

Consistent Seasonal Adjustment

Frank Masci

**Time Series Analysis
Australian Bureau of Statistics**

Outline

1. Definitions and goals
2. Objectives and requirements
3. Examples requiring consistent SA
4. How do we assess it?
5. Tests for quantifying consistency
6. Development of a consistency tool
7. Future / Wrap-up

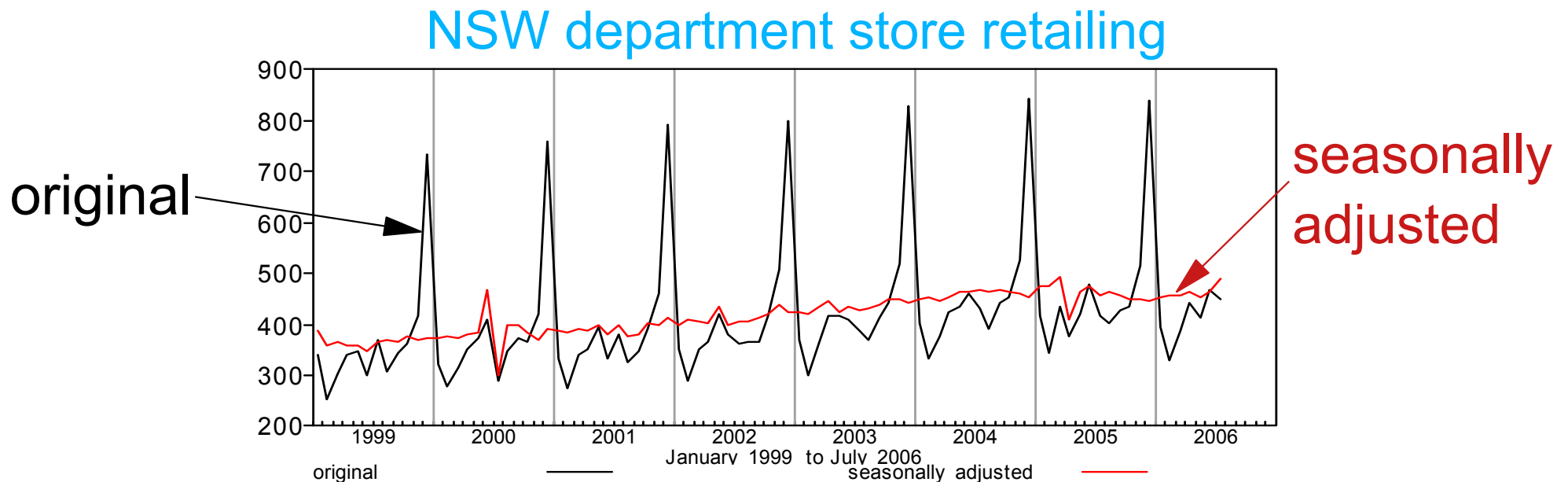
The Seasonal Adjustment (SA) process

Removal of systematic calendar related effects from a series of original estimates:

- periodic (repeating) seasonal patterns at relevant cycles
- Trading day: varying daily activity and frequency thereof
- Holiday proximity effects (e.g. Easter)
- prior corrections: outliers, breaks from real-world effects

Why Seasonally Adjust?

- So we can capture the 'real' underlying economic story or any business-cycles.
- Seasonal effects are a contaminant and not interesting from an economic standpoint.

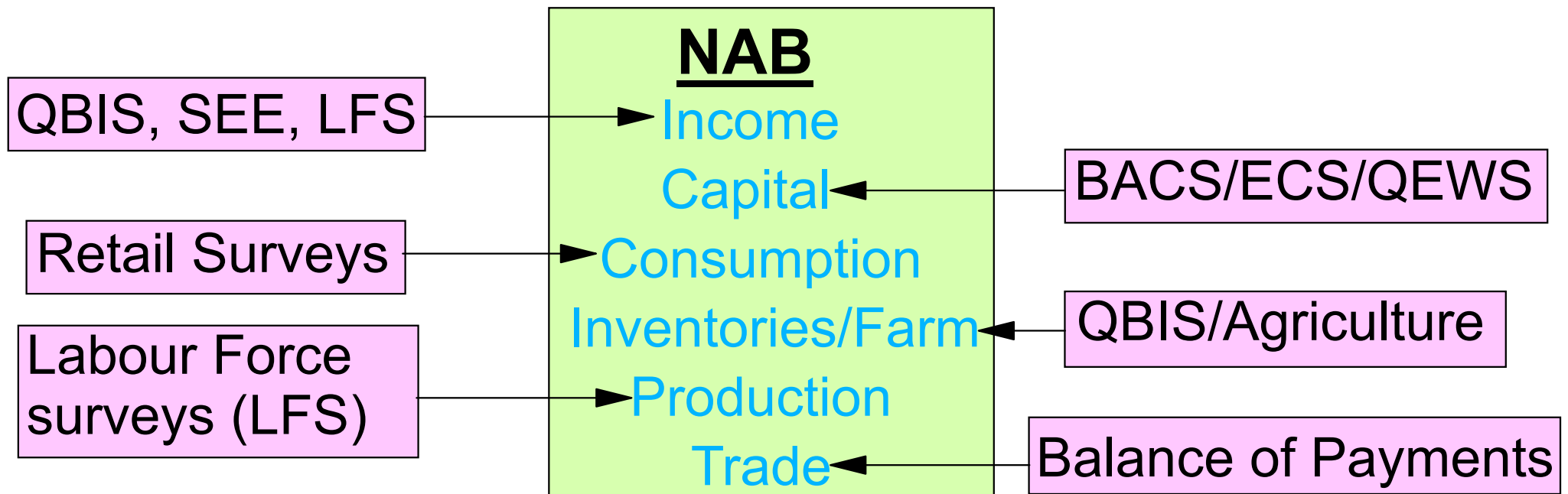


Consistency between what?

- Want to maintain appropriate consistency in ABS time series products, e.g. between published seasonally adjusted (SA) estimates & trends.
- This could be between series from:
 - conceptually related sources from different collections;
 - the same sources (e.g. collections feeding into Nat. Accnts);
 - national aggregates versus state levels (independent SA);
 - industry totals versus stratified industry levels.
 - the same source but with different periodicities: e.g. quarterly versus monthly collections.

e.g: Consistency with NAB

- For example, we perform independent seasonal adjustment for National Accounts and its source collections (ESG & PSG)
- National Accounts further tweak original estimates to be reconciled with annual benchmarks => justifiable differences.
- Want to maintain consistent stories across publications.



ABS requirement

Two recommendations from Sept 2004 ESSCC meeting:

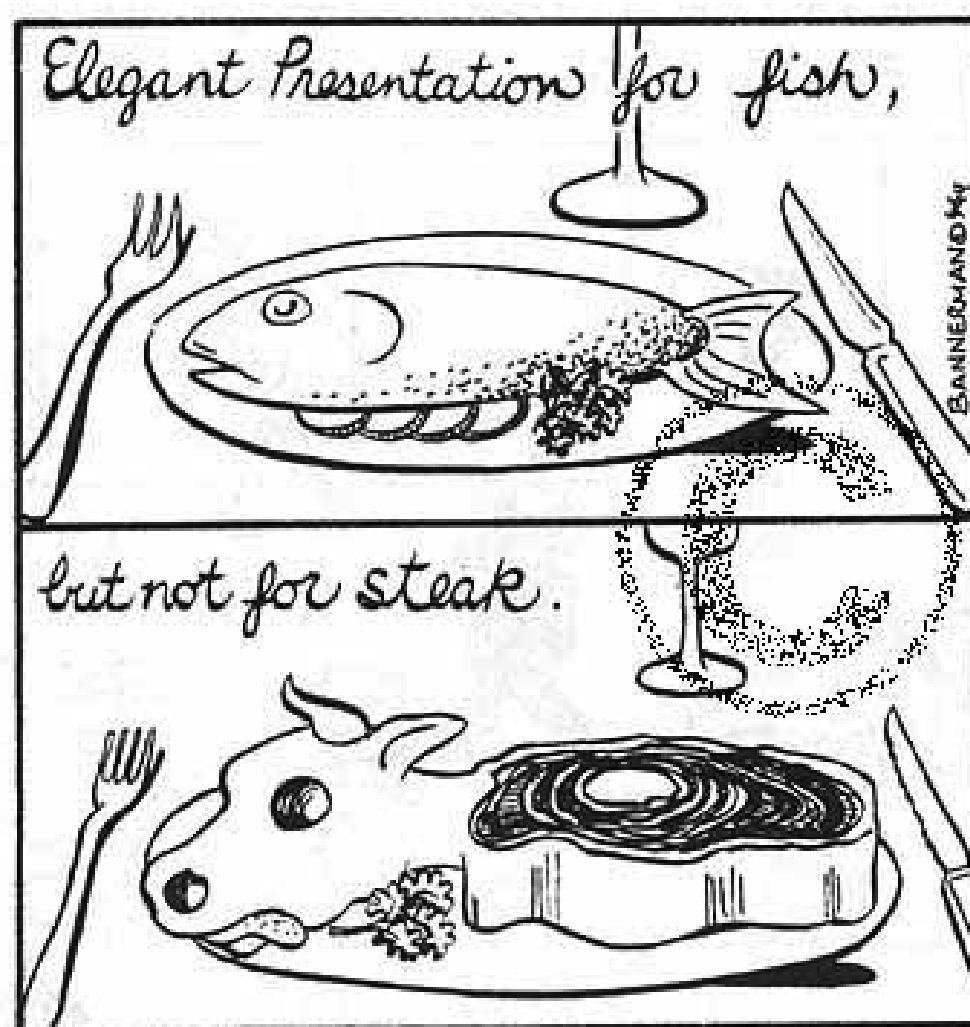
1. *discrepancies in methods of seasonal adjustment between related collections should be addressed manually on a case-by-case basis;*
2. *SEASABS functionality should be enhanced to provide links between related series and built-in checks for auditing the aspects of seasonal adjustment.*

