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Modelling the seasonality of hotel nights in Denmark by county and nationality

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Abstract

Over the past few decades preferences for holidays have changed. Today people are more inclined to separate their holidays into several sub-periods, giving them the opportunity for summer as well as winter breaks. When people are on holiday, they consume accommodation such as residential house nights, camping nights, hotel nights, etc. Therefore, a change in their preferences should be reflected in the seasonal pattern of the type of accommodation under consideration. In the present case, the seasonal variation of hotel nights in Denmark will be examined[1].

Such an analysis may be important for several reasons. Consider, as an example, the hotel demand for labour. During the peak season demand will be high, with an increasing wage rate, and off-season the unemployment rate will increase. In an economy with low mobility, and partly public financed unemployment benefits as is the case in Denmark, this situation is surely not optimal. Due to the lack of monthly labour market statistics for the sector, the presence of reliable monthly statistics on hotel nights provides the point of departure for the present analysis[2].

This change in the preferences of holiday makers has not only occurred for Danes, but throughout the world. Consequently, the data set used on hotel nights for Denmark is divided into 13 different nationalities. In order to consider the regional dimension, data are divided into the counties of Denmark. The period examined ranges over nearly 30 years with monthly observations.

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Background material, in the form of the data set used and detailed plots of all series, is available from the author. For the statistical analyses programming was done in PcGive/PcFiml 8.1 and WinRATS 4.3.

Introduction

Traditionally, the seasonal variation has been modelled by assuming deterministic seasonality, ie setting up a simple univariate model in which the variation is explained by seasonal dummies. Implicitly this method assumes that the seasonal variation expressed by the estimates of the dummy variable coefficients is constant in time. However, this modelling procedure may be inconsistent with the commonly used definition of seasonality in economics proposed in Hylleberg.[3] Here seasonality is defined as follows:

Seasonality is the systematic, although not necessarily regular, intra-year movement caused by the changes of the weather, the calendar, and timing of decisions, directly or indirectly through the production and consumption decisions made by the agents of the economy. These decisions are influenced by endowments, the expectations and preferences of the agents, and the production techniques available in the economy.

If seasonality is *systematic*, and also *not regular* in nature, this should be reflected in the choice of the model used for analysing seasonality. The unit root model captures these features. Here seasonality is modelled in a stochastic manner. Hylleberg, Jørgensen and Sørensen,[4] for example, used this stochastic univariate approach, and examined a large number of quarterly and monthly macroeconomic time series covering many variables and OECD countries. They found that a varying and changing seasonal component is a common phenomenon in many time series.

The paper is organized as follows. The second section, below, presents a test for seasonal unit roots at the monthly frequency. The subsequent section is the empirical application. It also gives a description of the data set used and presents some graphical tools to accompany the analysis. In the final section, conclusions are drawn.

Theoretical considerations[5]

A time series model with seasonal unit roots is an approximation that allows for changes in the seasonal pattern, ie integration at the seasonal frequencies. A test for seasonal unit roots in the quarterly case is developed by Hylleberg, Engle, Granger and Yoo,[6] and extended to the monthly case by Beaulieu and Miron[7] and Franses[8].

For a given time series variable x_t a univariate model integrated at all the seasonal frequencies as well as the long-run frequency is $(1-B^{12})x_t = \varepsilon_t \sim i.i.d(0,\sigma^2),\ t = 1,2,..,T,$ where B is the lag operator defined as $B^n x_t = x_{t-n}$. Franses[9] proved that an AR(p) process of the form $\varphi(B)x_t = \varepsilon_t$, using a proposition given in Hylleberg, Engle, Granger and Yoo[10] defining the form of $\varphi(B)$, in the monthly case can be written as

$$\begin{aligned}(1-B^{12})x_t = y_{8t} &= \pi_1 y_{1t-1} + \pi_2 y_{2t-1} + \pi_3 y_{3t-1} + \pi_4 y_{3t-2} \\ &+ \pi_5 y_{4t-1} + \pi_6 y_{4t-2} + \pi_7 y_{5t-1} + \pi_8 y_{5t-2} \\ &+ \pi_9 y_{6t-1} + \pi_{10} y_{6t-2} + \pi_{11} y_{7t-1} + \pi_{12} y_{7t-2} + \varphi^{\Delta}(B) y_{8t} + \mu_t + \varepsilon_t \qquad (1)\end{aligned}$$

In this equation x_t is a linear combination of the variables y_i, $i=1,...,8$. These variables are all various transformations of x_t. In all there are 12 coefficients π_j, $j=1,...,12$ to be estimated by applying OLS to equation (1). The coefficients of the π's correspond to the 12 solutions of the equation $(1-B^{12})=0$ all lying on the unit cycle.

The test for monthly seasonal unit roots can then be performed as a test of whether or not the coefficients are lying on the unit cycle. There will be *no* seasonal unit root if the coefficient to a given π is significantly different from zero. If the coefficient is insignificant, a unit root is present showing a changing seasonal component.

Consider as an example a situation in which *all* the π's are significantly different from zero. Consequently, no seasonal unit roots are present, and the data have a deterministic or constant seasonal pattern. Only in this case is the dummy variable model appropriate; ie by applying the filter $(1-B^{12})$ the time series x_t, will become stationary.

The transformations y_i $i=1,...,8$ of x_t remove the seasonal unit roots at certain frequencies while preserving them at other frequencies. For example $y_{1t} = (1+B)(1+B^2)(1+B^4+B^8)x_t = (1+B+B^2+.....+B^{11})x_t$ is a transformation which removes the seasonal unit roots and preserves the long-run or zero-frequency unit root.

