6 Conclusion

The critical values of a test statistic $r_n$ on testing outliers in a two-way table can be well approximated by those of Grubbs-type outlier tests. The test statistic is not used on its own but complemented with Q-Q plots of the r--1+k largest $\hat{\epsilon}$ values against approximate expected quantiles from a $\chi^2$ distribution. The method was applied to a real data set (data of Roberts & Cohnen (1968)) and suggested the number of outliers obtained by Bradic & Hawkins (1982) which conflicts with the views of Daniel (1978). The masking effect of a simulated data set, which is in a similar framework of one of the cases in Gentleman and Wilk (1975a), could also be avoided by the proposed method.

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A seasonal analysis of Chinese births

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SUMMARY

Investigation of monthly Chinese births in Singapore, Malaysia, Hong Kong and Taiwan shows a very similar seasonal pattern. The strong influence of Chinese culture has not altered this seasonal pattern significantly. The statistical methods presented in this paper to analyze Chinese births are readily applicable to many other areas.

1 Introduction

Examination of a Chinese births series indicates the presence of two cycles: one a long cycle which lasts more than a year and the other is an annual seasonal cycle. The long cycle is related to the 12 year animal cycle of the Chinese zodiac. For example, the year of the Dragon is favorable for marriages and births because a Dragon child is believed to bring luck and fortune to the family. Thus, births tend to peak in the Dragon year. The year of the Snake is very unfavorable for births, so the birth troughs could be expected in the Snake year.

The influence of Chinese culture on the seasonal cycle of births is less obvious. The possible cause of seasonality is the link between births and marriage. Marriages are more directly tied to customs and norms than are births. The presence of marriage in marriage is likely to generate a similar cycle in births. In this study we analyze the seasonal cycle of Chinese births and try to establish the influence of Chinese culture on the seasonality of births by examining data Chinese populations: Singapore, Malaysia, Hong Kong and Taiwan. The presence of a common seasonality would suggest the influence of the Chinese culture. In the course of the present study of Chinese births, we examine whether the seasonality of births.

Though this investigation is specifically about Chinese births, the statistical methodology presented in this paper is readily applicable to many other areas.
Furthermore, the method of handling both deterministic and stochastic seasonality can be easily expanded to regression models with seasonal-dependent variables. The Box-Jenkins seasonal model utilized here highlights an estimation procedure which avoids the problem of unit roots in the seasonally moving average part.

Data used in this study are Chinese births by month of occurrence and marriage by month of registration. For Taiwan, however, births data are available only by month of registration; and for Malaysia the marriage data by ethnic group are not available. The lengths of the series are as follows: Singapore, 1961-1986 (312 observations); Malaysia, 1966-1985 (240 observations); Hong Kong, 1971-1986 (192 observations); Taiwan, 1949-1986 (276 observations).

Lee (1988) has attempted to analyze this data using the ratio-to-moving-average method by assuming a multiplicative seasonal model. Though his statistical analysis is not rigorous, he has provided a good account of the Chinese zodiac and cultural practices related to marriages and births.

2 Methodology

Figure 1 shows the Chinese births of the four countries under consideration. The presence of seasonality is quite obvious from these graphs. The seasonal fluctuations appear to be stable over time. We can, therefore, use an additive unobservable component model to study the seasonality (see Nerlove et al., 1979). Using $y_t$ to denote a birth series we may write

$$y_t = T_t + S_t + I_t$$

where $T$ is the trend-cycle component, $S$ the seasonal component and $I$ the irregular component ($t$ is the time subscript.)

If Chinese culture is the cause of the seasonality of births, then we could expect a common deterministic seasonal pattern to be present in the births series. In fact, a closer examination of the four graphs in Fig. 1 shows that the seasonal peaks occur in the fourth quarter. For each country, however, we cannot expect the seasonality only completely deterministic. Therefore, we postulate that the seasonality observed in each births series is the sum of two components: a deterministic seasonality which is expected to be the same for all four series and a stochastic seasonality which may vary from one population to the other. Thus we may write

$$S_t = S_{1t} + S_{2t}$$

where $S_{1t}$ is the deterministic component and $S_{2t}$ is the stochastic component.