Goals

- Ensure consistent, but appropriate seasonal adjustment (SA) between a pair of conceptually related series.
- Consistent SA:
 - common (but justifiable) prior corrections, SA parameters and settings: e.g. seasonal & trend filter properties
- Ensure that the SA process does not introduce inconsistencies in economic stories due to an inconsistent treatment.

Must be appropriate!

Strict consistency is not the ultimate goal.



Working Hypothesis

- 'Conceptually related series':
 - where the SA components of two series have similar (correlated) underlying movements, not levels, i.e:

$$\% \Delta SA_t^A \sim \% \Delta SA_t^B ; \quad \text{where } \% \Delta SA = 100 \left(\frac{SA_t - SA_{t-1}}{SA_{t-1}} \right).$$

- Original estimates could have different intrinsic seasonal patterns => leads to different movements in original terms.
- The degree of relatedness between two series can be seen once seasonality is removed from the originals.
- So, a pair of series is declared to be 'related apriori' in terms of their underlying SA movements:
 - gives the 'real' story in economic/business-cycle patterns.

"Coherent" or "Consistent"?

Coherence:

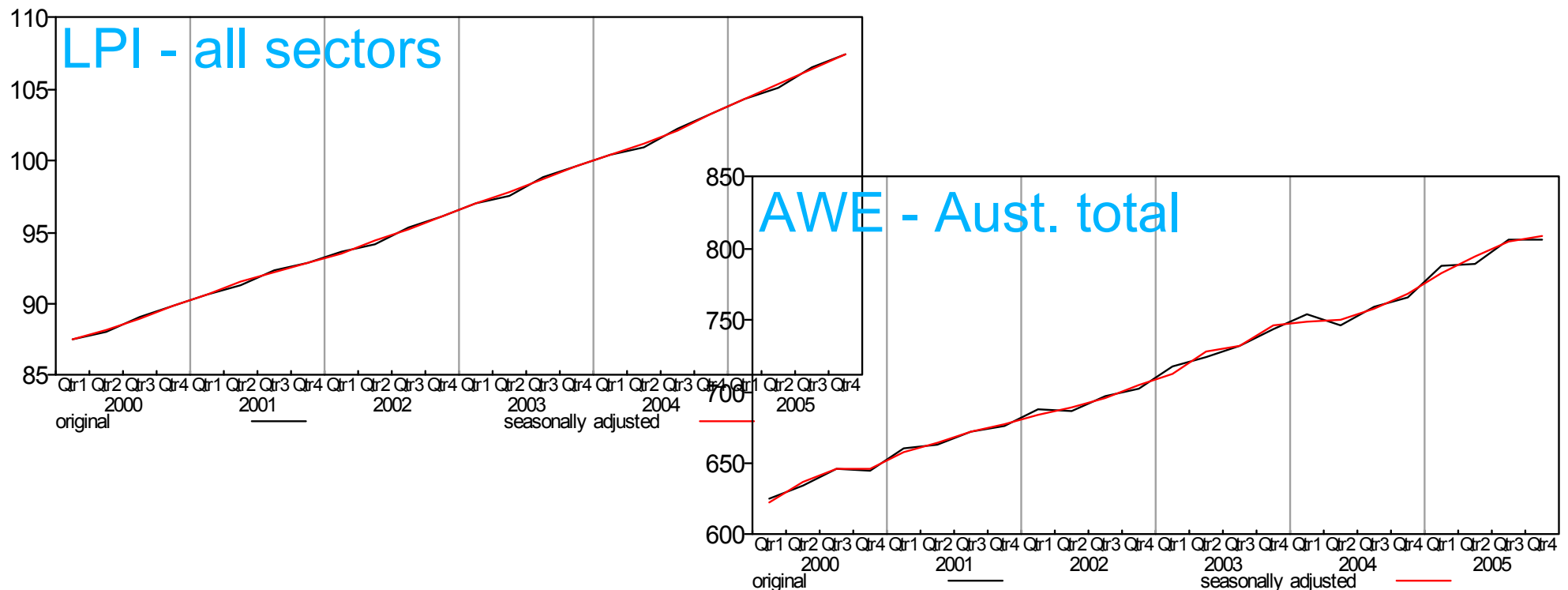
- A very general concept that attempts to assess an expected behaviour/relationship between series from different sources.
- Movements can be in opposite directions: e.g. as price of petrol goes up, car sales (or other luxuries) might go down.
- Is the underlying relationship maintained after SA? Usually yes, but in a broad sense => weak form of "consistency".

Consistency:

- Relates to ensuring similar prior corrections, param. settings and methodology for SA of conceptually related sources.
- conceptually related => similar underlying period-to-period movements.

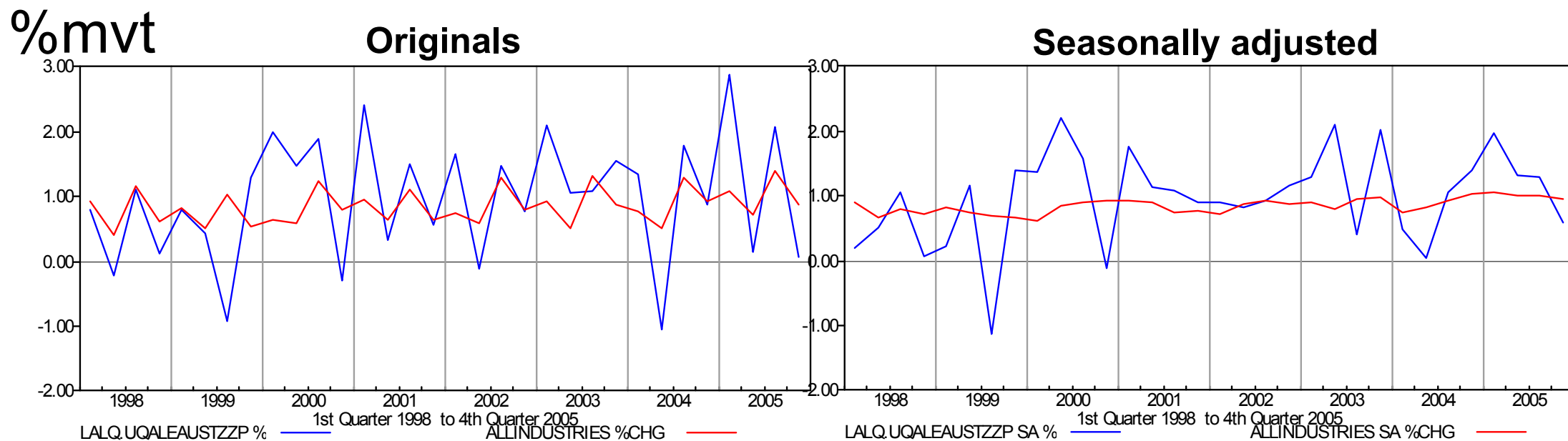
Example of 'Coherence'

- Average Weekly Earnings (AWE) \Leftrightarrow Labour Price Index (LPI)
- AWE \Rightarrow total \$ earnings by employees
- LPI \Rightarrow measure of the total 'cost of labour'
- conceptually different measures but expect that they track each other in the long term \Rightarrow both expected to increase with time.



Example of 'Coherence' contd..

- Comparison between % movements in AWE and LPI.
- Conceptually different in quarterly-to-quarterly movements!
- In long term: mean upward movement is ~1% in both.