The remaining transformations are $y_{2t} = -(1-B)(1+B^2)(1+B^4+B^8)x_t$, which preserves the frequency 6/12 corresponding to a six month period; $y_{3t} = -(1-B^2)(1+B^4+B^8)x_t$, which retains the frequency 3/12 (9/12) corresponding to a four month period; $y_{4t} = -(1-B^4)(1-\surd 3B+B^2)(1+B^2+B^4)x_t$, which leaves behind the frequency 5/12 (7/12); while $y_{5t} = -(1-B^4)(1+\surd 3B+B^2)(1+B^2+B^4)x_t$, $y_{6t} = -(1-B^4)(1-B+B^2)(1-B^2+B^4)x_t$, $y_{7t} = -(1-B^4)(1+B+B^2)(1-B^2+B^4)x_t$ retains the frequencies 1/12 (11/12), 4/12 (8/12) and 2/12 (10/12). Finally $y_{8t} = (1-B^{12})x_t$. A survey of the data transformations and test hypothesis is given in Table 1.

The test for seasonal unit roots at the relevant seasonal frequencies can then be performed either as t-tests for the estimates of $\pi_3,...,\pi_{12}$ or as joint F-tests for sets of parameters, ie π_3 and π_4 etc. The t-ratios corresponding to the estimates of π_1 and π_2 follow the Dickey-Fuller distributions. All critical values of the test have a non-standard distribution and have to be simulated by Monte Carlo experiments. Critical values are obtained from Franses and Hobijn.[11] Equation (1) is an extension of the Dicky-Fuller auxiliary regression for a zero-frequency unit root with augmented lagged values of the left-hand side variable.

Table 1. Testing for seasonal unit roots in monthly data.

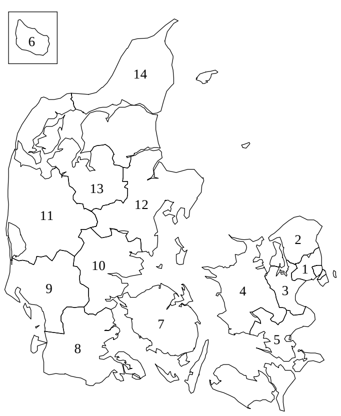
No.	Frequency			Transformation	H_0: Unit Root	H_1: No Unit Root
0	0		long-run	$y_{1t} = (1+B+B^2+..+B^{11})x_t$	$\pi_1 = 0$	$\pi_1 < 0$
1	6/12		semi-	$y_{2t} = -(1-B)(1+B^2)(1+B^4+B^8)x_t$	$\pi_2 = 0$	$\pi_2 < 0$
2			annual	$y_{3t} = -(1-B^2)(1+B^4+B^8)x_t$	$\pi_3 \cap \pi_4 = 0$	$\pi_3 \cup \pi_4 \neq 0$
3	3/12	(9/12)	quarterly	$y_{4t} = -(1-B^4)(1-3\surd B+B^2)(1+B^2+B^4)x_t$	$\pi_5 \cap \pi_6 = 0$	$\pi_5 \cup \pi_6 \neq 0$
4	5/12	(7/12)	monthly	$y_{5t} = -(1-B^4)(1+3\surd B+B^2)(1+B^2+B^4)x_t$	$\pi_7 \cap \pi_8 = 0$	$\pi_7 \cup \pi_8 \neq 0$
5	1/12	(11/12)	monthly	$y_{6t} = -(1-B^4)(1-B+B^2)(1-B^2+B^4)x_t$	$\pi_9 \cap \pi_{10} = 0$	$\pi_9 \cup \pi_{10} \neq 0$
6	4/12	(8/12)	monthly	$y_{7t} = -(1-B^4)(1+B+B^2)(1-B^2+B^4)x_t$	$\pi_{11} \cap \pi_{12} = 0$	$\pi_{11} \cup \pi_{12} \neq 0$
	2/12	(10/12)	monthly			

Note: Critical values can be obtained from P.H. Franses and B. Hobijn, 'Critical values for unit root tests in seasonal time series', *Journal of Applied Statistics*, Vol 24, 1997, pp 25-47.

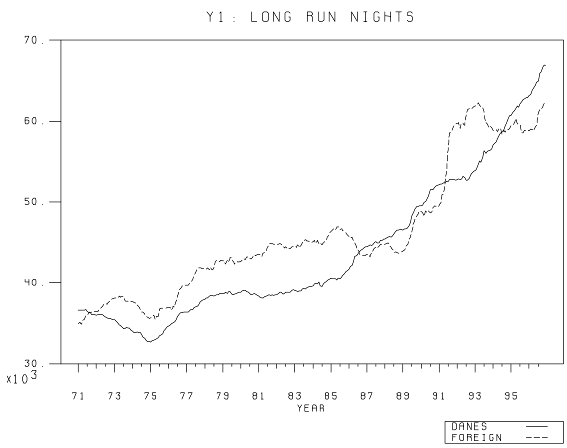
Finally, two more points concerning equation (1) should be made. First, μ_t is the included deterministic component such as a constant, a trend, and seasonal dummy variables. The test can be performed without these components, but the critical values will then change. Also, in this case critical values can be found in Franses.[12]

Second, equation (1) has to be augmented by lagged y_{8t}. This is done in order to make the residuals white noise, and leaves the asymptotic distribution unaffected. The power is negatively affected if too many nuisance parameters are used in the augmentation. In the present case, a strategy to determine $\varphi^{\Delta}(B)$ has been to start with 24

Figure 1. Counties of Denmark and hotel nights attributable to Danes and foreigners.



1. Copenhagen
2. Frederiksborg
3. Roskilde
4. West Zealand
5. Storstroem
6. Bornholm
7. Funen
8. South Jutland
9. Ribe
10. Vejle
11. Ringkoebing
12. Aarhus
13. Viborg
14. North Jutland



lags equalling two years, and then test down the significant augmented variables by carefully inspecting the test statistics for autocorrelation.

Testing for seasonal unit roots in Danish hotel nights

A databank has been set up covering monthly series from 1970.1 to 1996.12 by use of material from the regular publications on hotel nights supplied by Statistics Denmark. All series contain 324 observations. Data are divided into 16 geographical areas (counties), and 14 different nationalities. Before 1970 the geographical areas of many counties of Denmark were different. A map with the geographical location of the counties of Denmark is provided in Figure 1.