The deterministic seasonal component can be represented by a sin-cos function or equivalently by the dummy variable function

$$S_{1t} = \sum_{j=1}^{12} \beta_j d_{jt}$$

where the $\beta_j$ values are the seasonal factors which satisfy the condition $\Sigma \beta_j = 0$ and the $d_{jt}$ values are seasonal dummies such that

$$d_{jt} = 1 \quad \text{if } j = t \mod 12$$

$$d_{jt} = 0 \quad \text{otherwise}$$

A regression of $y_t$ on $S_{1t}$ simply estimates the seasonal means. We assume that $S_{1t}$ is a seasonal autoregressive moving average (SARMA) process (Box & Jenkins, 1970).
The trend cycle component \( T \) in equation (1) may also be written as the sum of a
deterministic and a stochastic component. Pierce (1978) has suggested a general
model to handle situations which involve both deterministic and stochastic trends
and seasonal (4). In his work we have developed the following procedure to
analyse our data series.

We observe that the non-seasonal component of the births series becomes
stationary in first differences. First differencing removes stochastic as well as
deterministic linear trends and leaves the deterministic seasonal and other stochastic
elements in first order.

Model (1) can be rewritten in first differences as

\[
\Delta y_t = \alpha + \sum_{j=1}^{p} \beta_j \Delta y_{t-j} + \Delta u_t
\]

where \( u_t \) is stationary and \( \Delta u_t \) is assumed to be stationary with an ARMA representation
involving stochastic non-seasonal and seasonal components. \( A \) is the difference
operator \( (\Delta y_t = y_t - y_{t-1}) \) and \( \Delta \) the slope of the time trend \( \delta \).
We may use a Box-
Jenkins multiplicative seasonal model for \( \Delta u_t \) such that

\[
\phi(B) \Phi(B^4) \Delta u_t = \psi(B) \Psi(B^4) \eta_t
\]

where \( \phi(B) \) is assumed to be iid \( N(0, \sigma^2) \) and \( \Phi(B) \) etc. are finite polynomials in the
backshift operator \( R = B \delta \eta_t = \delta, \ldots, \delta = 1 - B \).

A two-stage regression procedure may be used to estimate equations (4) and (5):
first obtain a residual series from equation (4) and then from model (5). However,
model (4) cannot be used directly to estimate \( \alpha \) and \( \beta \) values. We can write equation
(4) alternatively as

\[
\Delta y_t = \alpha + \sum_{j=1}^{p} \beta_j \Delta y_{t-j} + \Delta u_t
\]

where

\[
\delta_j = \beta_j - \beta_{j-1}, \quad j = 2, 3, \ldots, 12
\]

\[
\delta_0 = \beta_0 - \beta_1
\]

The residuals from a regression of equation (6), by suppressing \( \alpha \), can be used to
specify the form of equation (5). The procedure we use in this paper is first to identify
an ARMA (possibly seasonal) model for the residuals using the Box-
Jenkins identification procedure and then specify a subset of ARMA models for the residuals
using the identified model as a guide. Following this, we estimate the full model

\[
\Delta y_t = \alpha + \sum_{j=1}^{p} \beta_j \Delta y_{t-j} + \delta_0 \delta_1 \Delta u_t + \delta_2 \delta_3 \Delta u_{t-4}
\]

and

\[
\delta_j = \delta_{j-4}
\]

The values of \( \delta_j \), equation (7), can be solved for \( \beta_j \) from the cointegration
this solution can be written as

\[
\beta_j = \delta_j + \beta_{j-1}, \quad j = 2, 3, \ldots, 12
\]

\[
\beta_0 = \delta_0 + \delta_1 \delta_2 \delta_3 \delta_4 \eta_t
\]

By imposing the cointegration \( \Psi_0 = 0 \), we obtain

\[
\Delta y_t = \beta_0 \Delta u_t + \beta_1 \Delta u_{t-4} + \cdots + \beta_{12} \Delta u_{t-12}
\]

and

\[
\beta_{12} = \frac{1}{12} \sum_{j=1}^{12} \beta_j
\]