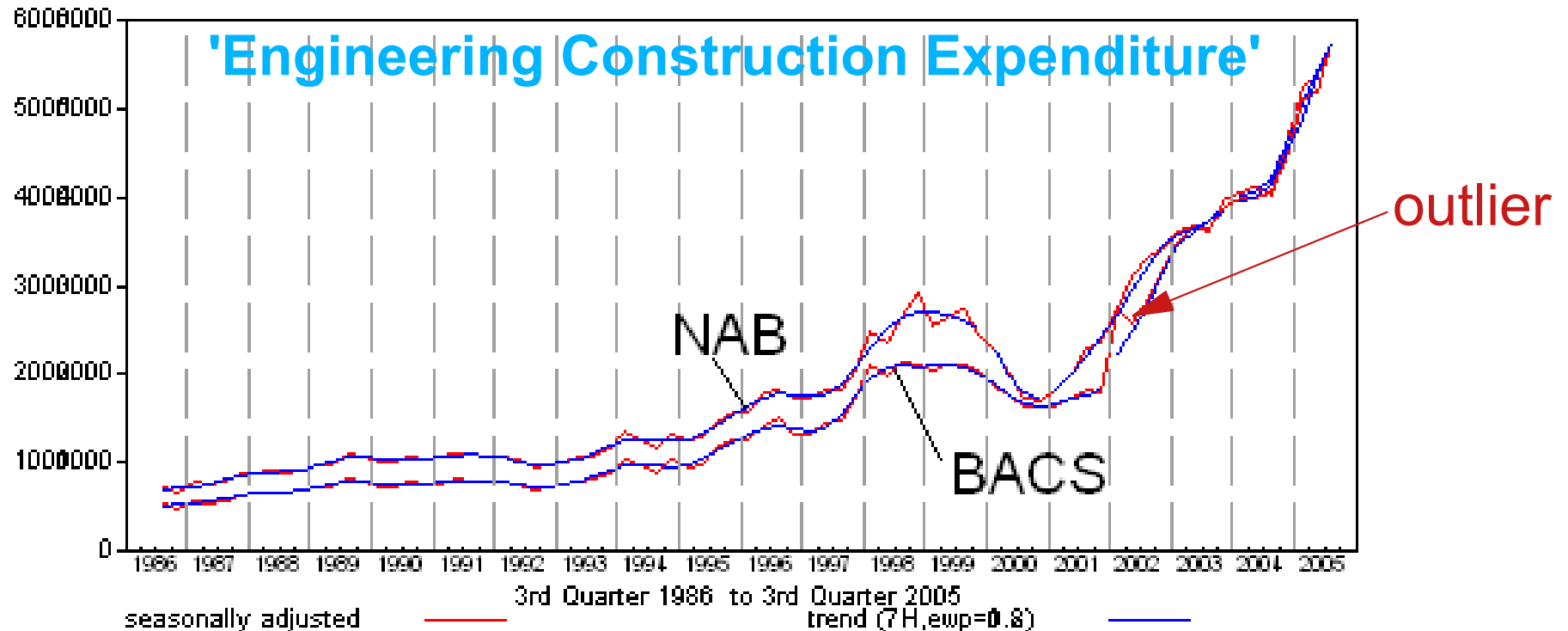


AWE - Aust. total

LPI - all sectors

Consistency example 1

- Example of retaining an inconsistent SA between conceptually related sources => appropriate SA.
- Outlier in one series (BACS) but not in the other (NAB equiv.)
- or, different levels of volatility => justifies using different (smoothing) filter lengths for trend and seasonal factors.

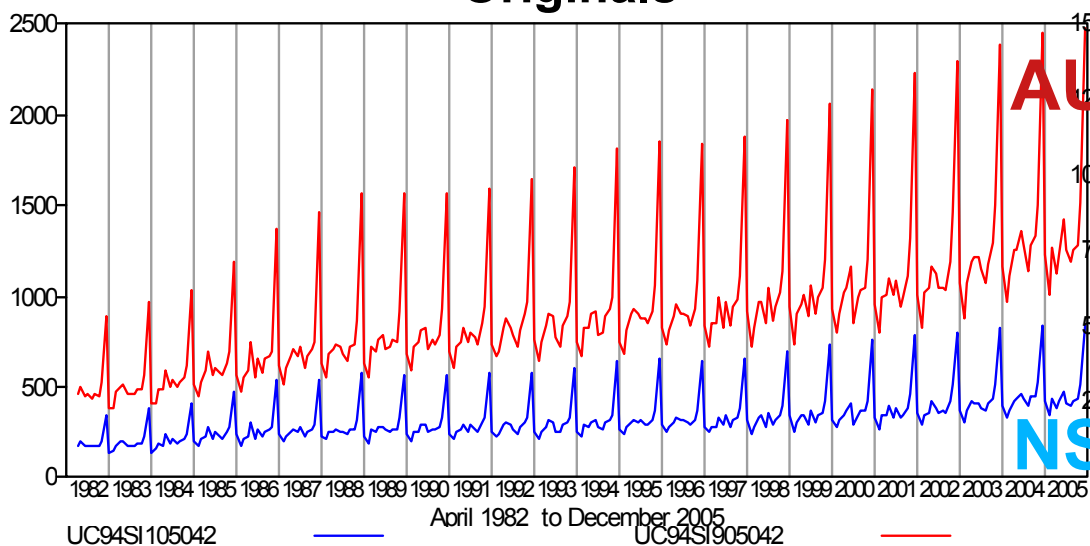


Consistency example 2

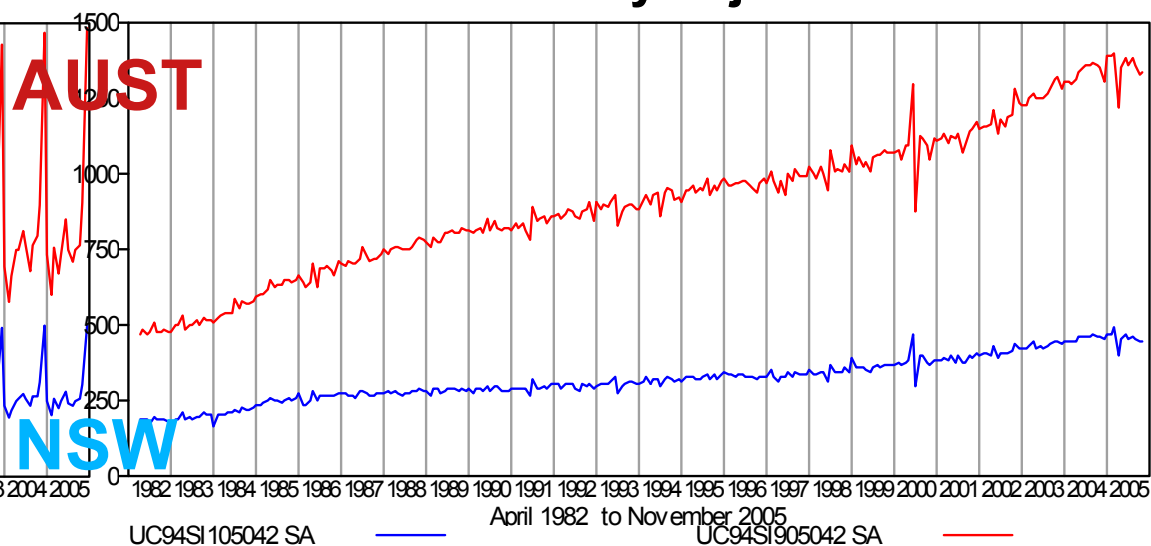
- Direct SA of national aggregate versus state component(s).
- As opposed to indirectly SA aggregate by summing SA states => prior corrections and consistency is implicit.
- e.g: all retail series are directly adjusted, then reconciled to add up to national aggregate.