In 1996 the total number of hotel nights in Denmark amounted to about 12.9 million, equivalent to an increase of about 80% since 1970. With regard to nationality, half the hotel nights are attributable to Danes, and half to foreign nationals. The graph in Figure 1 displays the long-run transformation y_{1t} of hotel nights by Danes (solid line) and foreigners respectively. The division of hotel nights between Danes and foreigners has remained relatively constant throughout the period. Notice also that the number of hotel nights has been affected by external events such as the slump in the mid-1970s. From the mid-1980s the pattern of hotel nights consumed by foreigners seems to have become more volatile, perhaps due to variations in taste or fluctuations in the exchange rate for some important foreign visitors. Tables 2 and 3 give some summary statistics.

Hotel nights by county

From Table 2 it can be seen that more than one-quarter of the hotel nights recorded are in the Copenhagen city area. Here, there are conference facilities as well as major Danish tourist attractions (for example the Tivoli amusement park, the royal residence Amalienborg, and the Little Mermaid). In addition, hotel accommodation is the natural choice in a larger city. Other counties with significant shares of hotel nights are Storstroem, Bornholm, Funen, Aarhus and North Jutland. Storstroem, Bornholm, and North Jutland are rural areas with beaches, etc, whereas the second and third largest cities of Denmark are located in the counties of Aarhus (Aarhus) and Funen (Odense - the birthplace of the Danish fairytale writer H.C. Andersen) respectively.

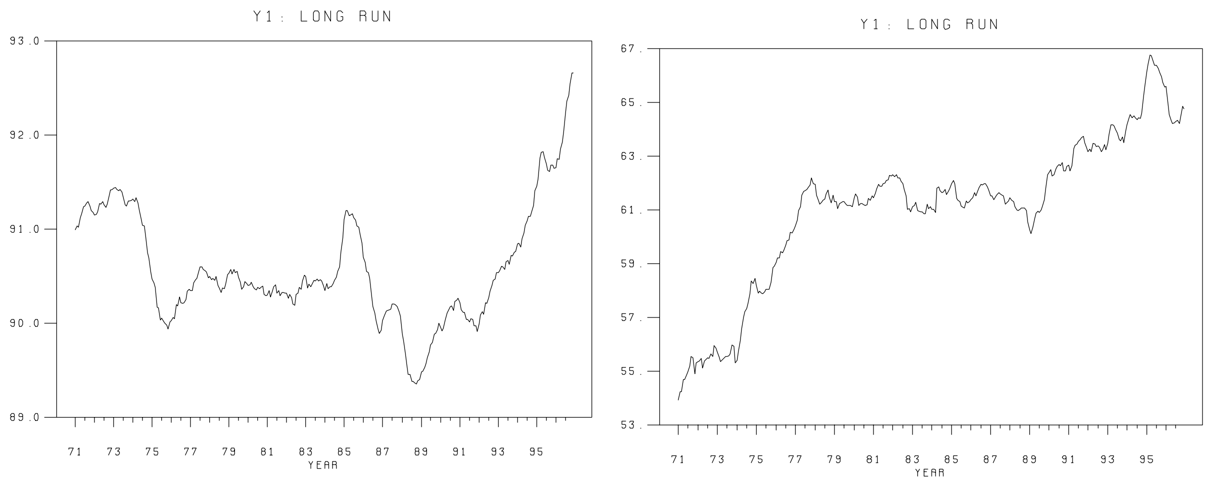
As stressed earlier, the number of hotel nights has increased by about 80% during the period. Above-average increases have taken place especially in the rural counties, whereas growth has been almost non-existent for the Copenhagen city area. However, compared with the county population, Copenhagen city is still very significant. But the most important area is the island of Bornholm with more than 12 hotel nights per inhabitant annually. In sum, the division of hotel nights has become more regional.

Table 2. Summary statistics on hotel nights in Denmark by county, 1970.1 to 1996.12.

County	Share	Growth, 1996	Nights, 1996	Coefficient of variation, *CV*			
	Average, %	Index	Relative to county	1970.1 - 1979.12	1980.1 - 1989.12	1990.1 - 1996.12	1970.1 - 1996.12
Denmark total	100.0	181	2.46	0.49	0.46	0.45	0.50
Copenhagen city	26.8	112	5.05	0.37	0.31	0.33	0.34
Copenhagen	4.9	141	0.97	0.35	0.38	0.36	0.37
Frederiksborg	2.9	121	1.06	0.48	0.39	0.40	0.44
Roskilde	1.1	210	0.69	0.36	0.33	0.32	0.44
West Zealand	1.5	132	0.67	0.42	0.39	0.21	0.42
Storstroem	5.5	419	4.04	0.54	0.60	0.49	0.89
Bornholm	6.4	183	12.31	1.35	1.20	1.09	1.22
Funen	7.2	176	1.92	0.43	0.38	0.39	0.44
South Jutland	4.5	187	2.25	0.54	0.58	0.58	0.62
Ribe	4.5	254	2.94	0.61	0.47	0.54	0.59
Vejle	4.3	225	1.93	0.39	0.36	0.40	0.47
Ringkoebing	4.4	262	2.02	0.60	0.51	0.46	0.61
Aarhus	8.8	164	1.79	0.37	0.37	0.42	0.43
Viborg	2.8	254	1.78	0.54	0.55	0.52	0.60
North Jutland	14.3	339	4.65	0.66	0.62	0.57	0.72

Note: The percentage shares are computed on the mean values for the full period, and consequently do not sum to 100%. The computations in the second and third columns are on annual data cumulatively aggregated from the monthly observations. In the second column the growth index is with the 1970 set equal to 100. In the third column the figures measure the number of hotel nights relative to the total population in the county. In the last four columns, *CV* is the coefficient of variation computed using the non-transformed data and defined as: *CV* = standard deviation divided by the mean.

