number of troughs = 13
Time interval ---> 1965.01 - 2009.06
Number of observations ---> 534

# STOCK: Turning points

ANALYSIS OF THE DATING OF ---> Stock Index

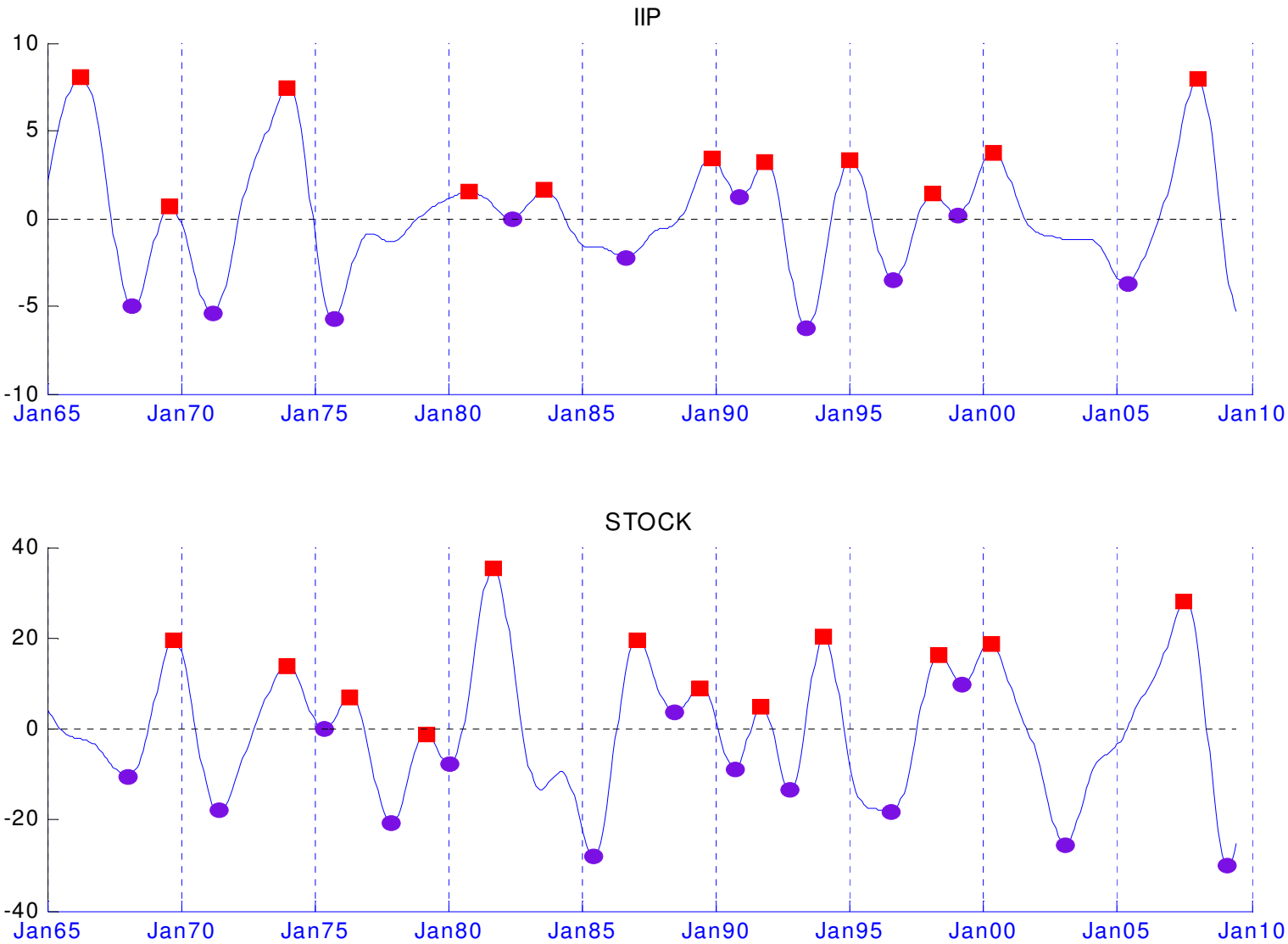
| DATE | | DURATION | | | AMPLITUDE | | STRENGTH | | ASYMMETRY | |
|---|---|---|---|---|---|---|---|---|---|---|
| PEAK | TROUGH | PEAK | TROUGH | CYCLE | PEAK | TROUGH | PEAK | TROUGH | DURATION | AMPLITUDE |
| - | 1968.01 | - | - | - | - | - | - | - | - | - |
| 1969.10 | 1971.06 | 21.00 | 20.00 | 41.00 | 29.99 | 37.63 | 1.43 | 1.88 | 1.05 | 0.80 |
| 1974.01 | 1975.05 | 31.00 | 16.00 | 47.00 | 31.73 | 13.83 | 1.02 | 0.86 | 1.94 | 2.29 |
| 1976.05 | 1977.11 | 12.00 | 18.00 | 30.00 | 6.98 | 27.41 | 0.58 | 1.52 | 0.67 | 0.25 |
| 1979.03 | 1980.01 | 16.00 | 10.00 | 26.00 | 19.31 | 6.48 | 1.21 | 0.65 | 1.60 | 2.98 |
| 1981.09 | 1985.06 | 20.00 | 45.00 | 65.00 | 42.97 | 63.11 | 2.15 | 1.40 | 0.44 | 0.68 |
| 1987.02 | 1988.06 | 20.00 | 16.00 | 36.00 | 47.43 | 15.94 | 2.37 | 1.00 | 1.25 | 2.98 |
| 1989.06 | 1990.09 | 12.00 | 15.00 | 27.00 | 5.42 | 17.86 | 0.45 | 1.19 | 0.80 | 0.30 |
| 1991.09 | 1992.10 | 12.00 | 13.00 | 25.00 | 13.84 | 18.64 | 1.15 | 1.43 | 0.92 | 0.74 |
| 1994.01 | 1996.07 | 15.00 | 30.00 | 45.00 | 34.07 | 38.81 | 2.27 | 1.29 | 0.50 | 0.88 |
| 1998.05 | 1999.03 | 22.00 | 10.00 | 32.00 | 34.50 | 6.32 | 1.57 | 0.63 | 2.20 | 5.46 |
| 2000.04 | 2003.01 | 13.00 | 33.00 | 46.00 | 8.88 | 44.34 | 0.68 | 1.34 | 0.39 | 0.20 |
| 2007.07 | 2009.02 | 54.00 | 19.00 | 73.00 | 53.60 | 57.87 | 0.99 | 3.05 | 2.84 | 0.93 |
| MEDIAN | | 18.00 | 17.00 | 38.50 | 30.86 | 23.02 | 1.18 | 1.32 | 0.99 | 0.84 |

