# A TIME SERIES ANALYSIS OF DATA ON REGISTERED MARRIAGES IN THE PHILIPPINES

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*Abstract*

Using the monthly vital statistics data relating to marriages for the period January 1962 – December 1975, decomposition analysis is carried out to isolate and quantify the trend-cycle and seasonal components latent in them. A time-trend model has been estimated to characterize the trend-cycle behavior. Using these results, ex-post forecasts of marriage registrations are made for the years 1976-78 and their accuracy measured against the actual figures. While the above analysis provides reasonably accurate short-term forecasts, it also throws evidence of further improvements in modelling and forecasting through more sophisticated seasonal adjustment procedures such as ARIMA and spectral analyses.

The paper also presents estimates of the proportion of registered marriages to the actual number of marriages derived from the population census data for the period 1960-1980.

## *1. Introduction*

Civil Registration is the process of recording, in appropriate registers, events that affect the civil status of individuals in a country.

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There are various events which are registrable in the Philippines. Out of these, the most common ones are births, deaths and marriages, often referred to as vital events. Recording of these events is known as vital registration. Drawn from these records are the country's vital statistics.

The history of civil registration in the Philippines, its organizational structure, various laws relating to it, its uses and the instruments of registration, etc. are given in detail in the *Manual on Civil Registration* of 1983.

This paper is concerned with the analysis of data from registered documents on marriages. These documents have legal, administrative and statistical values. At the macro level of regional and national planning, marriage data are useful for developing suitable family benefit schemes connected with health, housing, social security and welfare. They provide the essential material for extensive demographic research since marriages bear an intimate relation with the birth rate and population change.

The vital statistics derived from marriage registration, collected as a result of administrative exigencies, have certain advantages over those obtained through either censuses or sample survey methods. For instance, they are generally free from certain kinds of response errors; and they can be obtained over continuous time periods. There is one disadvantage, however, in using the data from vital registration. They are not complete in the sense that there is always some percentage of the event that is not registered.

Some efforts have been directed to find the levels of registration of births and deaths. These are reported, for instance, by Mijares (1974) and in the Seminar Proceedings (1975) of the National Census and Statistics Office (NCSO). However, no attempt seems to have been made to ascertain the level of registration with respect to marriages.

A method of assessing the level of marriage registration is presented here. This is accomplished by comparing the number of marriages registered with the number of married couples derived from the 1960-80 records of the population censuses. The relevant data from two successive censuses are used to obtain the number of marriages that have taken place during the intercensal periods. Also, the number of male and female deaths that occurred in each period is estimated for different age groups (10 years old and over) and marital status of the population using the age-specific survival ratio

$$ {}_nS_x = {}_nL_{x+n} / {}_nL_x $$

(The L values have been taken from the Philippines Life Tables A1-A6 of Flieger, *et al.* (1981) ). Care has been taken to account for the number of deaths that occurred among the registered brides and grooms during the same periods. The number of marriages as derived from the above estimates are shown in Column 2 of Table 1.

Table 1: Number of registrations per 100 marriages

| *Period* | *Number of Derived Marriages* | *Number of Registered Marriages* | *Number Registered per 100 Marriages* |
|---|---|---|---|
| 1960-70 | 2,392,725 | 1,854,661 | 78 |
| 1970-75 | 1,445,201 | 1,319,501 | 91 |
| 1975-80 | 2,441,768 | 1,650,759 | 68 |
| 1970-80 | 3,852,545 | 2,970,260 | 78 |
| 1960-80 | 6,086,523 | 4,824,921 | 79 |

Table 1 shows some interesting features. Although the level of registration in the two decades 1960-70 and 1970-80 has remained more or less the same, it shows considerable fluctuation within the period 1970-80 rising to as high as 91 in the first half and dropping to 68 in the second half. Overall, the level of registration has remained around 79 per 100 marriages in the 20-year period 1960-80.

The following may be some of the possible reasons for the phenomenon noted in Table 1:

(1) an increasing trend of living together as man and wife in recent years; while such couples would have been counted as married under the census (according to its definition of being "married") they may not be willing to be registered as being legally married;
(2) the census enumeration may not be free from error; and
(3) a general apathy over time on the part of those responsible for ensuring registration of marriages.

In addition to the above, under-registration may also be influenced by remoteness of areas such as Mountain Provinces and non-acceptance of the registration by muslim and other minority groups of the population.

While considerable efforts continue to be expended in the collection and tabulation of data on the three major events of vital registration; namely, marriages, births and deaths, not much work appears to have been done in terms of their analyses. The present paper takes up this seemingly neglected area and reports on the analysis of data on marriages.

The major factors influencing the data series on marriage in the Philippines are season and trend-cyle. The season is influential because of factors such as customs, traditions, beliefs and weather. For example, one of the beliefs of Filipinos is that marriage contracted during the first month of the year are happy unions. This should therefore contribute to sharp increases in the number of marriages in January consistently over years. The next choice for marriages is the traditional month of June. This month has been set perhaps due to climatic factors since, in the Philippines, the rainy season commences in July and tapers off towards December. The same factor may also partly contribute to marriages in January. Further, as Richards (1983) has noted, if in a given year, there are more legal marriages than in a normal year, then legal births are also expected to be higher than usual about a year or so later. On an aggregate, the effect of marriages on births is captured by an average schedule of fertility by duration of marriage. In turn, it affects births and deaths. Assuming a *status quo* in health services and medical facilities, the more number of births in a given year, the larger would be the number of deaths in the following year since infant mortality forms a large proportion of total deaths particularly in middle income countries.

High prices also influence nuptiality. The immediate effect of high prices may be to reduce marriages because individuals tend to postpone their marriages in hard times. Eventually, nuptiality may rise again as postponed marriages take place. Again temperature influences both fertility and nuptiality. All these factors bring about a trend over the years and seasonality within years.

Time series analysis and modelling is thus appropriate for such periodic data which are available for a number of years. It enables us: (i) to determine in quantitative terms, the trend of registration of marriages, and (ii) to measure the seasonality present in this event which is not possible with the data from population census and other cross-section surveys. Yet, another purpose of such a modelling is to obtain short-term projections of marriages registered for a few years ahead. Under certain reasonable assumptions, these may be considered to provide lower bounds for anticipated registrations in the projected years. Upon relevant comparisons with analyses of other data such as those from population censuses, they may also indicate gaps in the level of registration and suggest the extent to which the existing administrative and organizational functions of the vital registration system should be geared.

The next section presents the method of analysis and the results.