Figure 2. The logarithm of hotel nights: Copenhagen city and Bornholm, long-run, y_{1t}



Copenhagen city

Bornholm

The evolution of the number of hotel nights is further investigated in Figure 2, which shows the long-run transformation y_{1t} for the two most important areas of Denmark, Copenhagen city and the county of Bornholm. The picture is very diversified. For Copenhagen city the economic crisis in the 1970s surely affected the number of hotel nights. This could be due to the large number of foreign visitors (see below). Since the end of 1980s the number of hotel nights has increased quite dramatically. The peak in the mid-1980s could be due to variations in the US dollar exchange rate. As can be seen from the right-hand graph of Figure 2, the island of Bornholm, located in the Eastern Sea, was not affected at all by the oil crises in the 1970s. This could be due to the fact that Danes, Swedes, and Germans substituted a holiday closer to home for their usual trip to the Mediterranean region. For both counties an increased growth in the number of hotel nights is evident at the end of the 1980s.

The coefficient of variation indicating the relative variation of the time series takes the highest value for the county of Bornholm. This could suggest large variations between summer and winter - ie a very significant seasonal pattern. As shown later in Figure 4, this in fact proved to be the case. Compared with the sub-periods for the whole of Denmark, the coefficient of variation has remained almost constant throughout the period. At county level the coefficient of variation has decreased in nine cases, remained constant in five cases, and increased in only one case (for the county of Aarhus). This decrease in seasonal variation could be taken as an indicator of changed preferences for holidays, ie a decrease in the seasonal variation. As is evident from Table 2 this change took place in many counties from the 1970s to the 1980s.

Hotel nights by nationality

Turning to the number of hotel nights divided by nationality, this is shown in Table 3.

The most important foreign consumers of hotel nights in Denmark are Germans, Swedes and Norwegians; in other words people from the neighbouring countries. Tourists from these three nations account for more than half the foreign hotel nights. Overall, the number of hotel nights consumed by foreigners has doubled over the period. Interesting exceptions are observed for Norwegians, who show an increase of over 300%, and the decreased significance of hotel nights consumed by Americans.

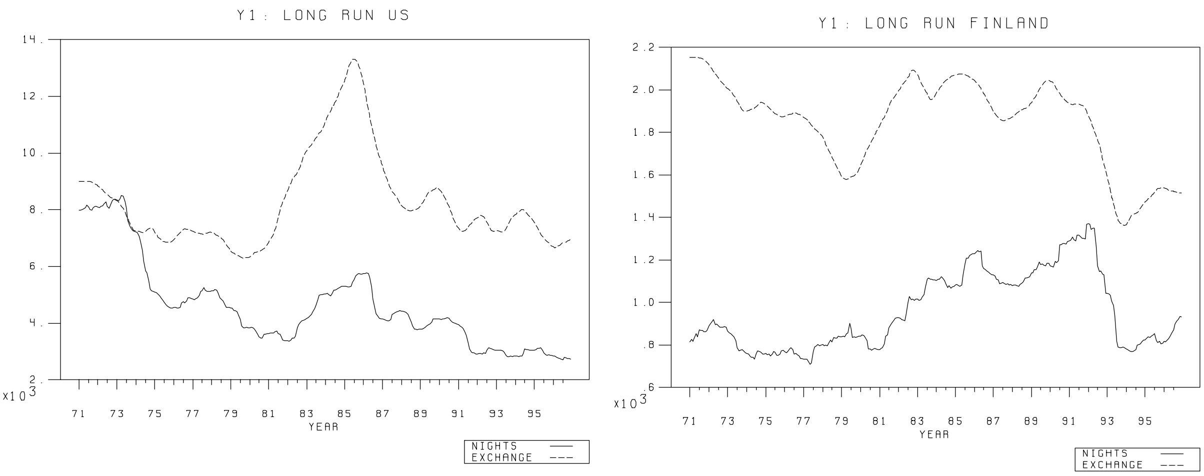
Figure 3 (left-hand graph) shows the long-run transformation y_{1t} of the hotel nights (solid line) by Americans and the US dollar exchange rate.[13] The decrease in hotel nights was already in evidence at the beginning of the 1970s. This pattern should not necessarily be taken as an indicator of a decreasing number of foreign visitors, but alternatively as an indicator of a shorter visiting period. Notice the close similarity between the exchange

Table 3. Summary statistics on hotel nights in Denmark by nationality, 1970.1 to 1996.12.

Nationality	Share	Growth, 1996	Nights, 1993	Coefficient of variation, *CV*			
	Average, %	Index	Relative to home	1970.1 - 1979.12	1980.1 - 1989.12	1990.1 - 1996.12	1970.1 - 1996.12
Danes	48.8	182	1.089	0.25	0.24	0.26	0.32
Foreigners, total	51.2	179		0.72	0.71	0.69	0.73
Swedes	11.2	226	0.165	0.65	0.65	0.65	0.73
Norwegians	6.0	421	0.182	0.91	1.19	1.15	1.29
Finns	1.1	121	0.015	0.59	0.79	0.80	0.76
Germans	13.4	239	0.021	1.10	0.96	0.85	0.99
English	3.3	149	0.005	0.42	0.50	0.49	0.50
Dutch	1.4	191	0.012	0.83	0.68	0.90	0.88
French	0.9	94	0.001	0.71	0.57	0.48	0.62
Italians	1.1	201	0.002	0.62	0.94	1.08	1.02
Rest of Europe	3.2	148		0.48	0.50	0.49	0.52
Americans (USA)	5.1	34	0.001	0.86	0.75	0.69	0.87
Japanese	1.0	205	0.008	0.46	0.52	0.65	0.57
Rest of world	3.7	200		0.49	0.45	0.38	0.48

Note: The percentage shares are computed on the mean values for the full period, and consequently do not sum to 100%. The computations in the second and third columns are on annual data cumulatively aggregated from the monthly observations. In the second column the growth index is with the 1970 set equal to 100. In the third column the figures measure the number of hotel nights relative to the total population in the home country. In the last four columns *CV* is the coefficient of variation computed using the non-transformed data and defined as: *CV* = standard deviation divided by the mean.