Number of peaks ---> 12
Number of troughs ---> 13
Total number of turning points ---> 25

Smoothness index ---> 0.9259

Time interval ---> 1965.01 - 2009.06
Number of observations ---> 534

# IIP and STOCK: turning points



# IIP and STOCK: turning points

FINAL PEAKS OF IIP Spain
AND THEIR DELAYS IN RELATION TO Stock Index
* MEANS NO CORRESPONDENCE

| | | |
|---|---|---|
| 1966. 4 | * | -- |
| 1969. 8 | 2 | 1969.10 |
| 1974. 1 | 0 | 1974. 1 |
| 1980.10 | 11 | 1981. 9 |
| 1983. 8 | * | -- |
| 1989.11 | -5 | 1989. 6 |
| 1991.11 | -2 | 1991. 9 |
| 1995. 1 | -12 | 1994. 1 |
| 1998. 2 | 3 | 1998. 5 |
| 2000. 5 | -1 | 2000. 4 |
| 2008. 1 | -6 | 2007. 7 |

FINAL TROUGHS OF IIP Spain
AND THEIR DELAYS IN RELATION TO Stock Index
* MEANS NO CORRESPONDENCE

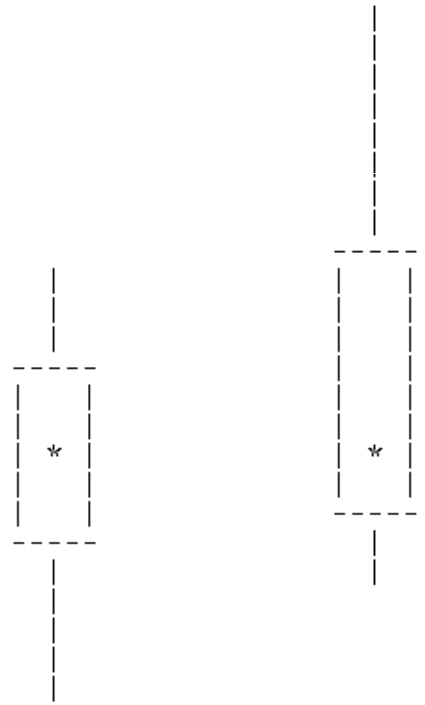
| | | |
|---|---|---|
| 1968. 3 | -2 | 1968. 1 |
| 1971. 3 | 3 | 1971. 6 |
| 1975. 9 | -4 | 1975. 5 |
| 1982. 5 | -28 | 1980. 1 |
| 1986. 8 | -14 | 1985. 6 |
| 1990.11 | -2 | 1990. 9 |
| 1993. 5 | -7 | 1992.10 |
| 1996. 8 | -1 | 1996. 7 |
| 1999. 1 | 2 | 1999. 3 |
| 2005. 5 | -28 | 2003. 1 |

CONFORMITY RATIOS:
Referece series ---> 0.9048
Classified series ---> 0.7600
MEDIAN DELAY ---> -2.0