## 2. *Analysis and Results*

The monthly series on registered marriages compiled by the NCSO for the years 1958-78, presented in Appendix 1, is subjected to analysis. A close exmination of the data shows that in comparison to those of the years 1962-78, the data relating to the first four years 1958-61 are erratic in behaviour and have therefore been excluded. Of the remaining years, decomposition analysis is performed on the logarithmic transformed data (given in Appendix 2) for the years 1962-75 so as to isolate and quantify the trend-cycle and seasonal components latent in them. The observations of the last three years 1976-78 have been kept aside for comparing them with the forecasts obtained from the model estimated from the analyses with a view to assessing the predictive performance of the model.

Plots of the actual series (Fig. 1) and of the logarithmic transformed series (Fig. 2) show that the variability of the latter is more uniform over time and is therefore more appropriate for analysis.

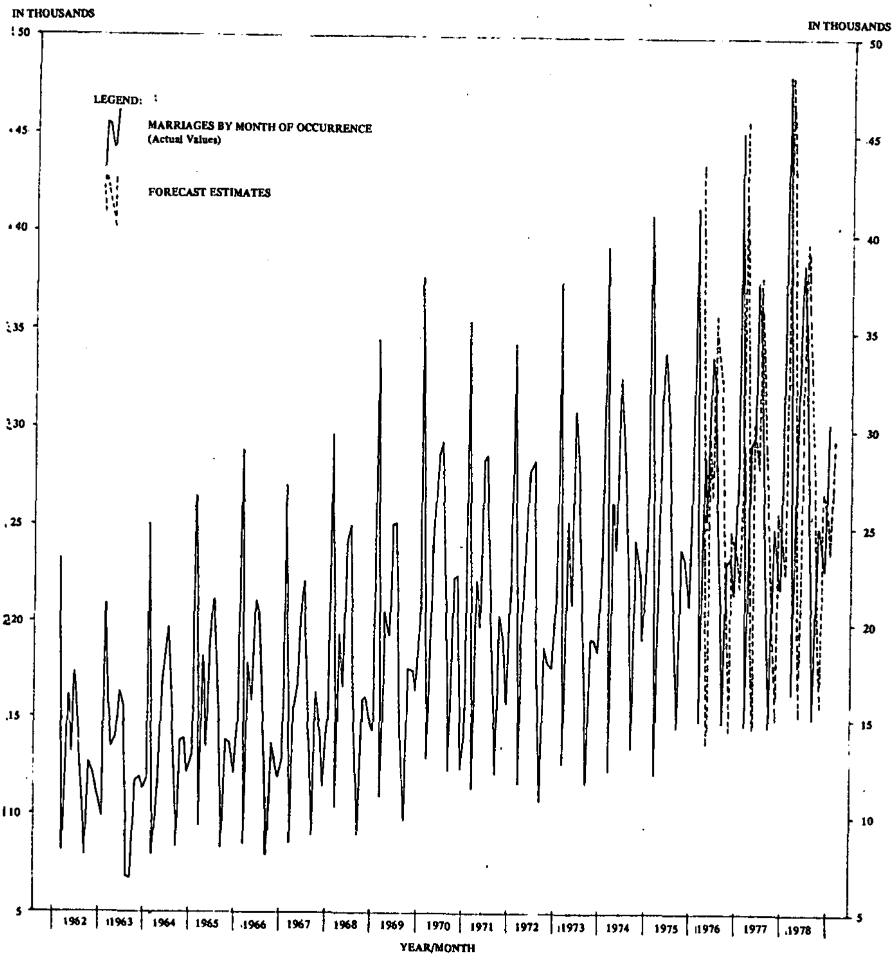


**Figure 1. Time series data (actual values) on number of registration marriages in the Philippines, 1962-1978 and forecast estimates for 1976-1978.**

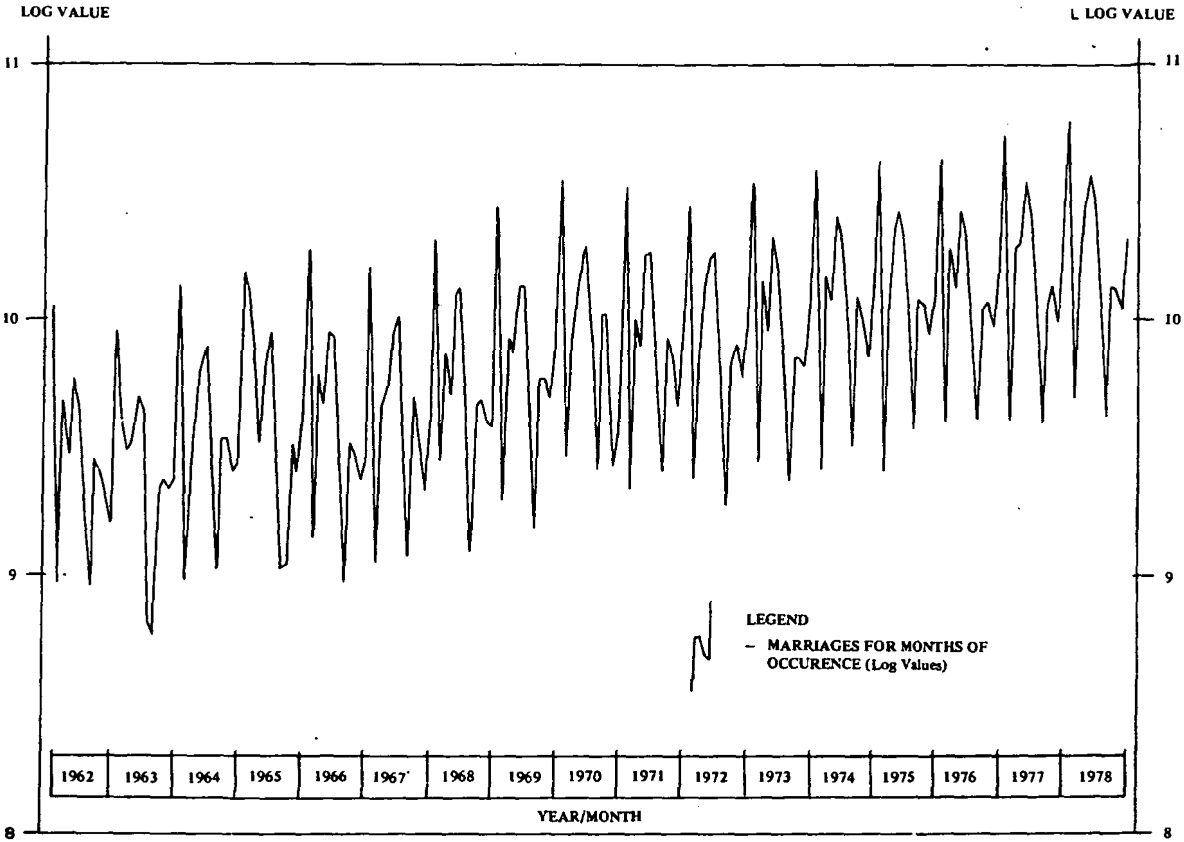


Figure 2. Time series data (logarithmic values) on number of registered marriages in the Philippines, 1962-1978.