Figure 3. Hotel nights and exchange rates: Americans and Finns, long-run, y_{1t}



Americans (USA)

Finns

rate and the number of hotel nights, suggesting a cointegrating relation at the long-run frequency. Particularly noticeable is the increase in hotel nights in the mid-1980s due to the market power of the strong US dollar.

The finding that economic changes in the home county affect the number of hotel nights in Denmark is also applicable to many other nationalities. For example, the right-hand graph of Figure 3 depicts the long-run transformation y_{1t} of the hotel nights (solid line) by Finns and the exchange rate of the Finnish Mark. The impact of the Finnish depression following the break-down of the trade with the former Soviet Union at the beginning of the 1990s is clearly demonstrated. In addition, very similar patterns in the two series can be observed.

For many nationalities, a relationship between the number of hotel nights and the exchange rate can be found. However, this depends on the exchange rate relationship between the relevant currency and the Danish Kroner. For example, the German Mark is found not to be influential on the number of hotel nights consumed by Germans in Denmark, perhaps due to the fixed exchange rate system between the two currencies. On the other hand, a shift in preferences away from Denmark in the 1980s is discernible.[14] In general, economics is of more importance in foreigners' consumption of Danish hotel nights than the climate. It can be shown that a variable such as the average temperature turns out to be a poor indicator of the hotel nights.

Overall, the coefficient of variation for foreigners exceeds that for Danes for the full period as well as for the sub-periods. This is not surprising. Foreigners' demand for hotel nights is high during the holiday season, and is also affected by their domestic economy, travel distance etc, whereas Danes can easily visit another part of the country throughout the year. For the full period, the highest coefficient of variation is found for Norwegians, Germans and Italians.

Comparing it with the evidence presented in Table 2, the evolution of the coefficient of variation within sub-periods is quite different. Of the 12 nationalities considered, the coefficient of variation has increased in six cases, remained constant in three cases, and decreased in three cases. An increase could be taken as indicative of a more significant season - ie that people only want to visit Denmark during the summer, at Easter, and so on. This is the case for Norwegians and Finns, but also for visitors from a number of countries further away, including Japan and Italy. As for German, French and American visitors, the season seems to have become longer.

Results of testing for monthly seasonal unit roots

The results of applying the auxiliary regression (1) are set out in Table 4. The test strategy for augmentation has been applied along the lines described earlier.

It is evident from the material that a varying and changing seasonal pattern is a common phenomenon with regard to both counties and nationality. The seasonal pattern has varied considerably in six of the counties investigated and for six nationalities.

For the counties in which the number of hotel nights is concentrated, the seasonal pattern is varying for Copenhagen city, Storstroem, and North Jutland, whereas the pattern is quite constant for the island of Bornholm. Given that it is a rather isolated rural area this could be a problem for the island, which over the past decade has faced a decreased population and increased unemployment rate.[15]

Table 4. Results of HEGY-tests for monthly unit roots in hotel nights in Denmark.

Nights by county	Unit roots at:	Nights by nationality	Unit roots at:
Denmark total	0, 2, 4, 5, 6	**Danes**	0, 2, 4, 5, 6
		Foreigners, total	0, 2, 4
Copenhagen city	0, 2, 4, 6		
Copenhagen	2, 4	Swedes	0, 2, 4, 6
Frederiksborg	0, 1, 2	Norwegians	0, 1, 2, 4
Roskilde	2, 4	Finns	0, 1, 2, 4
West Zealand	0, 2, 4, 6		
Storstroem	0, 1, 2, 3	Germans	0, 2, 4
Bornholm	0, 2	English	0, 1, 2, 4, 6
Funen	0, 2	Dutch	0, 1, 2, 5
		French	0, 2, 4
South Jutland	0, 1, 2, 3	Italians	0, 1, 2, 4, 6
Ribe	0, 2, 4	Rest of Europe	0, 2, 4
Vejle	0, 1, 2, 4		
Ringkoebing	0, 2, 4	Americans (USA)	0, 2, 4
Aarhus	0, 2	Japanese	1, 2, 4
Viborg	0, 4	Rest of world	2, 4
North Jutland	0, 2, 4, 5		

Note: See Table 1 for a description of the frequencies. Results from the auxiliary regression of equation (1) include a constant term, trend, and 11 seasonal dummies. Estimation period 1970.1 to 1996.12. Detailed regression results with augmentation, etc can be obtained on request from the author.

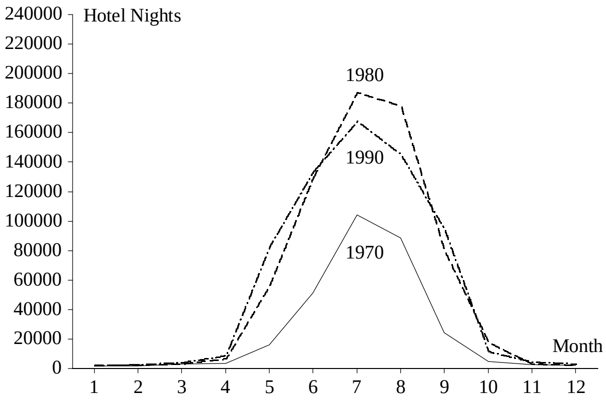
With regard to nationality, the seasonal pattern has been most varying for all the Scandinavian nationalities, and for English and Italian visitors. The most stable pattern is observed for Germans, Americans, and Japanese using hotels in Denmark.

Finally, it should be noted that the seasonal pattern of the aggregated series for hotel nights in Denmark seems to preserve the seasonal unit roots found at county level, whereas the picture is unclear with regard to nationality.