AUST / NSW department store retailing

Originals



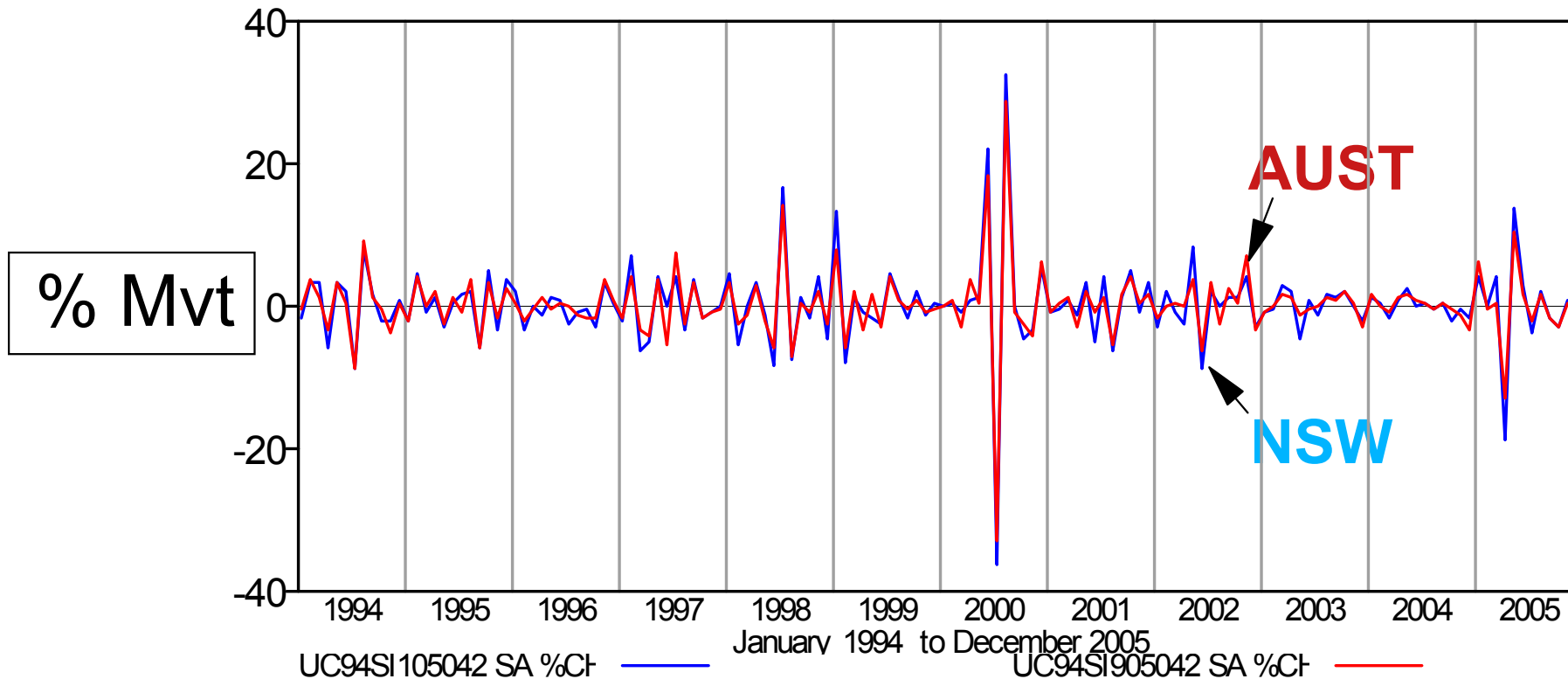
Seasonally adjusted



Consistency example 2 contd..

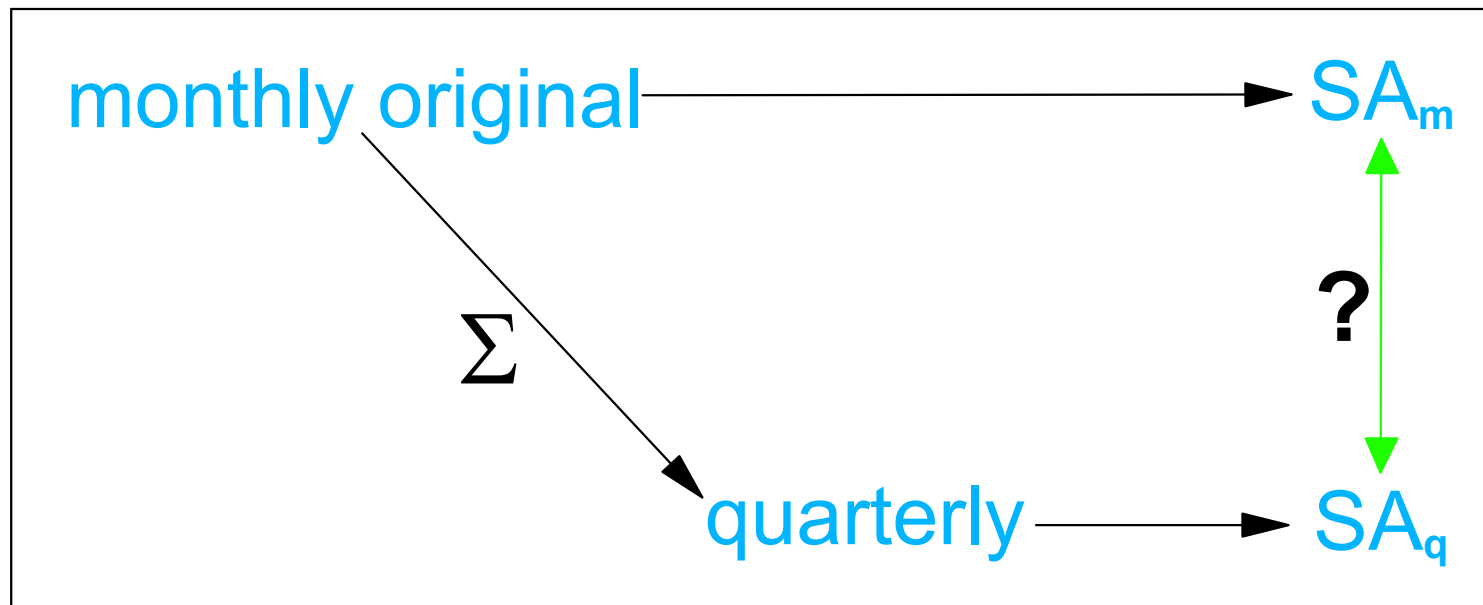
Underlying SA movements in the NSW and AUST series are a good match => obviously conceptually related.

AUST / NSW department store retailing



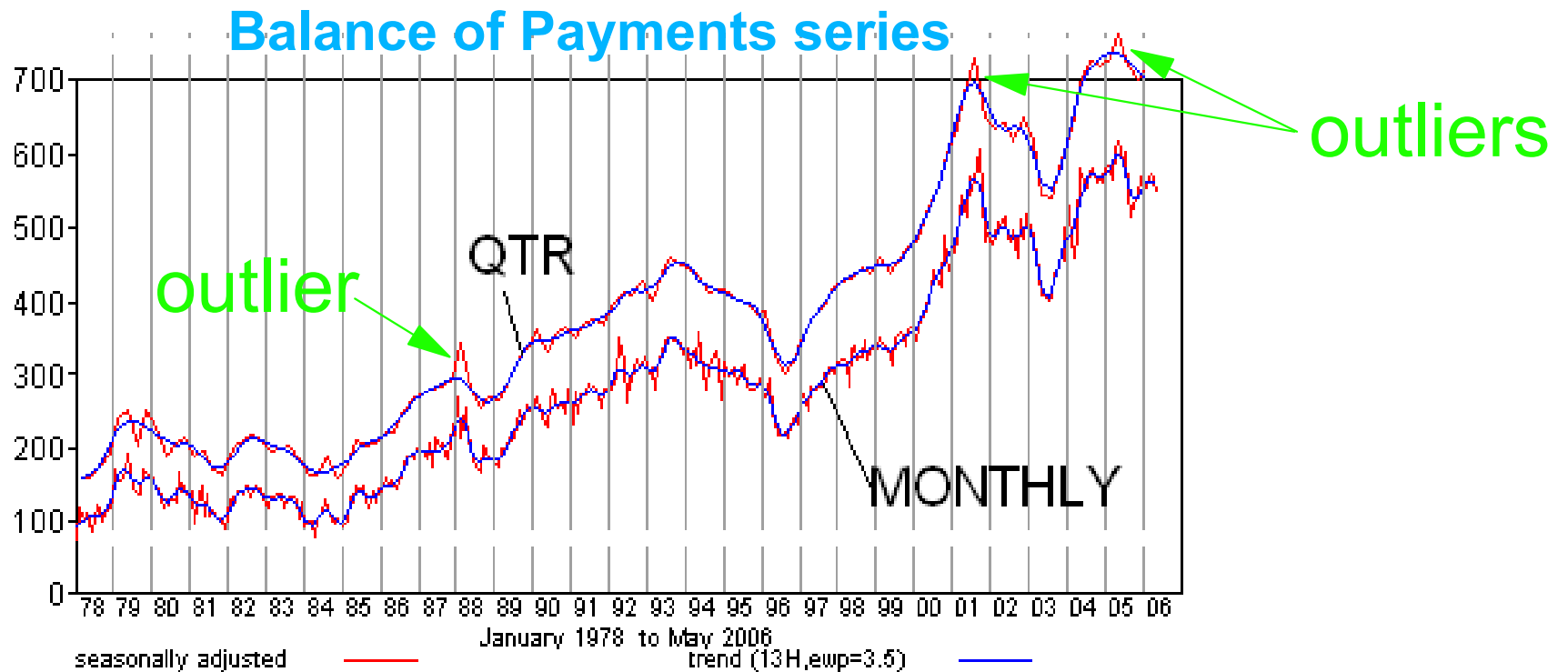
Consistency example 3

Between SA quarterly estimates derived from aggregating monthly originals versus directly SA monthly estimates:



Does it make sense to enforce strict consistency in the SA estimates?