Moreover, experience shows that many time series in the behavioural and sociological sciences may be better explained by a multiplicative model:

$$X_t = T_t \cdot S_t \cdot I_t$$

where X is the actual series, T and S are respectively the trend-cycle and seasonal components, I the short term irregular fluctuations and t the time index.

The X-11 procedure, an adaptation of the Bureau of the Census Method II Seasonal Adjustment Program of Shiskin, *et al.* (1967) is employed in the present analysis to separate the systematic signals T and S from the noise component I embedded in the data series. This procedure is a variant of the Census Method II and like its predecessors is a further refinement of the ratio-to-moving average method which was initially developed by Frederick R. Maculay of the National'Bureau of Economic Research in 1922. It consists of several iterations of the ratio-to-moving averages which provide a gradual treatment of extremes (if present). The method also offers a choice of several moving averages to estimate the trend-cycle component. On the whole, it is versatile, flexible, complete and economical; and, for these reasons, is widely used by time series analysts despite the availability of competing methods in the area of time series modelling and forecasting.

The final seasonal indexes as estimated by the X-11 program for the years 1962-75 are presented in Table 2.

As may be seen, Table 2 exhibits a constant seasonality over the years. However, the analysis of variance performed by the program shows that the hypothesis of their constancy between the months is to be rejected at 1% probability level, the value of F being as high as 217.54. As expected, January tops as the most favoured month for matrimony and August is the least favoured. As may be seen in Fig. 3, on an average, the summer months of March to June, all have their indexes above 100 whereas all the months of the second half of a year (corresponding to the rainy period) have their indexes below 100. The index for February is exceptionally low (being only 94.9), but this may be due to the high (in fact the highest) peak in the preceding month of January.

Table 2: Seasonal indexes

| *Year* | *Jan.* | *Feb.* | *March* | *April* | *May* | *June* | *July* | *Aug.* | *Sept.* | *Oct.* | *Nov.* | *Dec.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962 | 106.8 | 95.2 | 101.9 | 100.7 | 103.0 | 102.9 | 98.7 | 94.2 | 99.6 | 99.4 | 98.3 | 99.1 |
| 1963 | 106.8 | 95.3 | 101.9 | 100.7 | 103.1 | 103.0 | 98.7 | 94.2 | 99.6 | 99.4 | 98.3 | 99.1 |
| 1964 | 106.8 | 95.2 | 101.7 | 100.8 | 103.1 | 103.2 | 98.9 | 94.1 | 99.6 | 99.4 | 98.3 | 99.2 |
| 1965 | 106.7 | 95.1 | 101.5 | 100.8 | 103.2 | 103.4 | 99.0 | 94.0 | 99.6 | 99.3 | 98.2 | 99.1 |
| 1966 | 106.7 | 95.1 | 101.4 | 100.8 | 103.3 | 103.7 | 99.1 | 93.9 | 99.6 | 99.2 | 98.1 | 99.2 |
| 1967 | 106.6 | 95.1 | 101.4 | 100.9 | 103.4 | 103.7 | 99.0 | 93.9 | 99.6 | 99.1 | 98.1 | 99.3 |
| 1968 | 106.5 | 95.0 | 101.4 | 100.9 | 103.5 | 103.7 | 98.9 | 94.0 | 99.6 | 99.1 | 98.0 | 99.5 |
| 1969 | 106.4 | 95.0 | 101.4 | 100.9 | 103.5 | 103.7 | 98.8 | 94.1 | 99.6 | 99.1 | 98.0 | 99.7 |
| 1970 | 106.3 | 95.0 | 101.5 | 100.9 | 103.5 | 103.5 | 98.7 | 94.2 | 99.6 | 99.1 | 98.0 | 99.9 |
| 1971 | 106.1 | 94.9 | 101.5 | 100.9 | 103.6 | 103.3 | 98.7 | 94.3 | 99.6 | 99.1 | 98.1 | 100.2 |
| 1972 | 106.0 | 94.8 | 101.6 | 100.8 | 103.6 | 103.1 | 98.7 | 94.3 | 99.6 | 99.2 | 98.1 | 100.3 |
| 1973 | 106.0 | 94.6 | 101.6 | 100.9 | 103.7 | 102.9 | 98.7 | 94.4 | 99.7 | 99.3 | 98.3 | 100.5 |
| 1974 | 105.9 | 94.4 | 101.6 | 100.8 | 103.7 | 102.7 | 98.7 | 94.4 | 99.7 | 99.3 | 98.4 | 100.5 |
| 1975 | 105.8 | 94.4 | 101.6 | 100.8 | 103.7 | 102.6 | 98.7 | 94.4 | 99.7 | 99.3 | 98.4 | 100.5 |
| Average Seasonal Index | 106.4 | 94.9 | 101.6 | 100.8 | 103.4 | 103.2 | 98.8 | 96.2 | 99.6 | 99.2 | 98.2 | 99.7 |