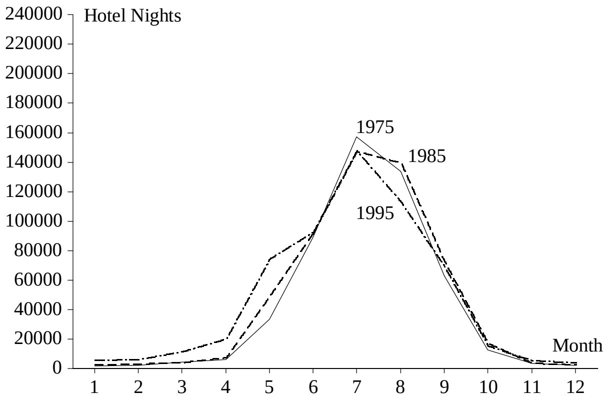
Graphical analysis

The question of whether the seasonal component in a time series is best described by a model with non-changing seasonal patterns - ie a dummy variable model - or by a model which allows the seasonal pattern to change is difficult to resolve. It may therefore pay to rely on other means of analysis than the test presented.

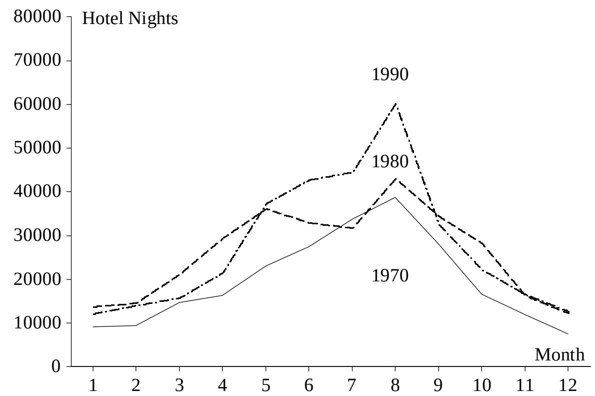
Figure 4. Bays-Ballot plots of hotel nights: the county of Bornholm and English visitors.



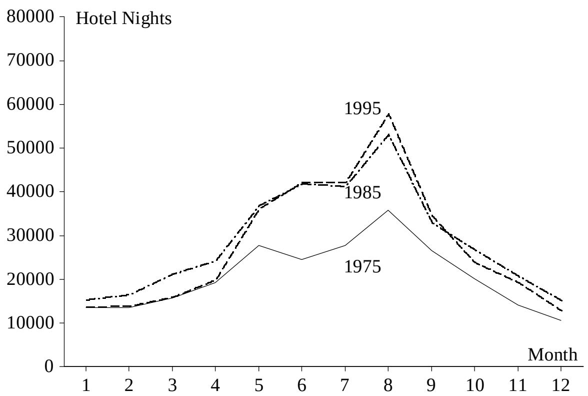
Bornholm, all nationalities



Bornholm, all nationalities



English, Denmark total



English, Denmark total

It is recommended that the test should be accompanied by a full graphical analysis of the transformed data - ie the transformations y_{1t} to y_{8t}. The Appendix presents a full graphical analysis of the logarithm of the hotel nights for Denmark total. As seen from Table 4, seasonal unit roots are present at many frequencies. Here pictures looking like ARCH processes are observed (ie a process with a positively autocorrelated variance and changing amplitude). In a case in which seasonal unit roots were not present one would expect the graphs to depict very regular processes with a quite constant amplitude.

There are two ways to simplify the graphical analysis. First, as proposed by Franses,[16] one could use a graph of the first quarter, second quarter, etc. However, in the monthly case, with $q_{i\tau}$, $i=1,2,....,12$, $\tau=1,2,...,T/12$ this complicates matters.[17] Consider as an alternative the use of the so-called Bays-Ballot plots, in which the series are depicted against the number of the month.[18] Figure 4 shows two examples - for the island of Bornholm, and for English visitors to Denmark. In the case of a constant seasonal pattern the yearly lines should be almost parallel. Evidently, and consistent with the test results reported in Table 4, the seasonal pattern for Bornholm is more stable than the seasonal pattern for the English. With regard to English visitors, the seasonal pattern seems to vary especially during the spring. Compared to Bornholm the travel season for the English is much longer, and concentrated over the spring and summer with the peak in August. For Bornholm, the peak is constant in July with a large range of variation over the year consistent with the results in Table 2.

Conclusion

It is found that a varying and changing seasonal component is a common phenomenon in many time series for hotel nights for Denmark covering the period from 1970.1 to 1996.12. This observation is found for hotel nights divided by counties as well as for hotel nights divided by nationality. Consequently seasonality is more frequently of a stochastic than of a deterministic nature. This feature should be understood and taken into account in the modelling procedure.

In 1996 the total number of hotel nights amounted to about 12.9 million, equivalent to an increase of about 80% since 1970. During the period the division of hotel nights has shifted away from the Copenhagen area. However, Copenhagen is still by far the most important region. Other important counties are Bornholm, Storstroem, Funen, Aarhus and North Jutland. Throughout the period, around half of the nights were demanded by foreigners, and Germans, Swedes, and Norwegians were the most important nationalities in this respect.

Hopefully the analyses will provide tourism economists with an incentive to investigate the literature on seasonal unit roots, and make use of the technique in their applied work.

Endnotes

1. People using hotels are by definition tourists. However, the material presented in this analysis is *not* equivalent to an examination of the total Danish tourist nights. Tourism nights may take many forms other than hotel nights - for example, residential house nights, camping nights, etc. For a recent analysis of the impact of tourism at county level in Denmark, see T. Rafn, *Turismens økonomiske betydning for de danske amter*, Report 2/1996. Research Centre of Bornholm, Denmark, 1996 (in Danish); or T. Ahmt and L. Eriksen, *The Building of a Tourism Databank and a Regional Economic Tourism Model*, AKF Publishing, Denmark, 1997 (in Danish with an English Summary).

2. The seasonal pattern of hotel nights can, for example, be related to input-output based coefficients on hotel demand for labour.

3. S. Hylleberg, *Seasonality in Regression*, Academic Press, New York, 1986.

4. S. Hylleberg, C. Jørgensen and N.K. Sørensen, 1993, 'Seasonality in macroeconomic time series', *Empirical Economics*, Vol 18, 1993, pp 321-335.

