EXAMINATIONS OF THE HONG KONG STATISTICAL SOCIETY

HIGHER CERTIFICATE IN STATISTICS, 2013

MODULE 7 : Time series and index numbers

Time allowed: One and a half hours

Candidates should answer **THREE** *questions.*

Each question carries 20 marks.
The number of marks allotted for each part-question is shown in brackets.

Graph paper and Official tables are provided.

Candidates may use calculators in accordance with the regulations published in the Society's "Guide to Examinations" (document Ex1).

The notation log *denotes logarithm to base* ***e****.*
Logarithms to any other base are explicitly identified, e.g. $\log_{10}$.

Note also that $\binom{n}{r}$ *is the same as* ${}^{n}C_{r}$.

This examination paper consists of 8 printed pages.
This front cover is page 1.
Question 1 starts on page 2.

There are 4 questions altogether in the paper.

1. (i) A 3 × 3 symmetric moving average is defined as a simple 3-point moving average of a simple 3-point moving average. Calculate the weights associated with such a moving average. What problem would you face if using such a moving average to smooth a time series?

(6)

(ii) Use the symmetric 5-term Henderson moving average (weights: –0.073, 0.294, 0.558, 0.294, –0.073) and the 3 × 3 symmetric moving average to estimate the trend of the time series in the table. Present your results to the nearest whole number.

(6)

Year 1 Q1	154
Year 1 Q2	166
Year 1 Q3	159
Year 1 Q4	165
Year 2 Q1	165
Year 2 Q2	164
Year 2 Q3	160
Year 2 Q4	163

(iii) Assuming there is a turning point during the eight periods in the table, where does it occur according to

(a) the 3 × 3 symmetric moving average,

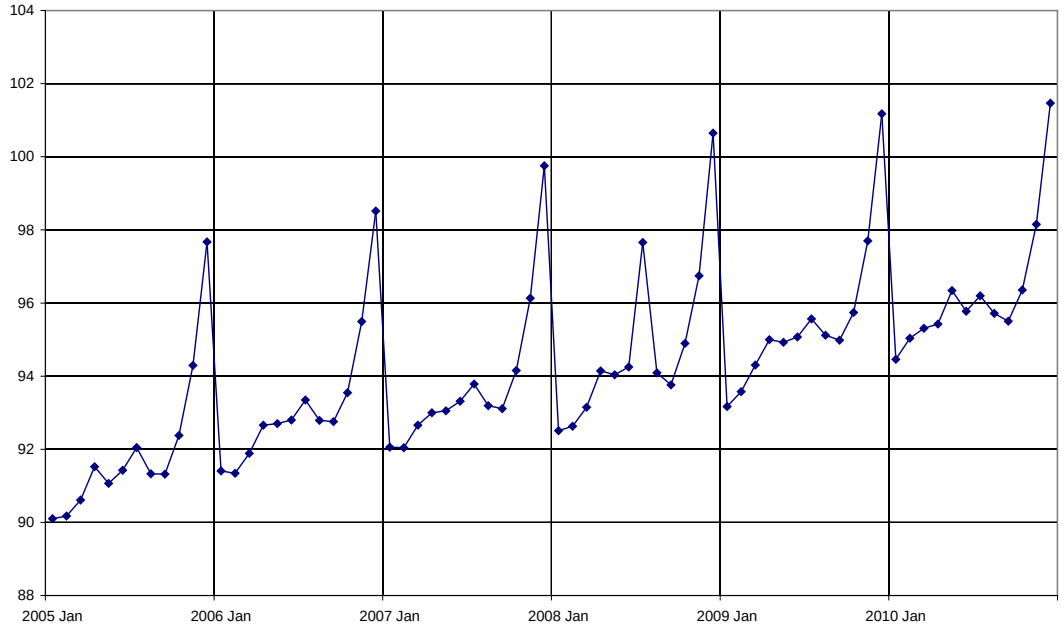
(b) the Henderson moving average?

(2)

(iv) Briefly specify three other ways of trend estimation or removal in time series, and give for each one a reason why it might be considered.