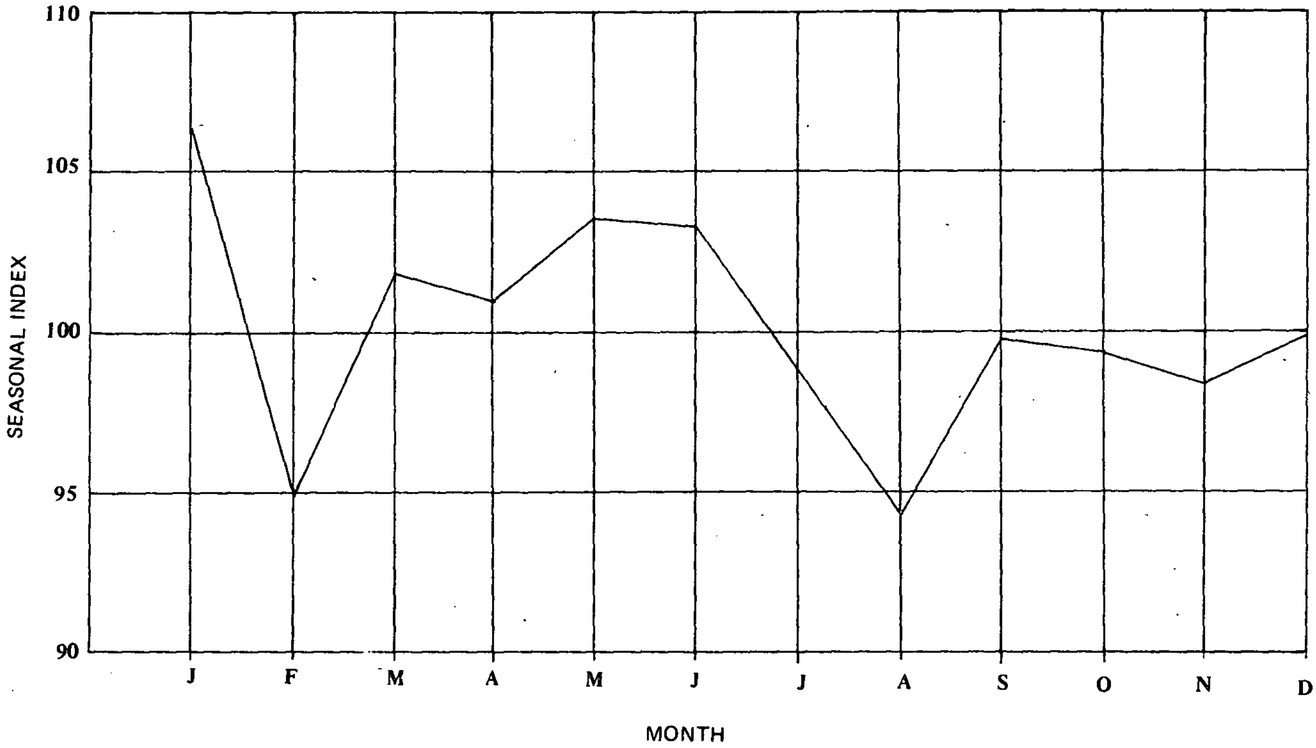


**Figure 3. Seasonality of registered marriages**

Table 3 gives the $T_t$ estimates (expressed in logarithms) of the final trend-cycle (trend for brevity) obtained by smoothing the seasonally adjusted series using the 13-term Henderson's moving-average.

The figures do reveal an increasing tendency over the years which may be explained by the dual facts of positive population growth and increases in the number of marriage registrations during the period covered.

In order to accomplish the next objective of the paper namely to obtain forecasts of marriage registrations using the above results from the decomposition analysis, one needs to have a mechanism by which the trend-cycle and seasonal components may be projected into the forecast period.

Presently, the X-11 program offers no computer method by which trend may be fitted and forecasts of the underlying trend obtained mechanically. We have, therefore, fitted a trend equation using the values in Table 3 so as to: (i) facilitate a quantitative insight of the trend behaviour, and (ii) obtain lead-time point forecasts of $\ell$-steps ($\ell \geqslant 1$) ahead which will in turn be used for constructing projections of registered marriages. A number of time trend and time series models involving $T_t$ as the dependent variable and t, and lagged values of $T_t$ as the explanatory variables were tried. The coefficient of determination $R^2$ and the DW value were used as the choice criteria for the selection of a final trend equation. The equation that scored over all others with respect to both these criteria is given in (2.1) below:

$$Z_t = \underset{}{0.0007} + \underset{(0.0745)}{1.8000^{**}} Z_{t-1} - \underset{(0.1272)}{1.3302^{**}} Z_{t-2} + \underset{(0.0744)}{0.2744^{**}} Z_{t-3} \quad \ldots\ldots (2.1)$$

$R^2 = 95.07\%$; $\hat{\sigma}^2 = 0.00001$; DW $= 2.04$

where $\quad Z_t = T_t - T_{t-1}$

The fact that (2.1) involves the variable $Z_t$, namely the first difference of $T_t$ shows that the lagged series $T_t$ is non-stationary in the mean. This may also be seen to be so in Fig. 2 in which the $T_t$

Table 3: Trend-cycle values (in logarithms)

| *Year* | *Jan.* | *Feb.* | *March* | *April* | *May* | *June* | *July* | *Aug.* | *Sept.* | *Oct.* | *Nov.* | *Dec.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962 | 9.4494 | 9.4429 | 9.4401 | 9.4342 | 9.4296 | 9.4290 | 9.4341 | 9.4444 | 9.4579 | 9.4709 | 9.4810 | 9.4883 |
| 1963 | 9.4913 | 9.4894 | 9.4759 | 9.4463 | 9.4079 | 9.3750 | 9.3592 | 9.3664 | 9.3918 | 9.4229 | 9.4492 | 9.4640 |
| 1964 | 9.4685 | 9.4720 | 9.4847 | 9.5090 | 9.5397 | 9.5696 | 9.5898 | 9.5947 | 9.5873 | 9.5757 | 9.5658 | 9.5594 |
| 1965 | 9.5570 | 9.5583 | 9.5460 | 9.5741 | 9.5862 | 9.5944 | 9.5993 | 9.6028 | 9.6051 | 9.6079 | 9.6138 | 9.6234 |
| 1966 | 9.6332 | 9.6374 | 9.6333 | 9.6229 | 9.6092 | 9.5956 | 9.5820 | 9.5687 | 9.5585 | 9.5494 | 9.5416 | 9.5379 |
| 1967 | 9.5403 | 9.5503 | 9.5661 | 9.5881 | 9.6136 | 9.6388 | 9.6585 | 9.6691 | 9.6706 | 9.6696 | 9.6698 | 9.6725 |
| 1968 | 9.6810 | 9.6972 | 9.7174 | 9.7326 | 9.7375 | 9.7358 | 9.7322 | 9.7331 | 9.7411 | 9.7554 | 9.7725 | 9.7881 |
| 1969 | 9.7973 | 9.7974 | 9.7898 | 9.7791 | 9.7690 | 9.7632 | 9.7671 | 9.7836 | 9.8114 | 9.8457 | 9.8823 | 9.9150 |
| 1970 | 9.9374 | 9.9488 | 9.9544 | 9.9586 | 9.9634 | 9.9669 | 9.9640 | 9.9514 | 9.9296 | 9.9021 | 9.8730 | 9.8479 |
| 1971 | 9.8347 | 9.8346 | 9.8454 | 9.8646 | 9.8914 | 9.9186 | 9.9402 | 9.9499 | 9.9448 | 9.9284 | 9.9084 | 9.8910 |
| 1972 | 9.8806 | 9.8790 | 9.8823 | 9.8843 | 9.8810 | 9.8739 | 9.8689 | 9.8690 | 9.8785 | 9.8966 | 9.9202 | 9.9447 |
| 1973 | 9.9637 | 9.9723 | 9.9720 | 9.9641 | 9.9496 | 9.9327 | 9.9193 | 9.9163 | 9.9250 | 9.9420 | 9.9619 | 9.9793 |
| 1974 | 9.9900 | 9.9959 | 9.9993 | 10.0062 | 10.0225 | 10.0455 | 10.0672 | 10.0824 | 10.0861 | 10.0759 | 10.0548 | 10.0315 |
| 1975 | 10.0136 | 10.0064 | 10.0121 | 10.0293 | 10.0528 | 10.0789 | 10.1015 | 10.1146 | 10.1192 | 10.1177 | 10.1125 | 10.1052 |

