EXAMINATIONS OF THE ROYAL STATISTICAL SOCIETY

HIGHER CERTIFICATE IN STATISTICS, 2011

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. $\log_{10}$.

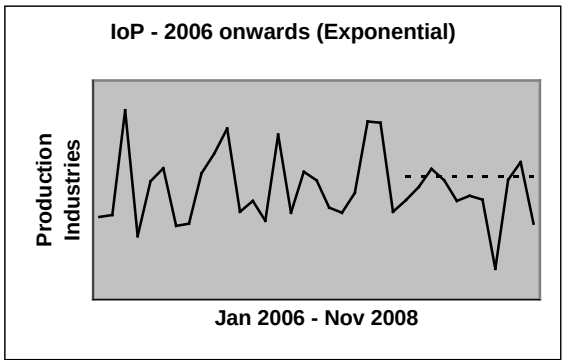
Note also that $\binom{n}{r}$ *is the same as* ${}^nC_r$.

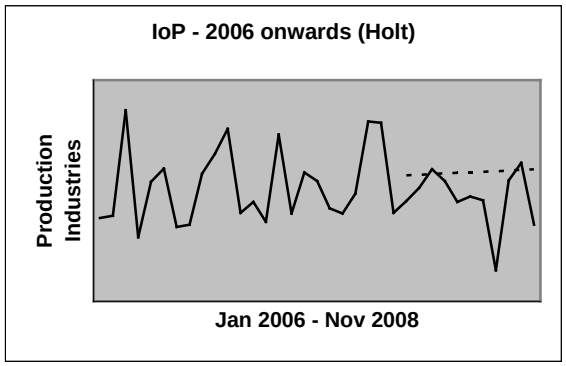
This examination paper consists of 6 printed pages **each printed on one side only**.
This front cover is page 1.
Question 1 starts on page 2.

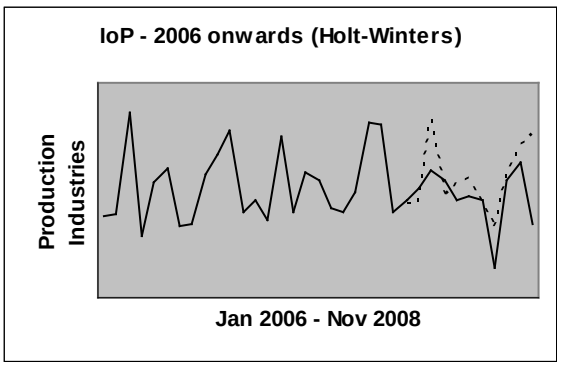
There are 4 questions altogether in the paper.

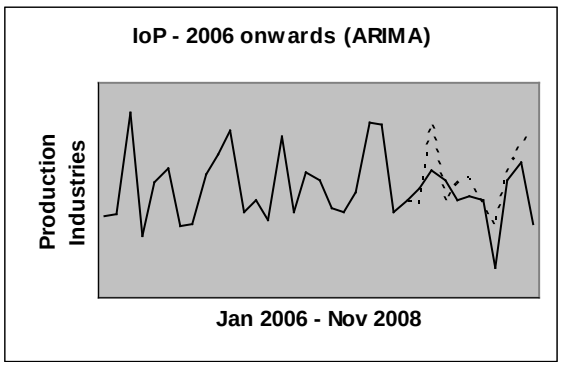
1. (i) Give a brief description of how you would decide between applying the following four methods of forecasting: simple (one parameter) exponential smoothing, Holt's (two parameter) exponential smoothing, Holt-Winters (three parameter) exponential smoothing, ARIMA. (8)

(ii) The solid line in each of the graphs below shows the monthly UK Index of Production time series for the period January 2006 to November 2008. The dotted lines show the forecasts for January to November 2008 based on data from January 1986 to December 2007, using the four different forecasting methods given in part (i).