Consistency example 3 contd..

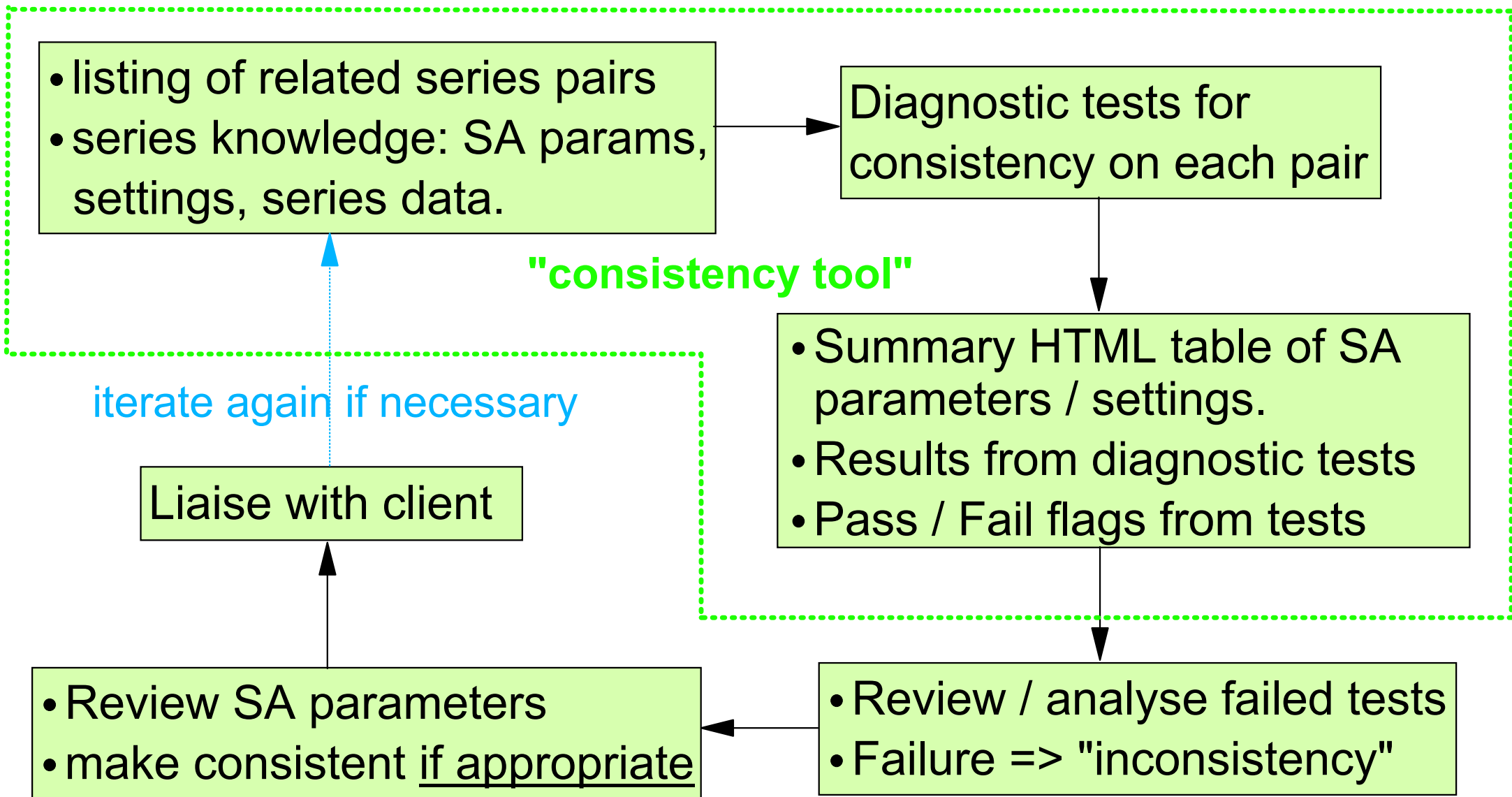


- Different periodicities give different interpretations.
- quarterly series => more sparsely sampled => monthly volatility and outliers get "smoothed" out.
- appropriate here to have different trend or seasonal (smoothing) filter lengths, trading day and other prior corrections.

How do we assess it?

- Consistent and appropriate SA can be achieved by comparing all residual (remaining) priors and systematic differences in the seasonally adjusted components of two series.
- Once differences are highlighted, can then proceed to assess whether they are appropriate or inappropriate for each series.
- We hope to achieve consistency at a level where any remaining differences are:
 1. 'appropriately justified' or expected from real world events, or
 2. purely stochastic in nature, i.e., dictated by varying degrees of volatility.

Process Flow



Prototype Consistency Tool

- We currently have a prototype (TSA developed) consistency tool which can:
 1. assess degree of 'relatedness' between series pairs.
 2. highlight all inconsistencies (and consistencies) in priors, SEASABS seasonal adjustment settings.
- Mapping between conceptually related series pairs (across collections) is managed via a "map-table" (now text input file).
- Plans are underway to build this tool and infrastructure into SEASABS. Related series mappings will be stored in a knowledgebase on the ABSDB.

Diagnostic Tests Summary

Input: SA series data / knowledge

TEST 1: SA parameter comparisons

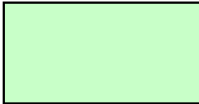
TEST 2: cross-correlations in Mvts

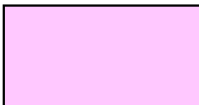
TEST 3: $H_0: \langle \text{Mvt1} - \text{Mvt2} \rangle = 0$

TEST 4: mvt1 vs. mvt2 outliers

TEST 5: pattern in $|\text{mvt1} - \text{mvt2}| > T$?

TEST 6: unit root & cointegration tests

 For information only, report to client if test outcomes severe.

 Can improve consistency depending on outcomes by modifying SA settings.

tests on % movements

test on series levels

TEST 1

- Reports when there is an inconsistency in any one or more of the following "main" SA processing parameters:
"Method", "Model", "TMA", "PUB_TMA", "PUB_EWP",
"SMA", "Trading day", "Easter" and "Father's Day" (+ other?)
- If all consistent => test passes.
- Only checked if 'periodicities' the same since expect justifiable differences otherwise. But must ensure appropriate!
- Action for failures: make SA parameters consistent, otherwise retain if appropriate.

TEST 1 contd..

Example SA parameters table: this example compares national aggregate of hotel rooms occupied versus state equivalents.

Series Name	TSUpdate_Spans	Period	Method	Model	TMA	PTMA	PEWP	SMA	TD	EP	FD
TASQ.UNTOT9RN	03/1988-03/2006	QUART	I	M	5	7	0.80	3x5	No	No	No
TASQ.UNTOT1RN	03/1988-03/2006	QUART	D	M	5	7	1.00	3x5	Yes	No	No
TASQ.UNTOT2RN	03/1988-03/2006	QUART	D	M	5	7	1.00	3x5	Yes	No	No
TASQ.UNTOT3RN	03/1988-03/2006	QUART	D	M	5	7	1.00	3x5	No	No	No
TASQ.UNTOT4RN	03/1988-03/2006	QUART	D	M	5	7	1.00	3x5	Yes	Yes	No
TASQ.UNTOT5RN	03/1988-03/2006	QUART	D	M	5	7	1.00	3x5	No	No	No
TASQ.UNTOT6RN	03/1988-03/2006	QUART	D	M	5	7	1.00	3x5	Yes	No	No
TASQ.UNTOT7RN	03/1988-03/2006	QUART	D	M	5	7	1.00	3x5	No	No	No
TASQ.UNTOT8RN	03/1988-03/2006	QUART	D	M	7	7	1.00	3x5	No	No	No

TEST 2

- Check that series are conceptually related by testing that movements are significantly correlated:

$$H_0 : \rho(M_1, M_2)_h = 0 \quad \text{vs.}$$

$$H_1 : \rho(M_1, M_2)_h \neq 0$$

- Rejection of H_0 at some p -value \Rightarrow series are indeed related.
- If movements not significantly correlated, notify client that series don't appear to be conceptually related.
- Provides a "weak" consistency check \Rightarrow this test must pass in order to proceed.