series exhibits a trend in mean. Thus (2.1) may be considered to be equivalent to the Box-Jenkins specification of an ARIMA (Auto-Regressive Integrated Moving Average) (p, d, q,) model with p=3, d=1, q=0. However, to the extent that it has not been obtained using their methodology, there is no guarantee that the model adheres to the "principle of parsimony", one of the basic tenets of their approach, nor does it ensure that it is the most adequate among the family of ARIMA models for the reason that it lacks "diagnostic checking", a built-in device in the Box-Jenkins methodology. All the same, the above equation holds promise for independent Box-Jenkins modelling of the series under study.

Equation (2.1) is used to generate the short-term monthwise forecasts of the trend component $T_t$ for the years 1976-78. For forecasting the corresponding seasonal component $S_t$, the equation

$$S_{t+1} = 1.5\ S_t - 0.5\ S_{t-1}$$

suggested in the X-11 program has been employed.

Assembling these two sets of forecasts, the final forecasts of the number of registered marriages in the period 1976-78 are shown in Table 4.

Fig. 1 gives a visual presentation of these forecasts in relation to the corresponding actuals.

Objective analyses of how well the forecasts align themselves with their respective actuals can be carried out in a number of ways, particularly in a study of time series analysis. One of the most commonly employed method is that of mean square error (MSE) and its decompositions expressed as inequality proportions.

In the context of time series observations, given the forecast values $f_t$ and the actuals $a_t$ at the time point, we may define the MSE as:

$$\text{MSE} = \frac{1}{m} \sum_{t=1}^{m} (F_t - A_t)^2 \qquad (2.2)$$

where

Table 4: Monthwise forecast values for the years 1976-78

| *Year* | *Jan.* | *Feb.* | *March* | *April* | *May* | *June* | *July* | *Aug.* | *Sept.* | *Oct.* | *Nov.* | *Dec.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | 43,450 | 13,767 | 28,511 | 26,442 | 35,756 | 32,153 | 21,978 | 14,319 | 24,629 | 23,716 | 21,672 | 26,834 |
| 1977 | 45,668 | 14,493 | 30,205 | 27,981 | 37,777 | 33,731 | 22,965 | 14,889 | 25,631 | 24,686 | 22,575 | 28,011 |
| 1978 | 47,774 | 15,108 | 31,579 | 29,226 | 39,479 | 35,179 | 23,935 | 15,495 | 26,746 | 25,768 | 23,579 | 29,321 |

$$F_t = \frac{f_t - a_{t-1}}{a_{t-1}}$$ is the predicted relative change,

$$A_t = \frac{a_t - a_{t-1}}{a_{t-1}}$$ is the actual relative change and

m is the number of forecasts.

Thus (2.2) can be rewritten, in term of $f_t$ and $a_t$ as

$$\text{MSE} = \frac{1}{m} \sum_{t-1}^{m} \left( \frac{f_t - a_t}{a_{t-1}} \right)^2 \tag{2.3}$$

As Theil (1966) has shown, it is possible to decompose (2.2) into three components as:

$$\text{MSE} = (\bar{F} - \bar{A})^2 + (S_F - S_A)^2 + 2(1\text{-}r)\, S_F\, S_A \tag{2.4}$$

or, as

$$\text{MSE} = (\bar{F} - \bar{A})^2 + (S_F - rS_A)^2 + (1 - r^2)S_A^2 \tag{2.5}$$

where $S^2$ denotes the variance and $r$ the correlation coefficinet between $F$ and $A$. The three quantities on the right of (2.4) are referred to as: bias, variance and covariance components, respectively, and the last two expressions on the right of (2.5) as regression and disturbance components, respectively, of MSE.

Certain desirable properties for the decomposition (2.4) follow as a result of its symmetry in predicted and realized changes i.e. its invariance to the interchanging of $F$ and $A$. However, it suffers from certain disadvantages in the context of optimal predictions. Without getting into a discussion of the related theoretical aspects, it suffices to say that the decomposition (2.5) is more enlightening in the matter of interpreting and judging forecast accuracy. The bias component $(\bar{F} - \bar{A})^2$ provides a measure of the extent to which MSE is affected by the mean level of the forecast variable in relation to that of the actual. The regression component $(S_F - rS_A)^2$, as also the bias component, constitutes a "systematic" error, whereas the disturbance component represents the variance of the residuals of the regression of $A_t$ on $F_t$.

For purpose of comparison, we may divide each one of these components by their sum i.e., by MSE and obtain the corresponding inequality proportions as:

Bias proportion : $U^M = \dfrac{(\bar{F} - \bar{A})^2}{\text{MSE}}$

Regression proportion : $U^R = \dfrac{(S_F - rS_A)^2}{\text{MSE}}$ and

Disturbance proportion : $U^D = \dfrac{(1 - r^2)\,S_A{}^2}{\text{MSE}}$ .