# IIP and STOCK: turning points

BOX-PLOT OF THE DELAYS

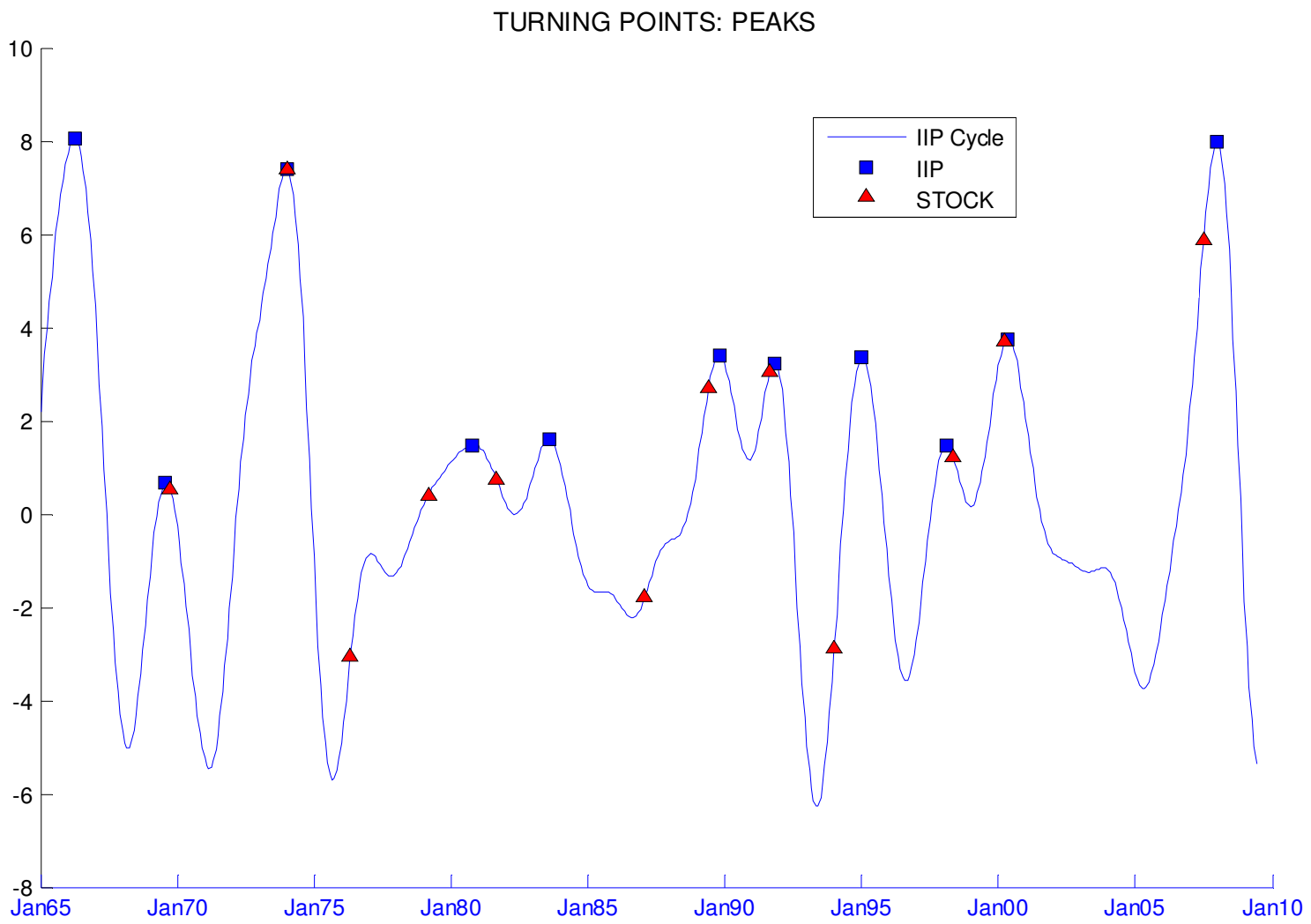