(6)

2. (i) Describe the time series plotted below in terms of its trend, its seasonality and any other noteworthy features. (3)



(ii) Adjustments for outliers are often made prior to the seasonal adjustment process. Why might this be necessary when moving averages are used for seasonal adjustment? (3)

(iii) Describe what is meant by the phrases *permanent prior adjustment* and *temporary prior adjustment* in the context of seasonal adjustment. In general, should prior adjustments for outliers be made temporarily or permanently? Justify your answer. (4)

(iv) Suggest two methods, other than plotting the raw data, for identifying possible outliers in a time series. (2)

(v) Briefly describe a statistical method for estimating the size of an outlier. (3)

(vi) Outline the inferences you might draw from the following extract of computer output taken from a seasonal adjustment run of the series illustrated in part (i) above. Based solely on this output, what action would you take when seasonally adjusting this series? What other information might you like to have before taking action? (5)

```
Regression Model
-----------------------------------------------
            Parameter    Standard
Variable    Estimate     Error       t-value
-----------------------------------------------
Automatically Identified Outliers:
2008.Jul    3.0297       0.20279     14.94
-----------------------------------------------
```

3. Consider a country entering and then recovering from an economic downturn, as quantified in the table below. For simplicity, assume that consumers purchase only two types of item, luxuries and necessities, with equal expenditure on each in 2007. The relatives shown in the table all have 2007 as the base period.

	2007	*2008*	*2009*	*2010*	*2011*
Price relative of luxuries	100	99	80	85	90
Volume relative of luxuries	100	90	70	80	100
Price relative of necessities	100	100	100	101	103
Volume relative of necessities	100	99	98	99	100

The following notation is used:
$v(t, i)$ is the expenditure on any item i in any period t;
$R(s, t, i)$ is the price relative for any item i comparing any year t with any year s;
$R^*(s, t, i)$ is the volume relative for any item i comparing any year t with any year s.

(i) Explain why $v(t, i)$, the expenditure on item i (either luxuries or necessities) in any year t, can be expressed as

$$v(t, i) = v(07, i)\frac{R(07, t, i)}{100}\frac{R^*(07, t, i)}{100}$$

where $v(07, i)$ is the expenditure on item i in 2007,
$R(07, t, i)$ is the price relative for item i comparing year t with 2007,
$R^*(07, t, i)$ is the volume relative for item i comparing year t with 2007.
(1)

(ii) The Laspeyres volume index Q_L for period t with period s as the base period can be written

$$Q_L(s, t) = \frac{\sum_i R^*(s, t, i)v(s, i)}{\sum_i v(s, i)}.$$

Prove that this can be expressed as

$$Q_L(s,t) = \frac{\sum_i R^*(s, t, i)R(07, s, i)R^*(07, s, i)}{\sum_i R(07, s, i)R^*(07, s, i)}.$$ (6)

(iii) For each year in the table above, calculate the chain-linked Laspeyres volume index, introducing a new base period in each of 2008, 2009, 2010 and 2011. Use 2007 as the reference period throughout. (10)

(iv) Without calculation, give the Laspeyres volume index for 2011 using 2007 as the base period. State why no calculation is necessary. (2)

(v) Considering your answer to part (iv), state why the chain-linked Laspeyres volume index for 2011 calculated in part (iii) is undesirable. (1)

4. (i) There are various ways in which index numbers can be applied to motor fuel consumption. One such way is to treat distance travelled per litre of fuel as being analogous to prices for economic index numbers, and the amount of fuel consumed as analogous to quantity. What variable is analogous to value (the product of price and quantity)?

(1)

(ii) State a formula for the Laspeyres "distance per litre" index, and a formula for the Paasche "distance per litre" index, in each case with period 0 as the base period and period t as the current period.

(4)

(iii) At the end of 2011 a company, wishing to reduce its expenditure on fuel, sent its employees on an "efficient driving" course. The table below gives data on the use of fuel and distance travelled by company employees on official business. Calculate the Laspeyres, Paasche and Fisher "distance per litre" indices for 2012, using 2011 as the base period. What do these indices tell us about the overall fuel efficiency of the company's drivers since attending the course?

(15)

Fuel type	*Distance travelled in 2011 (thousands of km)*	*Amount of fuel consumed in 2011 (thousands of litres)*	*Distance travelled in 2012 (thousands of km)*	*Amount of fuel consumed in 2012 (thousands of litres)*
Petrol (standard)	800.3	105.3	989.0	122.1
Petrol (high octane, used in high performance supercars only)	20.1	10.6	1.2	0.8
Diesel fuel	1135.4	89.4	1126.5	93.1

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