Of course, $U^M + U^R + U^D = 1$

The meaning of these proportions would be clear if we consider the decomposition (2.5) in relation to the regression:

$$A_t = F_t + \text{error} \tag{2.6}$$

Since the mean of the error would be zero, we would have $\bar{A} = \bar{F}$ so that the bias component of (2.5) and, consequently, the proportion $U^M$ would be zero. Also, the regression coefficient of (2.6) equals

$$\frac{\Sigma\,(F_t - \bar{F})\,(A_t - \bar{A})}{\Sigma\,(F_t - \bar{F})^2} = \frac{rS_A}{S_F}$$

If now, the value of this coefficient is indeed one, as the equation (2.6) stipulates, then the regression component of (2.5) and, correspondingly, $U^R$ would be zero. Thus, the MSE would solely consist of the third component of (2.5), namely the variance of the error or disturbance terms of the regression (2.6), leading to the value of unity for the proportion $U^D$. Evidently, such an ideal condition as depicted by (.26) would not exist in actual practice. All the same, if a prediction-realization diagram consisting of the plots $(F_t, A_t)$ is drawn, then the three inequality proportions provide measures of the extent of the spread of these plots around the line of perfect forecast: $A_t = F_t$. The closer the values of $U^M$ and $U^R$ to zero, the greater is the correspondence of the estimated forecast changes $F_t$ to the actual changes $A_t$ for all $t$.

Table 5 gives the values of MSE and the three inequality proportions for the three forecast years individually and for the entire period 1976-78.

Table 5: Values of mean square errors and inequality proportions

| *Year* | *MSE* | $U^M$ | $U^R$ | $U^D$ |
|---|---|---|---|---|
| 1976 | 0.002435 | 0.2939 | 0.1326 | 0.5735 |
| 1977 | 0.003264 | 0.1329 | 0.2268 | 0.6403 |
| 1978 | 0.010211 | 0.0464 | 0.2279 | 0.7257 |
| 1976-78 | 0.005385 | 0.1000 | 0.1834 | 0.7166 |

As to be expected, the MSE values of the predicted changes from the actual changes increase with years. This is reflected in the Prediction-Realization diagram of Fig. 4. On the other hand $U^M$ values decrease steadily showing that the mean levels of the predicted changes drift closer to those of actual changes over time. The "systematic" error component $U^R$ increases sharply between 1976 and 1977 but stabilizes thereafter to a value of 0.23. Correspondingly, the disturbance component $U^D$ moves towards unity; however, the fact that these values are still sufficiently away unity implies considerable departure of the predicted changes from those of the actuals and this is also corraborated by the increasing values of MSE for the years 1976 through 1978. In short then, the present analysis suggests that although the time series model that has been fitted yields forecasts that are not totally unacceptable (in relation to actuals), yet they are not sufficiently "perfect" in the sense that $U^R$ and $U^D$ are not close enough to 0 and 1, respectively.

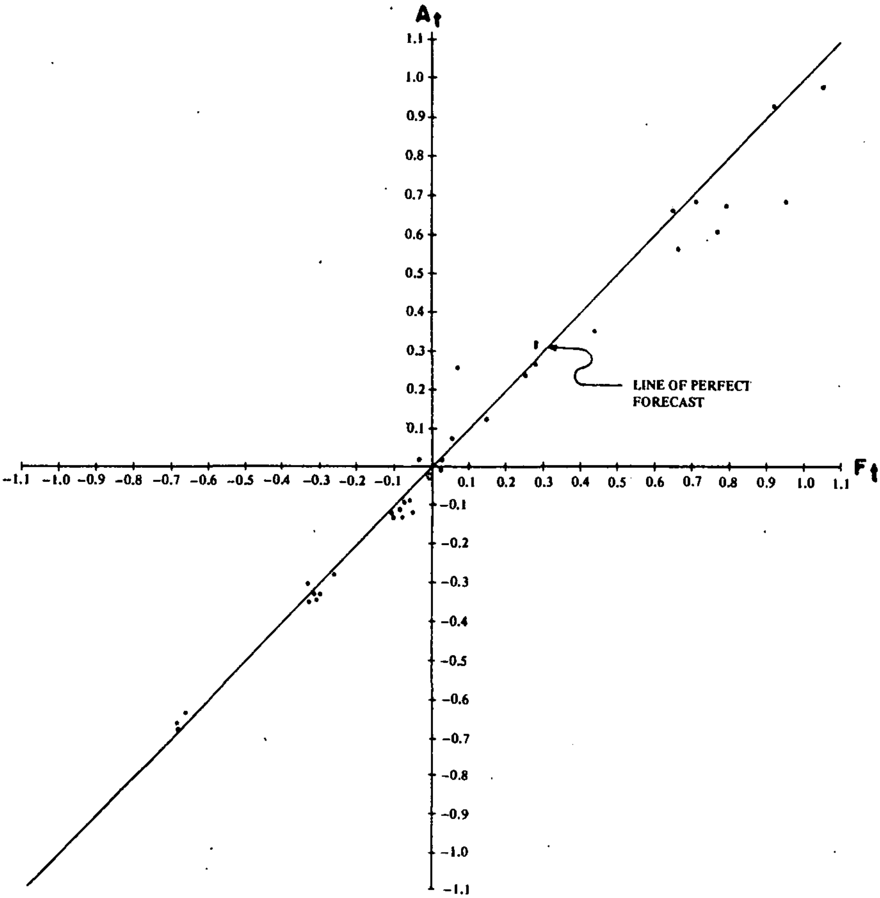


**Figure 4. Prediction realization diagram**

the regression lines

$$A_t = \hat{\alpha}_0 + \hat{\alpha}_1 F_t; \; t = 1, \ldots, m \tag{2.7}$$

for the three years 1976 to 1978 provide further evidence in this respect. The relevant estimates obtained from (2.7) for the forecast years are tabulated in Table 6 below:

Table 6. Estimates of regressions of actual changes on predicted changes

| *Year* | *m* | *Intercept* | *Slope* | $R^2$ *(%)* | $\hat{\sigma}^2$ | *DW* |
|---|---|---|---|---|---|---|
| 1976 | 11 | –.0243<br>(0.0125) | .9500<br>(0.0281) | 99.23 | .0017 | 1.83 |
| 1977 | 12 | –.0133<br>(0.0150) | .9441<br>(0.0297) | 99.02 | .0025 | 1.90 |
| 1978 | 12 | –.0091<br>(0.0282) | .8956<br>(0.0589) | 95.85 | .0089 | 2.44 |
| 1976-78 | 35 | –.0156<br>(0.0111) | .9323<br>(0.0233) | 97.98 | .0041 | 2.41 |

Figures in parenthesis refer to standard errors.

As may be seen, the intercept values $\hat{\alpha}_0$ and those of the slope coefficients $\hat{\alpha}_1$ steadily decrease between the years 1976 and 1978. Thus, relating them to those of the line of perfect forecast in which $\alpha_0 = 0$ and $\alpha_1 = 1$, we find that although none of the $\hat{\alpha}_0$ and $\hat{\alpha}_1$ values are statistically different from 0 and 1, respectively, yet the intercept coefficients move favourably in the desired direction and the slope coefficients drift away from that of the line of perfect forecast and that it is this latter factor which contributes to an increasing MSE as the forecast years advance.