TEST 3

- Provides a stronger test for consistency between movements.
- Null hypothesis => series are conceptually related.
- In a broad sense, tests whether movements in series 1 are different than those in series 2. Is a priori assumption false?

$$H_0 : \langle M1 - M2 \rangle = 0 \quad \text{vs.} \quad H_1 : \langle M1 - M2 \rangle \neq 0$$

- If H_0 rejected, can determine nature of mean movement difference using a robust linear regression fit to movements:

$$M_2 = \alpha M_1 + \beta,$$

- Above test becomes equivalent to testing:

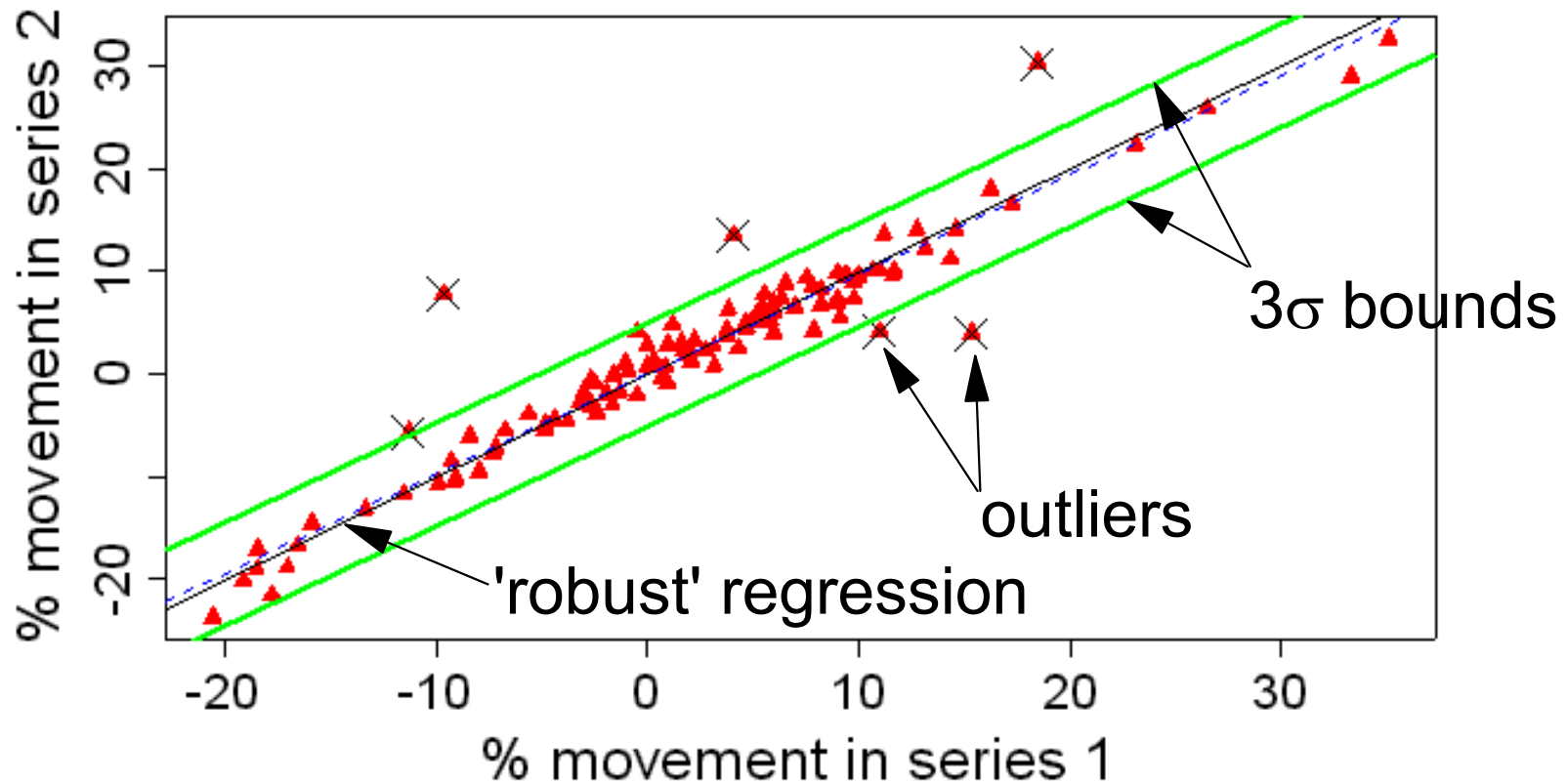
$$H_0 : \alpha = 1 \quad \text{versus} \quad H_1 : \alpha \neq 1 \quad \text{and}$$

$$H_0 : \beta = 0 \quad \text{versus} \quad H_1 : \beta \neq 0$$

"consistent" \longleftrightarrow "inconsistent"

TEST 4

- Highlights inconsistencies in movements at the same time points between two series.
- Based on detecting outliers from a 'robust' regression between movements above some nominal threshold:



TEST 4 contd..

- A deviant movement at some timepoint may imply:
 1. an inconsistent prior correction was applied to one series but not the other: e.g. Large extreme, Trend break.
 2. actual originals are conceptually different at that timepoint.
- Example output table of outlier movements:

```
*** NUMBER OF > 3 SIGMA OUTLIERS DETECTED IN MOVEMENT VS MOVEMENT PLOT = 6
* ALL OUTLIERS:
* MNTH or QTR/YEAR | MVT1(%) | MVT2(%) | approx.#SIGMA | P-VALUE:
* -----
* 3/1977      | -9.61      | 7.78      | 10.12      | 4.307e-024
* 4/1977      | 15.35     | 3.97      | -6.32      | 2.539e-010
* 3/1978      | 4.09      | 13.46     | 5.65       | 1.609e-008
* 3/1979      | 18.47     | 30.30     | 7.35       | 2.039e-013
* -----
```
- Want to ensure all outlying movements are represented as prior corrections (if appropriate) during SA.

TEST 5

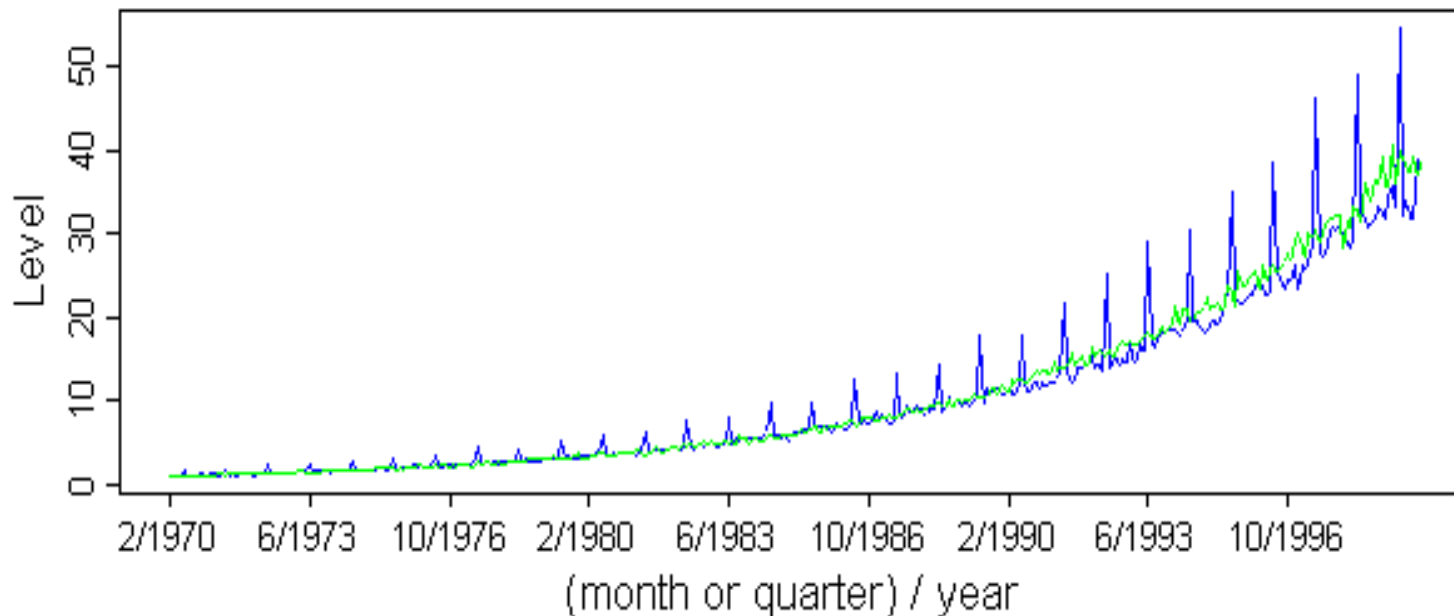
- Test for a pattern in "excess" movement difference "M1 - M2" as a function of time. By excess, we mean absolute values of mvt differences that exceed some threshold (e.g. 2σ).
- Purpose:
 - if we are comparing original components, then a significant pattern in "thresholded $|M1 - M2|$ " may imply different seasonal patterns and/or strengths.
 - if comparing SA components, a significant pattern in "thresholded $|M1 - M2|$ " may imply residual seasonality is present in one series but not the other => inconsistent SA.
- **N.B:** not sensitive at detecting significant residual seasonal movements of the same magnitude in both series.