The other \( \beta \) values may now be calculated.
5 Seasonality of births

As a preliminary step in the data analysis, we adjusted the data series for the length of the month. We found this necessary because the seasonal means estimated using the unadjusted monthly data showed unexpected dips in February. To adjust for this, we divided the average length of the month by the length of that month (in days) and multiplied by the average length of the month (30.4357 days i.e. 365.25 days). For January, we used the average length divided by 12 months. For February, we used the average length divided by 12 months. A shorter period is used because births are fewer during this month. For the other periods, we used the average length divided by 12 months.

The standard deviation reported in Table 1 shows that the seasonality of births has a significant impact on the seasonal pattern of births. In fact, the differences in the seasonal pattern of births in Hong Kong and Taiwan is seen as a result of the differences in the seasonality of births. This finding is consistent with the previous studies of the seasonality of births.

Table 1: Standard deviations of births series

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\[
\sigma = \sigma_{j} + (1 - 0.88\beta_{1})(1 - 0.17\beta_{2}) + 0.17\beta_{3}\sigma_{j}
\]

where \(\sigma_{j}\) is the seasonal component given in model (8) for \(j\). The \(F\) test for the presence of deterministic seasonality yields the following results.

- For the presence of deterministic seasonality, \(F = \chi^{2}\) at a 5% level of significance.

The presence of deterministic seasonality is tested for each model. The results show that the model that includes deterministic seasonality is better than the model that does not include deterministic seasonality. The estimated models for the difference in the seasonal pattern of births in Singapore and Malaysia. The model for Hong Kong and Taiwan is also presented in the paper.

The above findings are consistent with the previous studies of the seasonality of births. The estimated models are presented below without further discussion.

Malaysia

\[
\sigma_{j} = \sigma_{0} + (1 - 0.48\beta_{1})(1 - 0.17\beta_{2}) + 0.17\beta_{3}\sigma_{j}
\]

where \(\sigma_{0}\) is the seasonal component given in model (8) for \(j\). The \(F\) test for the presence of deterministic seasonality yields the following results.

- For the presence of deterministic seasonality, \(F = \chi^{2}\) at a 5% level of significance.

The above findings are consistent with the previous studies of the seasonality of births. The estimated models are presented below without further discussion.

Table 2: Seasonal factors of births

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\[
\sigma_{j} = \sigma_{0} + (1 - 0.36\beta_{1})(1 - 0.17\beta_{2}) + 0.17\beta_{3}\sigma_{j}
\]

where \(\sigma_{0}\) is the seasonal component given in model (8) for \(j\). The \(F\) test for the presence of deterministic seasonality yields the following results.

- For the presence of deterministic seasonality, \(F = \chi^{2}\) at a 5% level of significance.

The above findings are consistent with the previous studies of the seasonality of births. The estimated models are presented below without further discussion.

Table 3: Seasonal factors of births

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4 Stochastic seasonality

The models chosen for Malaysia and Hong Kong, i.e. models (12) and (13), indicate that the seasonality is not purely deterministic and that there is a stochastic or a moving seasonal component as well. Although the model chosen for Singapore (model (11)) does not show any autoregressive or moving seasonal components at seasonal lags 12 and 24 are relatively large in magnitude though statistically insignificant.

The presence of a stochastic seasonal component in Chinese births may be due to a calendar problem. The births and marriages are recorded according to the Western calendar while these events take place according to the Chinese lunar calendar. Although there is a close correspondence between the two calendars they cannot be strictly comparable on an annual basis.

A lunar month called a 'moon' lasts 29 or 30 days. Therefore, 12 months (with six or seven 30 day moons) make 354 or 355 days. The Chinese have reconciled the difference between twelve moons and the solar year by duplicating a moon (i.e. by adding an 'emission') every two or three years. This is based on the calculation that there should be seven equlibinations in a period of 19 years. As a result, a month moves over two or three Western calendar months. For example, the Chinese New Year's Day may fall on any date between January 21 and February 20 (see De Koninkie, 1983; Palmer, 1985).