While the above criteria – the MSE and the three inequality proportions – enable one to measure forecast performance of an estimated model, another line of inquiry is also possible, namely to assess how "good", in some absolute sense, is a particular set of forecasts. In the absence of a competing model whose forecasts may be compared against those generated by a given model, the simplest way is to construct a "naive" model and then to judge how "good" the forecasts of the given model are in relation to the "naive" forecasts – i.e., the forecasts obtained without the support of or lacking any underlying subject-matter theory.

The inequality coefficient $U^2$ proposed by Theil (1966) comes under this category. This is given by:

$$U^2 = \frac{\Sigma (F_t - A_t)^2}{\Sigma A_t^2} \tag{2.8}$$

It compares the MSE of a forecast with that of a naive "no-change" model $f_{t+1} = a_t$ in which the future values forecasted are the same as the last available actual values. If the fitted model performs no better than this naive model, the value of $U$ would be close to one. It may also be seen that if the fitted model turns out perfect forecasts, i.e., $f_t = a_t$ for all $t$, then $U = 0$.

In the recent literature on forecasting of time series data, more highly refined naive competitive models have been constructed. Nevertheless, they are exposed to a number of theoretical criticisms and their superiority over the simple ones like the one above in practical situations is by no means obvious. For these reasons, we would be content with using (2.8) above in our present analysis.

The value of $U^2$ for the three individual years 1976 through 1978 and over the entire forecast period 1976-1978 are given in Table 7 below.

Table 7. Values of the inequality coefficient $U^2$

| *Year* | $U^2$ |
|---|---|
| 1975 | 0.0134 |
| 1977 | 0.0144 |
| 1978 | 0.0542 |
| 1976-78 | 0.0270 |

That the values of $U^2$ are away from unity indicate that the model fitted is superior to the naive "no-change" model: $f_{t+1} = a_t$; also, while being close to zero, they increase over the forecast period thus suggesting that the forecast changes derived from the fitted model drift away from the actual changes. This is in line with the evidence given by the earlier criteria of MSE and the inequality proportions.

## *3. Concluding Remarks*

The forecasting analysis has shown that the X-11 method of decomposing the time series under study into its systematic constituents of trend-cycle and seasonal components coupled with a suitable parametric modelling of the trend-cycle component is capable of generating forecasts that are reliable in the sense that, by and large, they are reasonably close to the actuals. However, the efficiency of these forecasts is an open question since no alternative models have been attempted except for the two naive models viz. the line of perfect forecast and the random walk model.

Also, the equation (2.1) fitted suggests that modelling the series through specifications such as ARIMA which are more sophisticated than X-11 would be in order. In this connection, it must be noted that the X-11 procedure isolates the trend-cycle as a composite component with the result that the oscillatory movement of cycles is enmeshed with the secular trend. Also, there are evidences to suggest that X-11 method cannot adequately cope with seasonals having constant patterns but varying amplitudes. In such situations, the technique of spectral analysis might seem to be a more appropriate approach for effecting seasonal adjustments.

Thus, all in all, it would be instructive to analyze these data using the above alternative model constructs and to evaluate the accuracy of the forecasts generated by them against the ones obtained here with the help of a somewhat standard procedure such as the X-11.

## *4. Acknowledgments*

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Appendix 1: Monthly data (actual) on registered marriages for the years 1958-78[4]

| *Year* | *Jan.* | *Feb.* | *March* | *April* | *May* | *June* | *July* | *Aug.* | *Sept.* | *Oct.* | *Nov.* | *Dec.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1958 | 17,127 | 7,366 | 12,046 | 13,519 | 13,758 | 12,961 | 8,883 | 6,178 | 10,419 | 10,412 | 8,413 | 8,198 |
| 1959 | 16,887 | 6,271 | 9,514 | 16,641 | 15,428 | 17,168 | 12,783 | 7,088 | 10,474 | 11,250 | 9,417 | 8,955 |
| 1960 | 18,651 | 12,654 | 12,731 | 10,917 | 18,549 | 11,312 | 7,959 | 6,475 | 11,649 | 11,118 | 10,463 | 10,570 |
| 1961 | 22,853 | 9,205 | 31,208 | 11,793 | 20,613 | 6,779 | 4,463 | 4,342 | 9,719 | 10,262 | 10,421 | 11,649 |
| 1962 | 23,203 | 8,007 | 16,003 | 13,036 | 17,388 | 15,388 | 10,318 | 7,851 | 12,657 | 12,166 | 10,807 | 9,993 |
| 1963 | 20,963 | 15,403 | 13,210 | 13,835 | 16,352 | 15,483 | 6,763 | 6,487 | 11,605 | 11,846 | 11,325 | 11,809 |
| 1964 | 25,199 | 7,868 | 11,793 | 16,622 | 18,305 | 19,731 | 13,659 | 8,300 | 13,801 | 13,897 | 12,120 | 12,988 |
| 1965 | 26,462 | 9,320 | 18,176 | 13,514 | 18,689 | 21,008 | 14,278 | 8,362 | 13,973 | 13,625 | 12,111 | 14,750 |
| 1966 | 28,899 | 9,461 | 17,846 | 15,854 | 21,033 | 20,546 | 13,350 | 7,941 | 13,663 | 12,900 | 11,805 | 12,623 |
| 1967 | 27,099 | 8,540 | 15,590 | 16,793 | 20,773 | 22,109 | 13,846 | 8,830 | 16,269 | 14,285 | 11,290 | 14,473 |
| 1968 | 29,785 | 10,304 | 19,230 | 16,421 | 24,117 | 25,035 | 15,412 | 8,983 | 15,821 | 16,018 | 14,912 | 14,482 |
| 1969 | 34,448 | 10,914 | 20,409 | 19,328 | 25,140 | 25,100 | 14,967 | 9,794 | 17,494 | 17,468 | 16,221 | 19,918 |
| 1970 | 37,702 | 12,860 | 20,442 | 24,292 | 28,620 | 29,286 | 19,185 | 12,287 | 22,273 | 22,462 | 12,361 | 14,012 |
| 1971 | 35,487 | 11,336 | 22,119 | 19,789 | 28,378 | 28,650 | 18,203 | 12,116 | 20,228 | 19,059 | 15,631 | 21,735 |
| 1972 | 34,278 | 11,786 | 18,327 | 24,483 | 27,803 | 28,481 | 16,672 | 10,668 | 18,734 | 17,862 | 17,593 | 21,574 |
| 1973 | 37,578 | 12,686 | 25,350 | 20,820 | 30,888 | 26,893 | 17,759 | 11,681 | 19,128 | 19,046 | 18,556 | 22,953 |
| 1974 | 39,297 | 12,321 | 26,184 | 23,858 | 32,614 | 29,393 | 20,952 | 13,471 | 24,246 | 22,663 | 19,071 | 23,914 |
| 1975 | 40,841 | 12,157 | 22,553 | 31,059 | 33,828 | 30,189 | 21,478 | 14,443 | 23,859 | 23,363 | 20,812 | 24,932 |
| 1976 | 41,305 | 14,836 | 28,584 | 24,836 | 33,794 | 29,675 | 21,328 | 14,794 | 23,133 | 23,527 | 21,492 | 26,684 |
| 1977 | 45,098 | 14,627 | 29,036 | 29,635 | 37,646 | 33,134 | 21,631 | 14,492 | 23,359 | 25,107 | 21,911 | 28,790 |
| 1978 | 48,045 | 16,201 | 27,382 | 34,495 | 38,460 | 34,250 | 22,907 | 14,954 | 25,153 | 25,012 | 22,931 | 30,318 |