TEST 5 contd..

- Pattern in "thresholded $|M1 - M2|$ " is tested for by computing the ACF of the temporal indicator sequence:

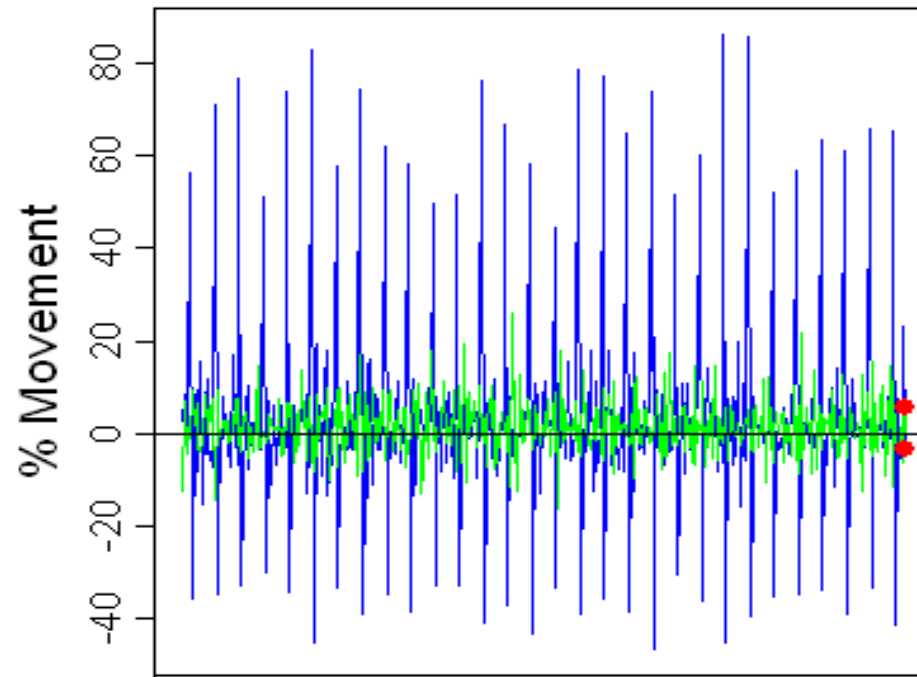
$$\text{if } (|M1_t - M2_t| > \text{thres}) \{ i(t) = 1 \} \text{ else } \{ i(t) = 0 \}$$

- Simulation: suppose we have two series: **green** has good SA, **blue** series has (exaggerated) residual seasonality (\Rightarrow bad SA):

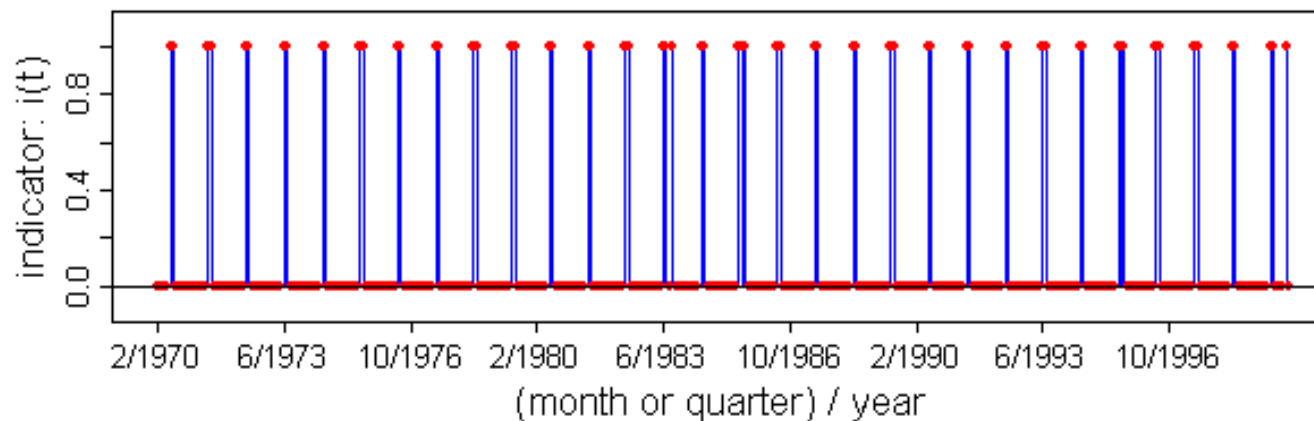


TEST 5 contd..

- Movements versus time:

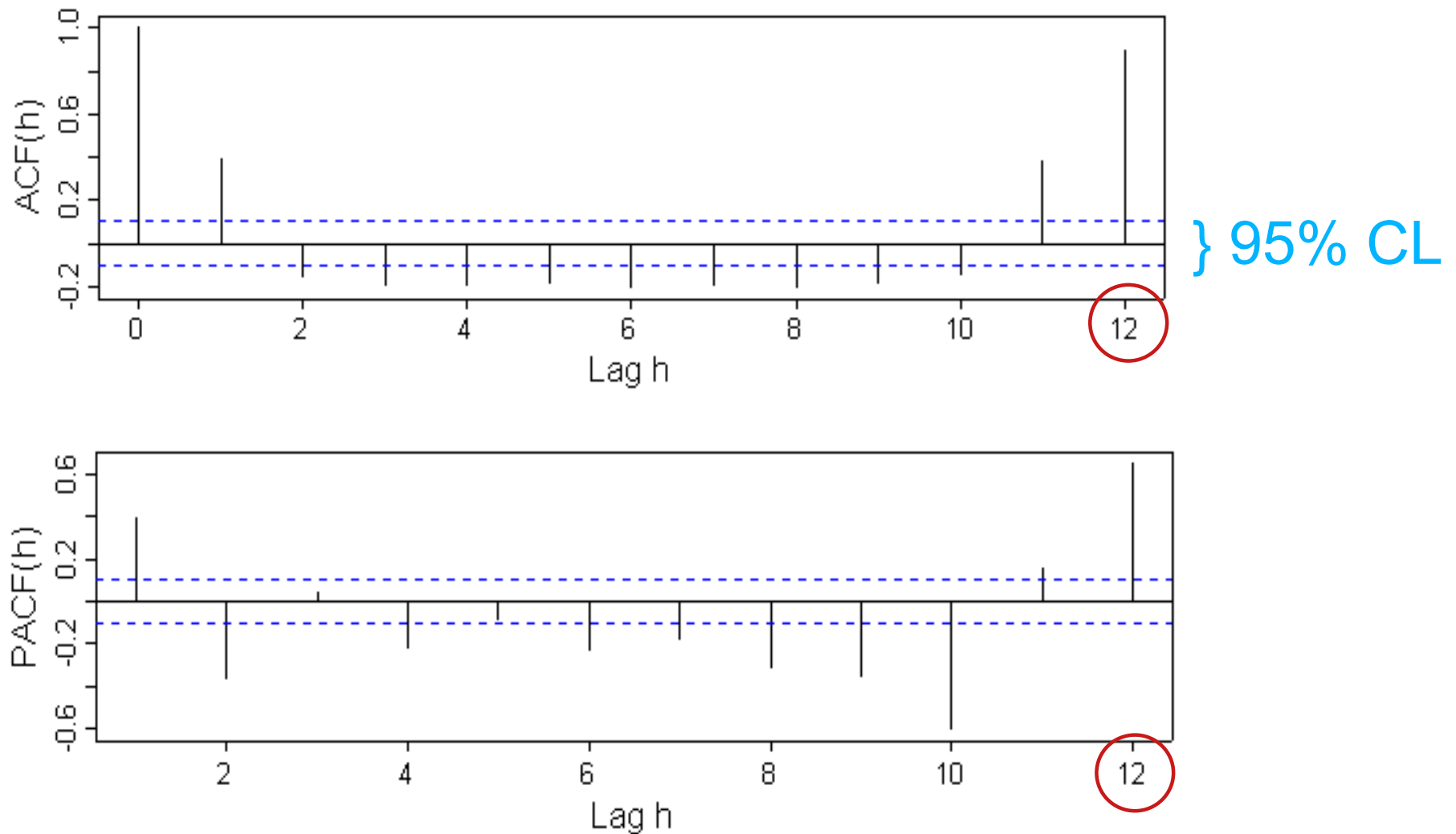


- Indicator sequence $i(t)$ after thresholding: $|M1(t) - M2(t)| > 2\sigma$:



TEST 5 contd..