PEAKS TROUGHS



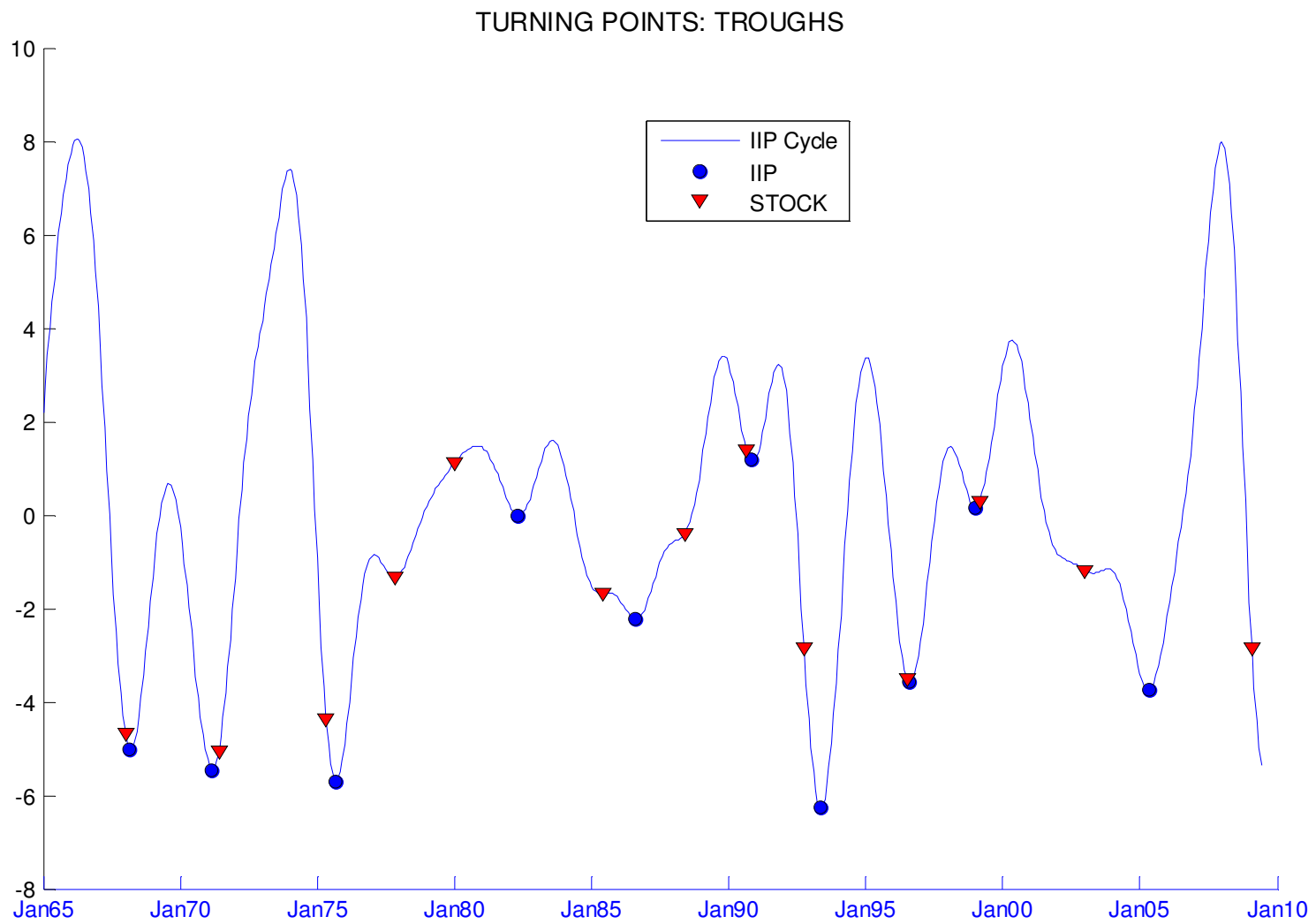
RANK AND DISPERSION STATISTICS OF THE DELAYS