What we see as moving seasonality, therefore, could be the result of moving moons. A simple counting of birth peaks shows that the peaks move through September, October and November. This pattern records the highest frequencies of peaks. If seasonality is really stochastic then the peaks wander away slightly. We do not observe such a behaviour in the birth series.

5 Economic development and births seasonality

Next we investigate whether economic development has changed the seasonality of Chinese births. For this we use the Singapore births series because this data series can be divided into two periods which are likely to have marked differences. We did not gather enough information for a similar exercise in other countries.

Prior to December 1969, Singapore allowed induced abortion on very restrictive grounds. Between 1969 and 1974, abortion has been available on request. In fact, abortion figures show a dramatic increase since 1974. The period after 1974 is characterized by a higher level of contraception development in Singapore. These changes may have modified the seasonality of Chinese births.

To assess the impact of economic development on seasonality, we carried out the previous exercise separately for the two periods 1961-1969, 1974-1986. The estimated seasonal factors are given in Table 3. The seasonal pattern in the two periods is similar. This indicates that economic development has not changed the seasonality of Chinese births in Singapore.

6 Seasonality of marriages and births

If the seasonality of marriages causes the seasonality of births then the residual birth seasonality of births can be easily traced because marriages are more closely connected to customs and norms than are births. Some months are believed to be auspicious for marriages (and conceptions) and some months are insidious. The most favourable period for marriages is the Chinese New Year (January-February) followed by two other festival periods, these being The Moon Cake Festival and the Festival of the Winter Arrival (October-November). Due to stochastic seasonality, we observe that the residual during these periods, especially during the Lunar New Year, are believed to be labelled. The bad periods for marriages are the Chinese New Year (January-February), the Feast of the Hungry Ghosts (August-September) and the Qing Yang Festival (October-November). As a tradition requires a couple to have a child during the first year of their marriage, the marriage seasonality is likely to be major determinant of the seasonality of Chinese births. However, it is worth noting that the degree of emphasis on these festivals is likely to vary from one Chinese population to another.

Figure 2 shows the Chinese marriages in Singapore, Hong Kong and Taiwan. Unlike the birth series, only Taiwanese marriages show a pronounced seasonality. The seasonality of marriages in Singapore and Hong Kong appears to be mild. All these series have increasing fluctuations at the seasonal frequency of the marriage series even though not much success. These series appear to be composed of both additive and multiplicative seasonal components (see Darbin & Kenny, 1978). Marriages as an exogenous variable of births seasonality did not show much variation. We used transformed original data, so we decided to use the original data. The Singapore marriage series shows outliers due to conceptions registered in November and December of 1973, and January and February of 1974. We replaced these outliers by its average of the same month in 1972 and 1973. All the series were corrected for month length.

Running least-squares regressions using model (6) (by suppressing a), we estimated the seasonal means of marriages which are shown as Table 5. Here we did not try to model the stochastic part with an ARIMA model. The objective is to estimate the pattern of the deterministic seasonal part (assuming its presence in order to relate it to the seasonality of the birth series. We expected a marriage peak during the Chinese Lunar New Year (January-February) with mild peaks in November and December. Although this is the case for Singapore and Hong Kong the peaks occur in November and December. The peaks in the December-January period, which is due to the early registration of marriages, there is a time gap between the date of registration and the actual marriage ceremony during the Lunar New Year. The observed dips in marriages in February is mainly a result of this practice. Given that actual marriage (and conception) takes place during the Lunar New Year, the births should take place in the weeks if i.e. in October and November. This is exactly what we observe in the seasonal factors of the births.