The table below summarises the percentage prediction error (PE) and percentage absolute prediction error (APE) of the four forecasting methods.

Method	*Measure*	*Min*	*Max*	*Mean*	*Standard Deviation*
Exponential	PE	–1.87	14.19	3.01	4.41
	APE	0.45	14.19	3.53	3.96
Holt	PE	–0.94	15.09	3.66	4.52
	APE	0.63	15.09	3.94	4.25
Holt-Winters	PE	–2.48	12.83	2.58	4.61
	APE	0.45	12.83	3.69	3.68
ARIMA	PE	–3.04	13.22	2.50	4.74
	APE	0.40	13.22	3.75	3.73

(a) Which method seems to work best? Justify your choice based on the results as shown in the graphs and table. (5)

(b) By reviewing the theoretical properties of each forecasting method, suggest a hypothesis regarding the structure of the time series that would explain why your chosen method works best. How would you test this hypothesis? (7)

Turn over

2. The following table contains a time series of estimates of exports (in millions of pounds).

	Q1	*Q2*	*Q3*	*Q4*
1996	771	1016	1519	1013
1997	775	1010	1542	1027
1998	807	1086	1543	1076
1999	858	1034	1516	1027
2000	831	1113	1562	1051
2001	875	972	1434	854
2002	746	1008	1491	1044
2003	799	975	1524	1079
2004	855	1150	1660	1197
2005	987	1272	1728	1335
2006	1073	1423	2003	1432
2007	1160	1390	2056	1480
2008	1208	1521	2036	1417
2009	1169	1454	2030	1432

(i) Calculate a 4-term symmetric moving average of the data from Q1 of 2007 to Q4 of 2009. Next calculate a 2-term symmetric moving average of the averages just calculated. Explain why the two-stage average constructed in this way may be appropriate as part of the analysis of this time series, and state what component of the underlying time series you have estimated. How many terms are there in the series of two-stage averages you have calculated, and what potential problems are there in using your calculated series in the seasonal adjustment process? Describe a method to address these potential problems, and discuss its benefits and drawbacks.

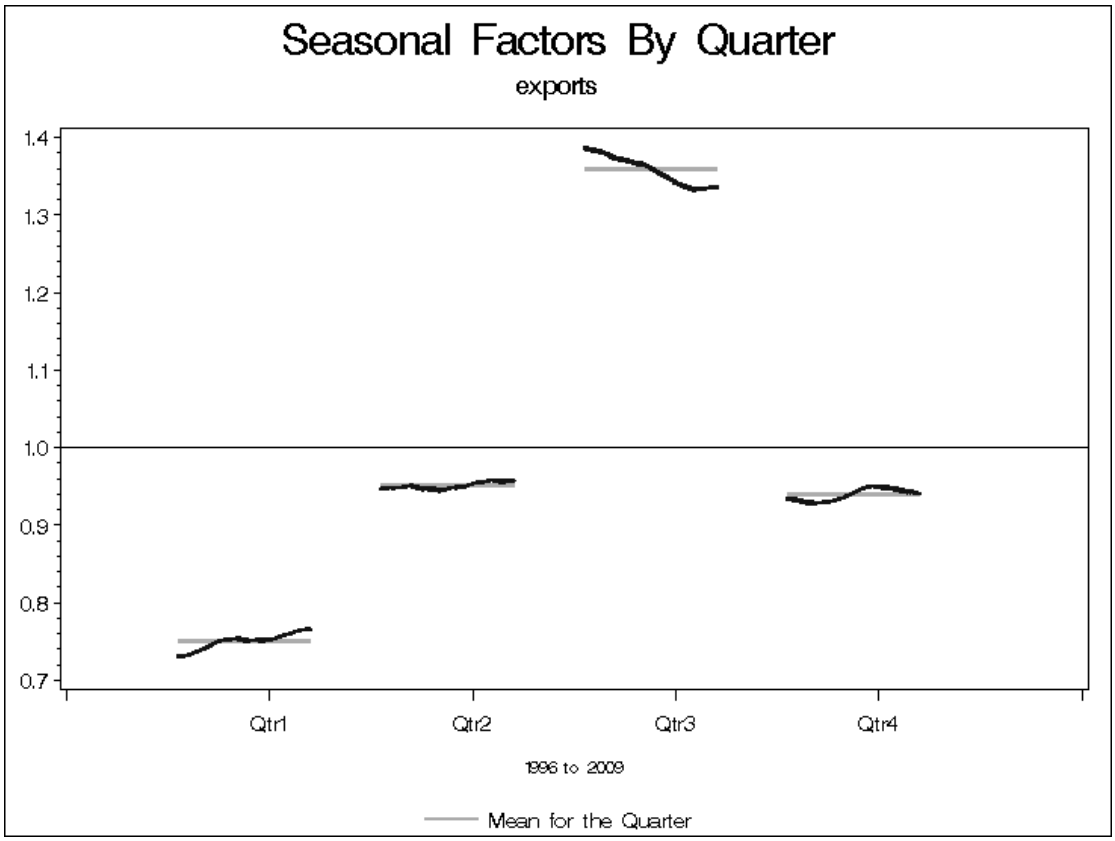
(10)