| | PEAKS | TROUGHS |
|---|---|---|
| min | -12.0 | -28.0 |
| q1 | -5.5 | -14.0 |
| median | -1.0 | -3.0 |
| q3 | 2.5 | -1.0 |
| max | 11.0 | 3.0 |
| max-min | 23.0 | 31.0 |
| q3-q1 | 8.0 | 13.0 |

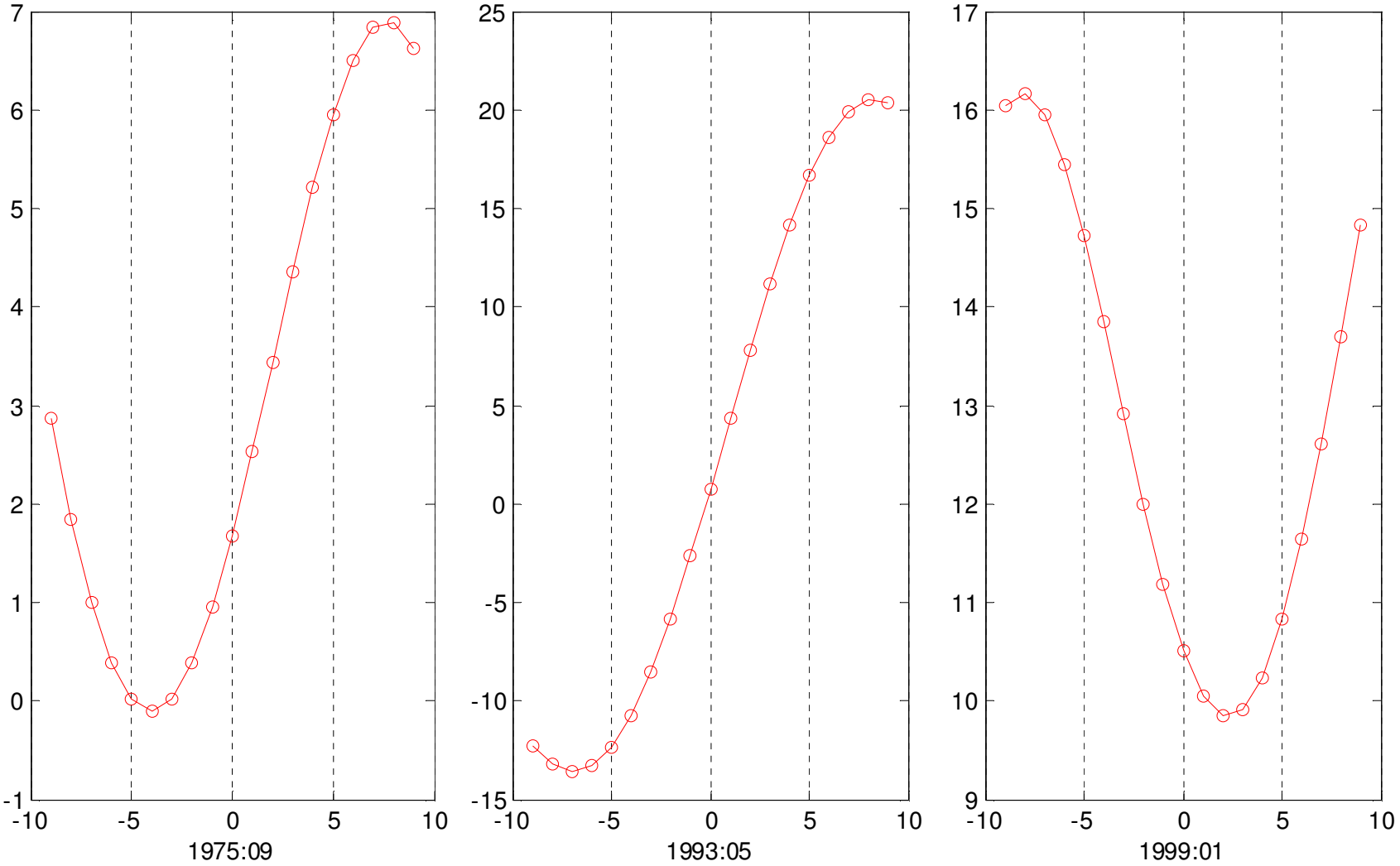
# IIP and STOCK: turning points



# IIP and STOCK: turning points



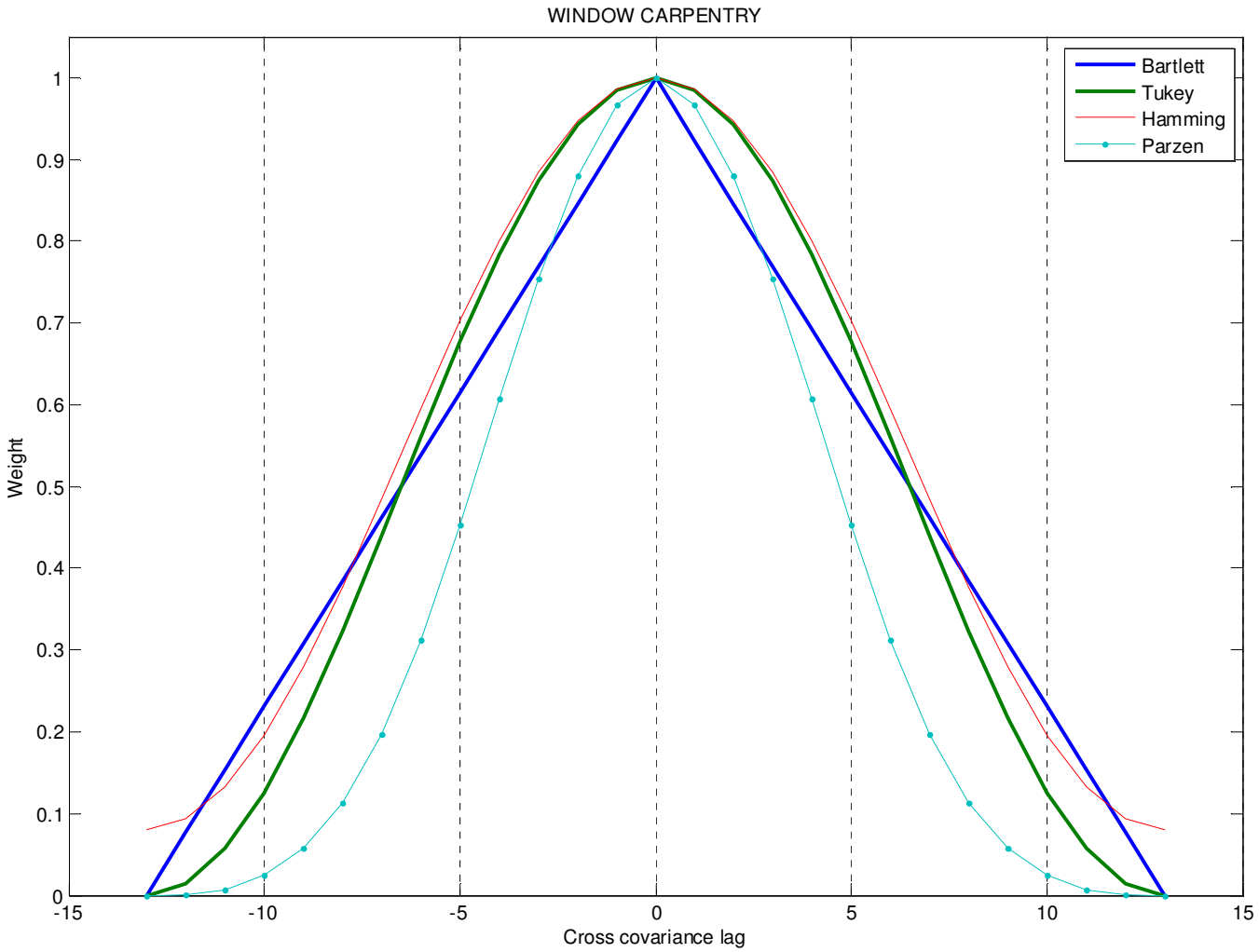
# IIP and STOCK: turning points



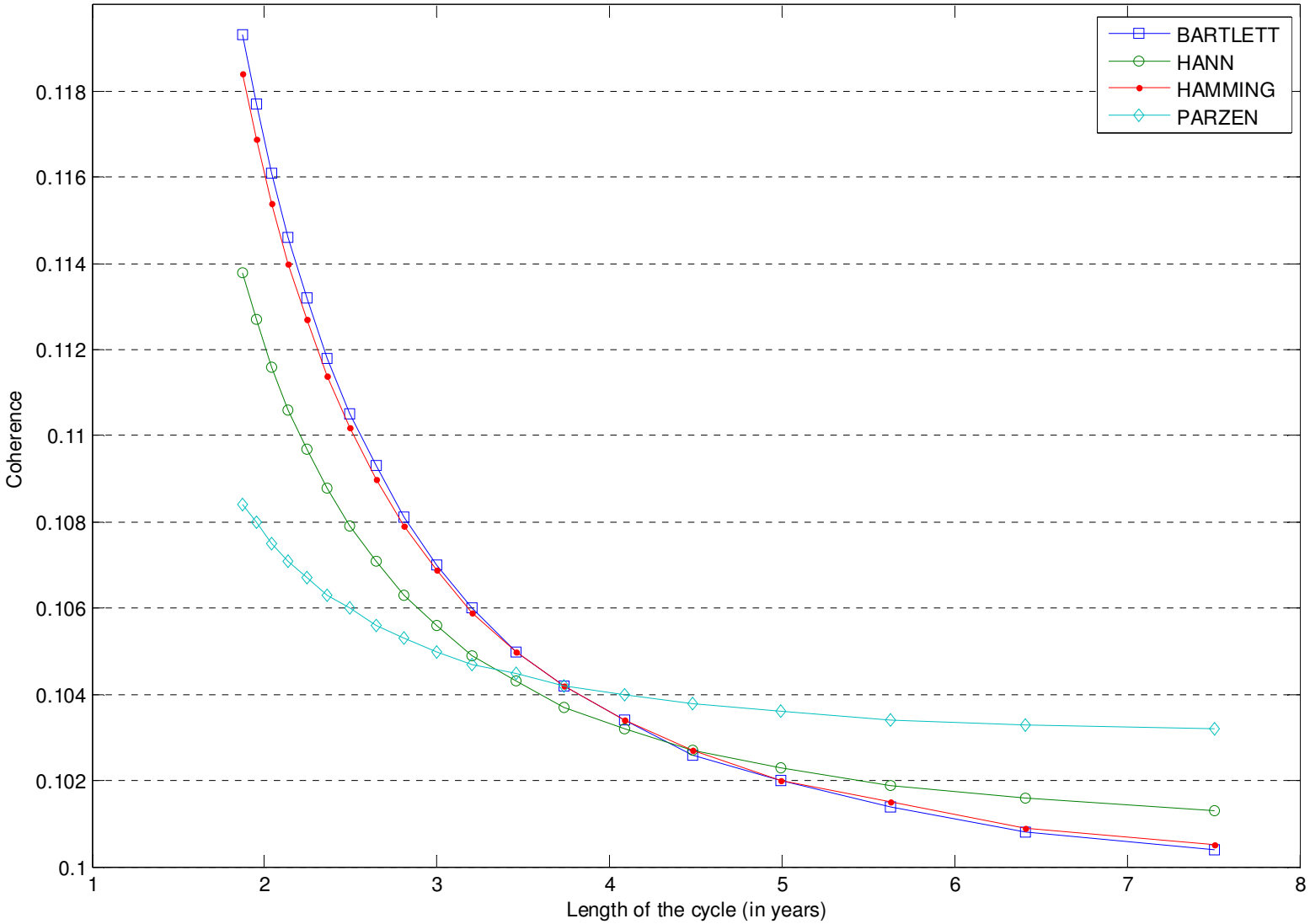
# IIP and STOCK: TURNING POINTS

- STOCK leads consistently IIP, median lead = 2 months.
- The lead is higher at troughs than at peaks: 1m vs 3m.
- The leads have noticeable variability, specially in the case of troughs.