5. This heading should be understood in an econometric sense. The present analysis is purely empirical, and no attempt is made to set up a theoretical model to explain preferences for choosing hotel nights over alternative types of nights during holidays and other stays. The present text is written especially with tourism economists in mind, with technical explanations kept to a minimum.

6. S. Hylleberg, R.F. Engle, C.W.J. Granger, and B.S. Yoo, 'Seasonal integration and cointegration', *Journal of Econometrics*, Vol 44, 1990, pp 215-238.

7. J.J. Beaulieu and J.A. Miron, 'The seasonal cycle and the business cycle', *Journal of Political Economy*, Vol 97, 1993, pp 503-535.

8. We rely here on Franses, who gives a more formal theoretical deviation of the test: P.H. Franses, *Model Selection and Seasonality in Time Series*, Tinbergen Institute Series No 18, Thesis Publishers, Amsterdam, 1991. The test presented in this section is also known as the HEGY-test (see Hylleberg *et al*, *op cit*, Ref 6).

9. Franses, *op cit*, Ref 8.

10. Hylleberg *et al*, *op cit*, Ref 6.

11. P.H. Franses and B. Hobijn, 'Critical values for unit root tests in seasonal time series', *Journal of Applied Statistics*, Vol 24, 1997, pp 25-47.

12. Franses, *op cit*, Ref 8.

13. Data on exchange rates have kindly been supplied by Dan Knudsen from the Danish National Bank. The cointegrating relationship between the exchange rate and the number of hotel nights, ECM-modelling, periodic cointegration, etc, will be considered in future work.

14. See also T. Jensen, 'Income and price elasticities by nationality for tourists in Denmark', *Tourism Economics*, Vol 4, 1998, pp 101-130.

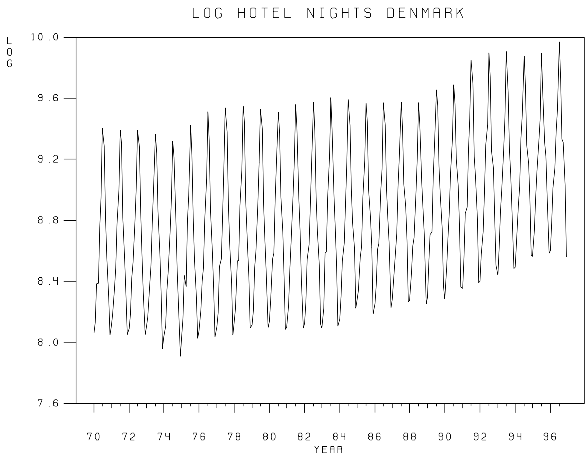
15. See also S. Schønemann, *Bornholm: Economic Structures and Development*, Report 6/1996. Research Centre of Bornholm, Denmark, 1996 (in Danish).

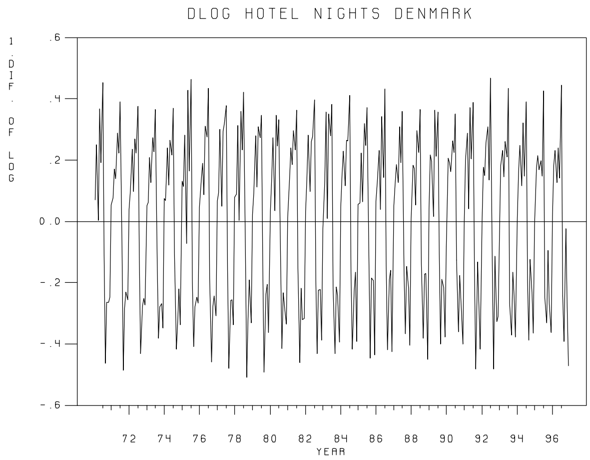
16. Franses, *op cit*, Ref 8.

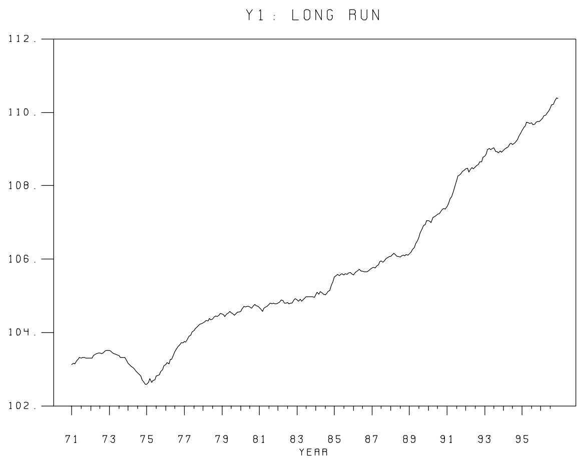
17. Full sets of such plots for all the time series being considered are available on request from the author.

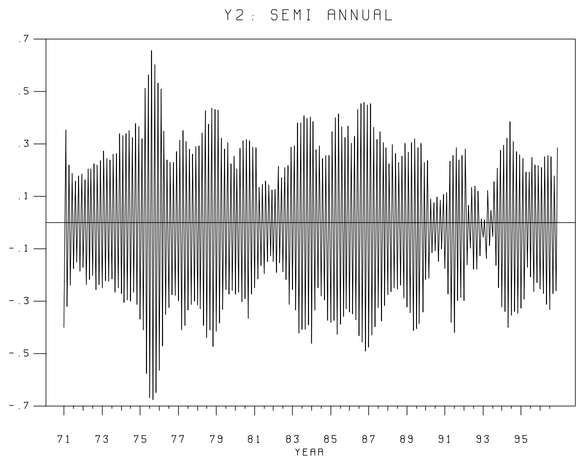
18. See, for example, S. Hylleberg, *Modelling Seasonality*, Oxford University Press, Oxford, 1992.