The major marriage troughs are in August. This is due to the Feast of Hungry Ghosts which is considered to be a bad omen for marriages. Correspondingly, births troughs should be in August. This is also what we observe in the births series. Thus a regression of births on marriages lagged by nine months for marriages. Correspondingly, births troughs should be in September. However, for Singapore and Hong Kong we have to make an adjustment to account for the time lag between registered marriage peaks and actual marriage peaks. To take account of this, we introduce another set of variables in the regression. To define these regressors, let $M_t$ be the number of marriages registered at time $t$ and $d_{t} (t = 1, \ldots, 12)$ the seasonal dummy variables defined earlier.
Thus we run a regression of births on the following variables:

- $\mathcal{Z}_n = \mathcal{M}_n - \mathcal{M}$: to account for the regular nine-month lag between marriages and births.
- $\mathcal{Z}_n = \mathcal{M}_n - \mathcal{M}$: to account for the effect of marriages registered in November of year $n$ on births peaks in September of year $n+1$.
- $\mathcal{Z}_n = \mathcal{M}_n - \mathcal{M}$: marriages in December, births in October.
- $\mathcal{Z}_n = \mathcal{M}_n - \mathcal{M}$: marriages in November, births in October.
- $\mathcal{Z}_n = \mathcal{M}_n - \mathcal{M}$: marriages in December, births in November.
- $\mathcal{Z}_n = \mathcal{M}_n - \mathcal{M}$: marriages in November, births in November.

It should be noted that $\mathcal{Z}_n$ to $\mathcal{Z}_n$, take zero values except for the months indicated by the variable $d_n$.

The regression used for Singapore and Hong Kong is

$$ \mathcal{Y}_n = \mathcal{B}_n + \sum_{i=1}^{r} \mathcal{P}_i \mathcal{Z}_{n-i} + \mathcal{M}_n + \mathcal{E}_n $$

and the one used for Taiwan is

$$ \mathcal{Y}_n = \mathcal{B}_n + \sum_{i=1}^{r} \mathcal{P}_i \mathcal{Z}_{n-i} + \mathcal{M}_n + \mathcal{E}_n $$

where $\mathcal{Y}_n$ stands for births $y_n$. was introduced in equations (14) and (15) to make the residual autocorrelations compatible with those from the first-differenced series $\Delta_y$, series of $\Delta_o$ from equations (14) and (15) has to be non-seasonal. The autocorrelations of given in Table 4. Surprisingly, what we see in Table 4 is that though these regressions reduce autocorrelation at seasonal lags, the reduction is rather mild. Seasonal non-stationarities in the residual series $\mathcal{B}_n$ in other words, there appears to be no seasonal 'regression' between births and marriages (Engle & Granger, 1987).

The above results show that the marriage seasonality does not fully explain the total number of births in a given month it greater third child and so on. The marriage seasonality relates only to the seasonality of subject to seasonal variation. Most conceptions (not only the first child) are likely to take place during the Lunar New Year as this is the most celebrated festive season.

<table>
<thead>
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<th>Table 4. Autocovariances of births at seasonal lags before and after removing the effect of marriages</th>
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among Chinese. Moreover, couples who are physically separated due to distance between home and the workplace get together during the Lunar New Year period. Thus, the seasonality of higher-order births is also likely to be a result of Chinese culture.

7 Conclusions

The statistical tests carried out in this study suggest that Chinese births have a strong deterministic seasonal component. The similarity of this pattern in four Chinese populations suggests that it is strongly influenced by Chinese culture, which seems to be unmitigated by economic development. The seasonality of Chinese marriages fails to explain fully the seasonality of births, suggesting that the influence of Chinese culture on births is more direct than one might think. Perhaps Palmer (1985) is right when he states

... in Chinese communities in Southeast Asia, Hong Kong and Taiwan, and in Europe, North America and Australia, the Almanac continues to exercise much more influence than its former power [p.13].

Apart from the deterministic seasonal component, the birth studies have a stochastic (moving) seasonal component as well. This is likely to be a result of the difference between the Chinese lunar calendar and the Western calendar. Important events of life are linked to the former, which official records are kept according to the latter. However, the presence of stochastic seasonality indicates that the regression models of fertility which attempt to eliminate the seasonality of births through the use of dummy variables may lead to misleading results.

Acknowledgements

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