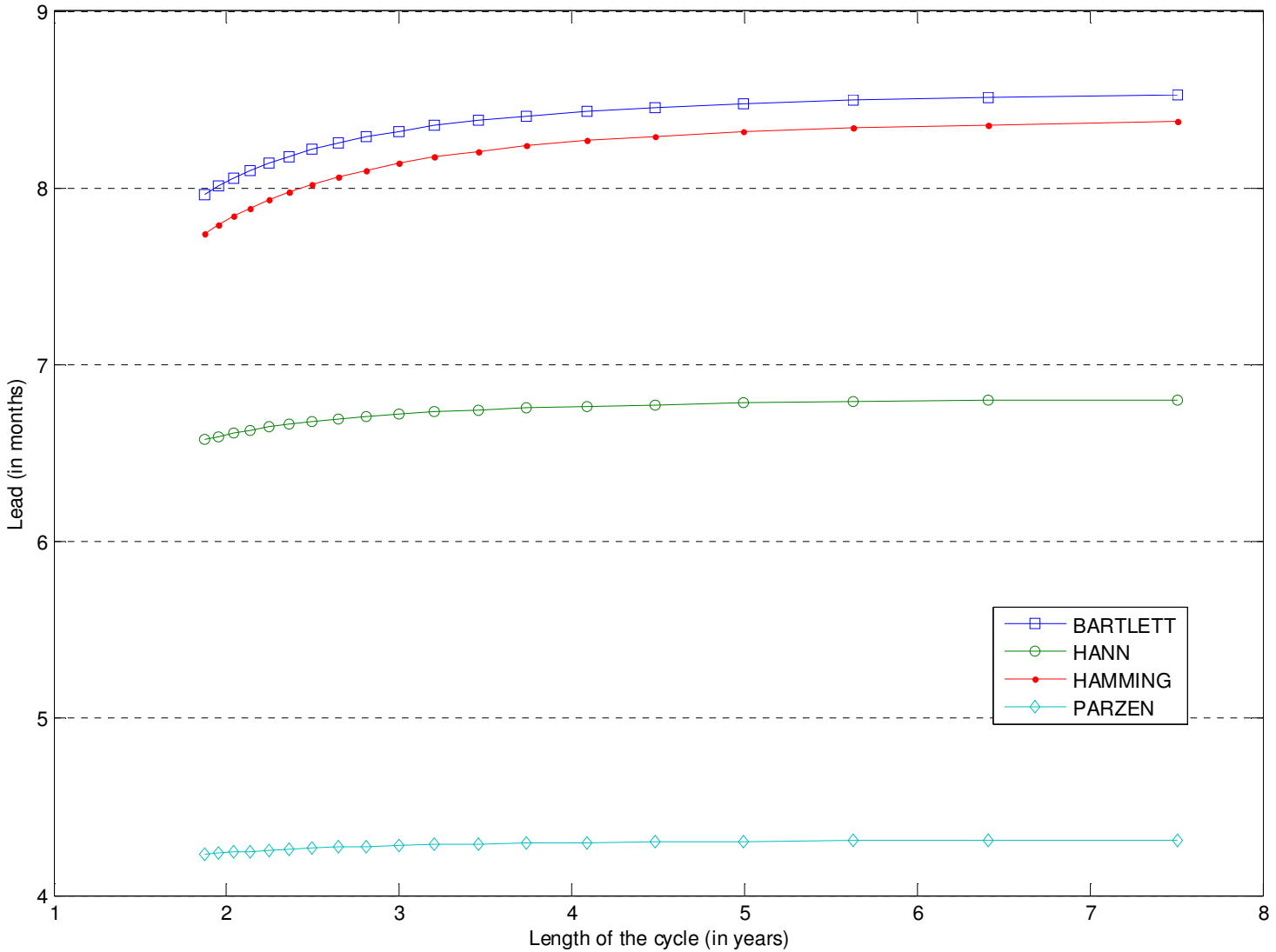
# IIP and STOCK: spectral analysis
# Window carpentry



# IIP and STOCK: spectral analysis Coherence



# IIP and STOCK: spectral analysis Phase



# IIP and STOCK: SPECTRAL ANALYSIS

- STOCK and IIP have weak coherence, specially at lower frequencies (longer cycles).
- STOCK leads consistently IIP across windows. The lead may be estimated next to 7m.
- Different quantitative measures across windows may are consistent with varying leads.

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# Thanks for your attention


DIRECCIÓN GENERAL DE ANÁLISIS MACROECONÓMICO
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# Business cycle indicators. Methods, applications, and limits.

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