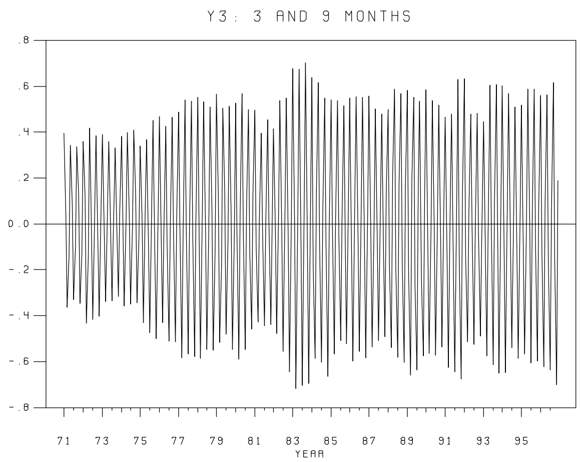
Appendix: Plots of hotel nights, Denmark total, 1970.1 - 1996.12

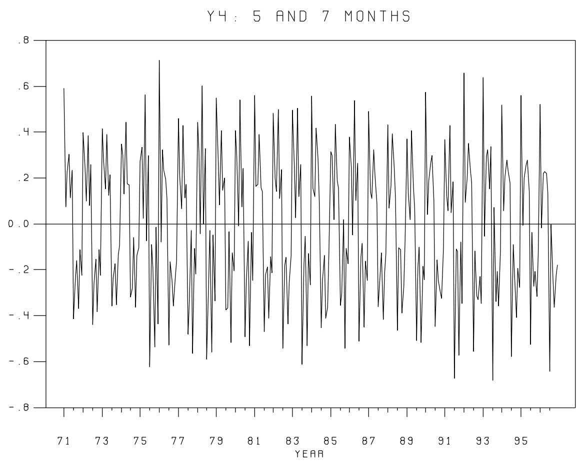


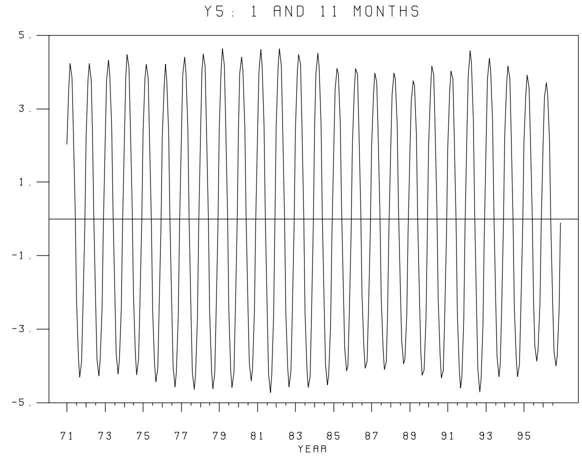


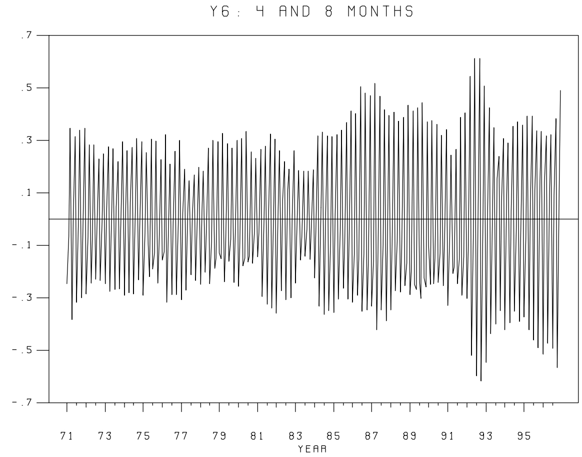


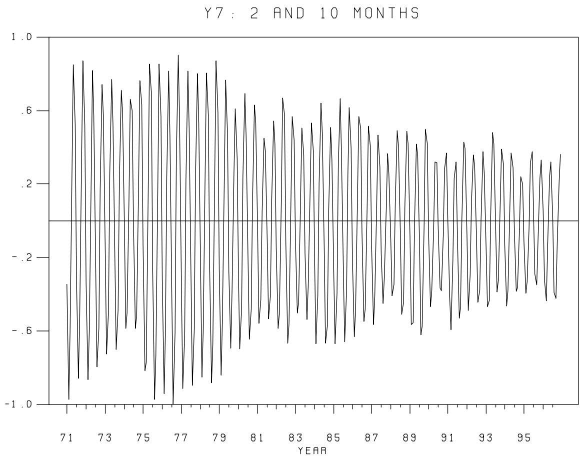


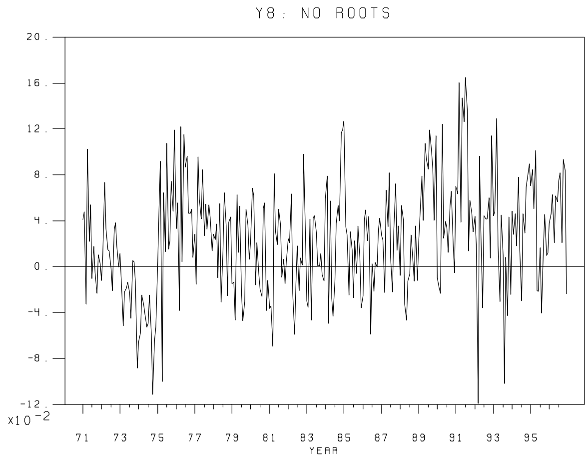





Y5: 1 AND 11 MONTHS
5.
3.
1.
-1.
-3.
-5.
71 73 75 77 79 81 83 85 87 89 91 93 95
YEAR


Y6: 4 AND 8 MONTHS
.7
.5
.3
.1
-.1
-.3
-.5
-.7
71 73 75 77 79 81 83 85 87 89 91 93 95
YEAR


Y7: 2 AND 10 MONTHS
1.0
.6
.2
-.2
-.6
-1.0
71 73 75 77 79 81 83 85 87 89 91 93 95
YEAR


Y8: NO ROOTS
20.
16.
12.
8.
4.
0.
-4.
-8.
-12.
x10^-2
71 73 75 77 79 81 83 85 87 89 91 93 95
YEAR