ACF and PACF of indicator sequence suggests strong temporal pattern in excess movement difference on 12 mnth timescale:



TEST 5 contd..

- Outcome from this test:
 - * REJECT "H0: ACF & PACF[j(t)]=0" OF NO PATTERN IN MOVEMENT DIFFERENCES
 - * SYSTEMATIC INCONSISTENCY EXISTS AT (LAG) PERIODICITY of 12.
- Action: peruse seasonal factors and ensure that seasonality is eradicated as much as possible in SA series.
- Note: a pattern at a non-annual lag would be intriguing since this will suggest behaviour on some underlying business cycle

TEST 6

- Cointegration: powerful test for 'relatedness' between levels.
- Previous 4 tests focused exclusively on movements since:
- movement estimates:
 - => 'first differencing' a series: $(SA_t - SA_{t-1}) / SA_{t-1}$
 - => stationarity in movement series: moments indpt of time
 - => correlation (ρ) and regression estimates between movements will be unbiased
- If attempt to correlate levels directly, then ρ measures may be spurious due to presence of non-stationarity => ρ measures will be biased towards explaining long-term correlation in trend.

TEST 6 contd..

- Condition which enables us to correlate levels directly is that two series have to be "cointegrated":
 - => have common "long-term" trends
 - => they track each other consistently in the long run.
 - => there may be a causal relationship between the series.
- Two series X_t and Y_t are cointegrated if a linear combination of them is stationary:

$$u_t = Y_t - \beta X_t - \alpha \sim iid$$

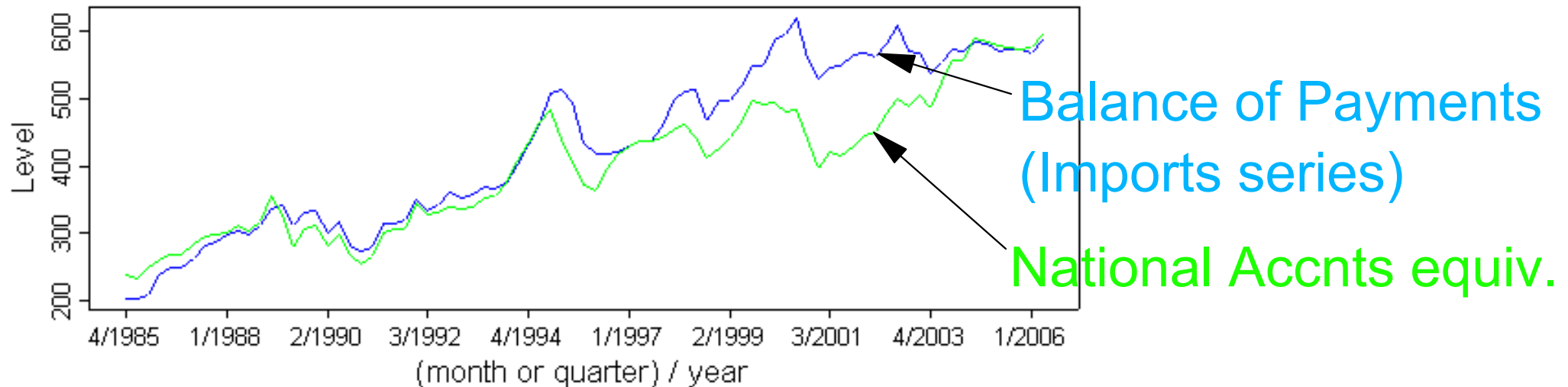
where *iid* = "independent and identically distributed" residuals

TEST 6 contd..

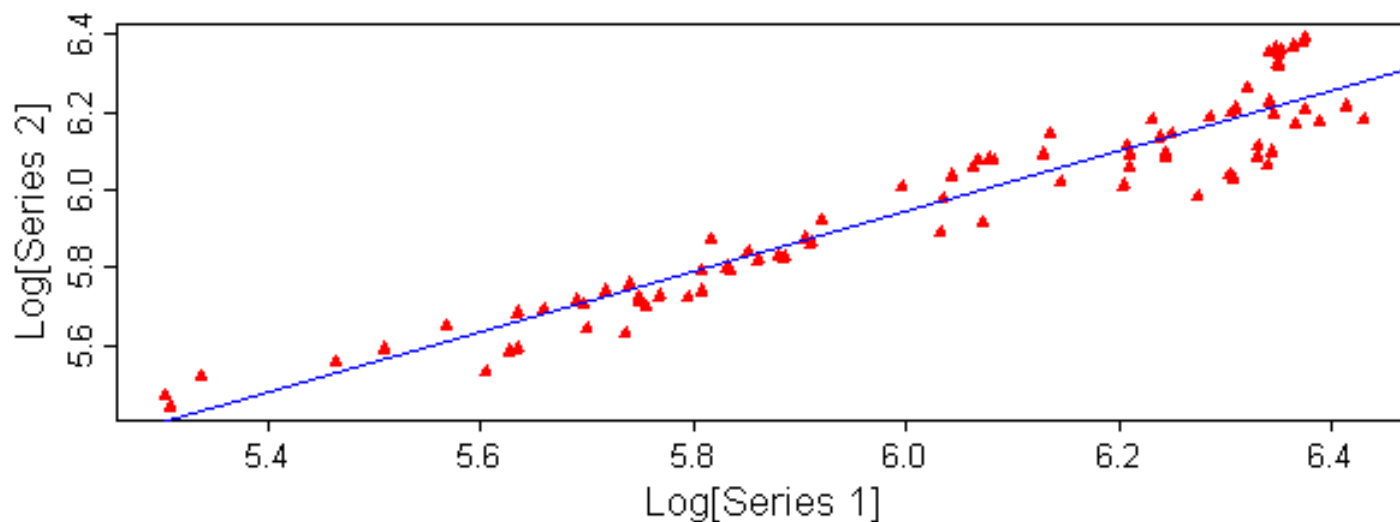
- Before testing for cointegration, need to first ensure that two series are integrated of the same order (\Rightarrow non-stationary).
- 'integrated' \Rightarrow a cumulative sum of repeated stochastic disturbances over time: e.g, a classic random walk.
- We test for integrated processes using "unit-root" tests.
- If series pair not integrated with same order \Rightarrow not related!
- Otherwise proceed with a linear regression: compute $\rho(s_1, s_2)$.
- If regression residuals stationary \Rightarrow series cointegrated \Rightarrow stronger evidence that series are conceptually related.
- FYI, the Engle-Granger and Johansen tests are performed.

TEST 6 (eg: cointegrating pair)

Series 1 (Blue) : Series 2 (Green)



Log[Series2] vs. Log[Series1]

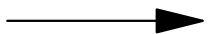


Putting it all together..

- All six diagnostic tests have been integrated into the "prototype" consistency checking tool.
- Truncated example of output HTML table for a pair is below.
- Procedure involves assessing all failed tests for each series pair and modifying SA parameters where appropriate.

Group.Series	Analysis Span.	Update Span...	Period	Method	Model
SEASABS_QGOODSDR.A3_110_1.3.11_PLASTICS	03/1981-03/2005	03/1981-02/2006	QUART	D	M
INTGOODS.N0QQ.UVCHOTH#PLA## Diagnostic tests failed: 1, 3, 4	03/1985-04/2005	03/1985-02/2006	QUART	D	M

↓ continued with more series pairs



What remains..

- We are about 80% of the way there with regards to design of a consistency tool for integration into SEASABS.
- Currently putting our prototype tool into practice in annual seasonal reanalysis runs. Lots of feedback and ideas.

- May need to manage more time series dimensions to check for consistency: N interrelated series $\Rightarrow N(N-1)/2$ related pairs!
- Efficient way of managing consistency mappings.
- ABSDB infrastructure to store related series across all collections will be released in Dec '06 \Rightarrow giant leap!

- Development of Best Practice Guidelines for section/clients
- Alert and train subject matter areas about consistency issues.

Want to avoid..



*"I am sure you'll appreciate
our new policy."*

But we're getting closer and closer to avoiding this..

Wrap-up

Reminder of overall objective:

- Maintain consistency in ABS time series products derived from conceptually related sources across ABS collections.
- Appropriate SA is the key, not strictly consistent SA.
- Development of a prototype consistency checking/assessment tool has been ongoing. This will:
 - alleviate the burden of manual book-keeping by time series analysts given different SMAs are on different pub. cycles.
 - improve quality assurance
 - get our story straight to the outside world.
 - bridge any communication gaps between SMAs and also with the TSA team.