(ii) The figure **on the next page** is a graph of the seasonal factors. Discuss what the graph tells you about (a) indications for seasonality, (b) issues with seasonality, for this series. What actions could be taken to ensure appropriate seasonal adjustment? Briefly explain how to seasonally adjust the series.

(10)

The figure for part (ii) is on the next page

Turn over


Seasonal Factors By Quarter
exports
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
Qtr1
Qtr2
Qtr3
Qtr4
1996 to 2009
Mean for the Quarter

Turn over

3. (i) Prove that the ratio of the Paasche price index to the Paasche volume index is equal to the ratio of the Laspeyres price index to the Laspeyres volume index when these indices are calculated from the same data.

(6)

(ii) Starting from the Paasche price index formula expressed as a function of prices and quantities, show that this index can be expressed as a weighted harmonic mean of price relatives. State what the weights are.

(5)

(iii) Show that the Paasche price index can also be expressed as a weighted arithmetic mean of price relatives. State what the weights are.

(5)

(iv) The formula for the Walsh price index is

$$P_W\left(0,t\right)=\frac{\sum_i p_{ti}\sqrt{q_{0i}q_{ti}}}{\sum_i p_{0i}\sqrt{q_{0i}q_{ti}}}$$

where P_W is the index, 0 is the base period, t is the current period, p represents price, q represents quantity and i identifies commodities contributing to the index.

Show that this index can also be expressed as a weighted arithmetic mean of price relatives. State what the weights are.

(4)

Turn over

4. (i) Prove that the growth of a Paasche price index from some period 1 to a later period 2, where the base period is some earlier period 0, is equal to the growth in value from period 1 to period 2 divided by the growth in the corresponding Laspeyres volume index from period 1 to period 2.

(5)

(ii) The table below gives some data on the sales of a tea and coffee market stall. Using these data:

(a) Calculate the Paasche price index for 2010, using 2008 as the base period.

(3)

(b) Calculate the chain-linked Paasche price index for 2010, introducing and linking a new base period in 2009.

(7)

(c) Calculate the chain-linked Paasche tea price index (loose and bags) for 2010.

(2)

(d) Calculate the chain-linked Paasche coffee price index for 2010 (hint: because there is only one coffee commodity, the algebra simplifies).

(2)

(e) State what is surprising about the values of the indices in parts (b) to (d).

(1)

Commodity	*Price increase from 2008 to 2009*	*Price increase from 2009 to 2010*	*Value of sales in 2009*	*Value of sales in 2010*
Loose leaf tea	0%	0%	1	1
Tea bags	100%	50%	40	45
Ground coffee	50%	100%	180	450