[4]Source: NCSO, Vital Statistics Reports

Appendix 2: Monthly data (log-transformed) on registered marriages for the years 1958-78

| *Year* | *Jan.* | *Feb.* | *March* | *April* | *May* | *June* | *July* | *Aug.* | *Sept.* | *Oct.* | *Nov.* | *Dec.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1958 | 9.7484 | 8.9046 | 9.3965 | 9.5119 | 9.5294 | 9.4697 | 9.0919 | 8.7287 | 9.2514 | 9.2507 | 9.0375 | 9.0116 |
| 1959 | 9.7343 | 8.7437 | 9.1605 | 9.7196 | 9.6439 | 9.7508 | 9.4559 | 8.8662 | 9.2567 | 9.3281 | 9.1503 | 9.1000 |
| 1960 | 9.8337 | 9.4457 | 9.4518 | 9.2981 | 9.8282 | 9.3362 | 8.9821 | 8.7757 | 9.3630 | 9.3163 | 9.2556 | 9.2658 |
| 1961 | 10.0368 | 9.1275 | 10.3484 | 9.3753 | 9.9337 | 8.8216 | 8.4036 | 8.3761 | 9.1818 | 9.2362 | 9.2516 | 9.3630 |
| 1962 | 10.0520 | 8.9881 | 9.6805 | 9.4755 | 9.7635 | 9.6413 | 9.2416 | 8.9684 | 9.4460 | 9.4064 | 9.2879 | 9.2096 |
| 1963 | 9.9505 | 9.6423 | 9.4887 | 9.5350 | 9.7021 | 9.6475 | 8.8192 | 8.7776 | 9.3592 | 9.3797 | 9.3348 | 9.3766 |
| 1964 | 10.1346 | 8.9706 | 9.3753 | 9.7185 | 9.8149 | 9.8899 | 9.5222 | 9.0240 | 9.5325 | 9.5394 | 9.4026 | 9.4405 |
| 1965 | 10.1835 | 9.1399 | 9.8079 | 9.5115 | 9.8357 | 9.9527 | 9.5665 | 9.0315 | 9.5449 | 9.5197 | 9.4019 | 9.5990 |
| 1966 | 10.2716 | 9.1549 | 9.7895 | 9.6712 | 9.9538 | 9.9304 | 9.4993 | 8.9798 | 9.5224 | 9.4650 | 9.3763 | 9.4433 |
| 1967 | 10.2073 | 9.0525 | 9.6544 | 9.7287 | 9.9414 | 10.0037 | 9.5358 | 9.0859 | 9.6970 | 9.5670 | 9.3317 | 9.5800 |
| 1968 | 10.3018 | 9.2403 | 9.8642 | 9.7063 | 10.0907 | 10.1280 | 9.6429 | 9.1031 | 9.6691 | 9.6815 | 9.6099 | 9.5807 |
| 1969 | 10.4472 | 9.2978 | 9.9237 | 9.8693 | 10.1322 | 10.1306 | 9.6136 | 9.1895 | 9.7696 | 9.7681 | 9.6941 | 9.8994 |
| 1970 | 10.5375 | 9.4619 | 9.9253 | 10.0979 | 10.2619 | 10.2849 | 9.8619 | 9.4163 | 10.0111 | 10.0196 | 9.4223 | 9.5541 |
| 1971 | 10.4769 | 9.3357 | 10.0042 | 9.8929 | 10.2534 | 10.2629 | 9.8093 | 9.4023 | 9.9148 | 9.8553 | 9.6570 | 9.9867 |
| 1972 | 10.4423 | 9.3747 | 9.8161 | 10.1057 | 10.2329 | 10.2570 | 9.7215 | 9.2750 | 9.8381 | 9.7904 | 9.7753 | 9.9792 |
| 1973 | 10.5342 | 9.4483 | 10.1405 | 9.9437 | 10.3381 | 10.1996 | 9.7846 | 9.3657 | 9.8589 | 9.8546 | 9.8285 | 10.0412 |
| 1974 | 10.5789 | 9.4191 | 10.1729 | 10.0799 | 10.3925 | 10.2885 | 9.9500 | 9.5083 | 10.0960 | 10.0285 | 9.8559 | 10.0822 |
| 1975 | 10.6174 | 9.4057 | 10.0236 | 10.3436 | 10.4290 | 10.3152 | 9.9748 | 9.5780 | 10.0799 | 10.0589 | 9.9433 | 10.1239 |
| 1976 | 10.6287 | 9.6048 | 10.2606 | 10.1200 | 10.4280 | 10.2981 | 9.9678 | 9.6020 | 10.0490 | 10.0659 | 9.9754 | 10.1918 |
| 1977 | 10.7166 | 9.5906 | 10.2763 | 10.2967 | 10.5360 | 10.4083 | 9.9819 | 9.5814 | 10.0587 | 10.1309 | 9.9947 | 10.2678 |
| 1978 | 10.7799 | 9.6928 | 10.2176 | 10.4486 | 10.5574 | 10.4414 | 10.0392 | 9.6127 | 10.1327 | 10.1271 | 10.0402 | 10.3195 |