حول بناء سلاسل زمنية ربع سنوية لاقتصاديات مجلس التعاون الخليجي

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(قُدم للنشر في ١٩/٤/١٤١٤هـ؛ وقبل للنشر في ١/١٠/١٤١٤هـ)

ملخص البحث. تسعى هذه الدراسة إلى تقويم مدى ملاءمة توزيع السلاسل الزمنية السنوية إلى بيانات ربع سنوية باستخدام قاعدة القطع المكافىء (سمبسون) في التكامل العددي. ولقد تم تطبيق هذه القاعدة لبناء سلاسل زمنية ربع سنوية لحسابات الدخل القومي في دول مجلس التعاون الخليجي. ودلت الاختبارات الإحصائية والبيانية على أن السلاسل الزمنية ربع السنوية التي تم بناؤها باستخدام قاعدة القطع المكافىء يمكن الثقة بها على الأقل مثل الثقة بالبيانات المنشورة رسميًا. ولقد تم إضافة بيانات السلاسل الزمنية السنوية (المنشورة رسميًا والتي استخدمت في الدراسة) وربع السنوية (التي تم بناؤها).

Further examinations of both annual and quarterly series show that the generated quarterly series do conform to the properties of the original annual series. These further examinations include those of sample auto-correlation (ACF) and partial auto-correlation (PACF) functions(9).

Conclusion

In this paper, alternative methods of interpolation are discussed and the appropriateness of a numerical method based on the parabolic (Simpson's) rule is closely examined. It turns out that such a rule provides a reasonable method for interpolation. The rule is applied to construct quarterly time series for the national income accounts in the GCC countries.

Although the parabolic rule, as discussed in this paper, was applied to construct quarterly series from annual observations, it can be applied equally-well to construct monthly figures from annual observations. All one needs to change are equation sets (4) and (5) in the text to account for the change in interval from a quarter to a month. In fact, it is expected that the approximation to monthly figures would be better than approximation to quarterly figures, as the interval becomes smaller in the former.

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(9) It is obvious that quarterly series show more auto-correlation than the annual series so that the former give significant ACF and PACF at lags longer than the former. However, the point here is that both quarterly and annual sereis have the same characteristics regarding stationarity and non-stationarity.

imports, and gross fixed capital formation and total (private and government) consumption, respectively. As it turns out, the quarterly figures resemble the annual series closely if not completely, with the effect of distributing sharp jumps in annual series being clear in the quarterly series.

It is hoped that the generated series preserve the properties of the original series and, at the same time, the former provide more information than the latter, for otherwise, the generation of quarterly series would be misleading and useless. Table 2 shows the descriptive statistics for both annual (Table 2.a) and quarterly (Table 2.b) time series. It is interesting to note that since the quarter data sum to the corresponding annual observation, the mean of the annual figure is exactly four times the quarterly figure(7). Moreover, it is clear that quarters should have less variations than the annual observations. This is indicated by the standard deviations, which are far less for the quarter figures. Higher order moments of the time series (skeweness and kurtosis) for the annual figures are preserved in quarter data(8).

Table 2. Annual and quarterly time series for the Saudi Arabian economy: Descriptive statistics

Variable	PC	GC	IV	X	M	CS	GDP
2.a Annual Data:							
Mean	62.72	50.17	44.00	106.08	−73.77	−0.24	188.96
Standard deviation	12.98	10.16	8.73	21.38	15.10	1.56	34.77
Skeweness	0.48	0.43	0.47	1.28	−0.57	0.93	5.56
Kurtosis	−1.69	−1.65	−1.35	1.36	−1.19	2.22	−0.83
2.b Quarterly data:							
Mean	15.68	12.54	11.00	26.52	−18.44	−0.06	47.24
Standard deviation	1.60	1.25	1.08	2.65	1.86	0.20	4.29
Skeweness	0.46	0.41	0.45	1.24	−0.55	0.88	0.55
Kurtosis	−1.62	−1.58	−1.32	1.06	−1.81	2.18	−0.86

Notes: The data cover the period 1964-1988 annually for Table 2.a and 1964. I-1988. IV quarterly for Table 2.b. For variable definitions, see Table 1. All variables are measured in billions of current Saudi Riyals.

Source: Table 2.a: International Monetary Fund, International Financial Statistics Tape. Table 2.b: Generated from the data of Table A.1 using equations (5).

(7) This is the overall mean of the sample. This means that the quarterly figures are 0.25 of the annual figures on average.

(8) Although the level of significance of the skeweness and kurtosis coefficients are not the same due to the difference in sample sizes.

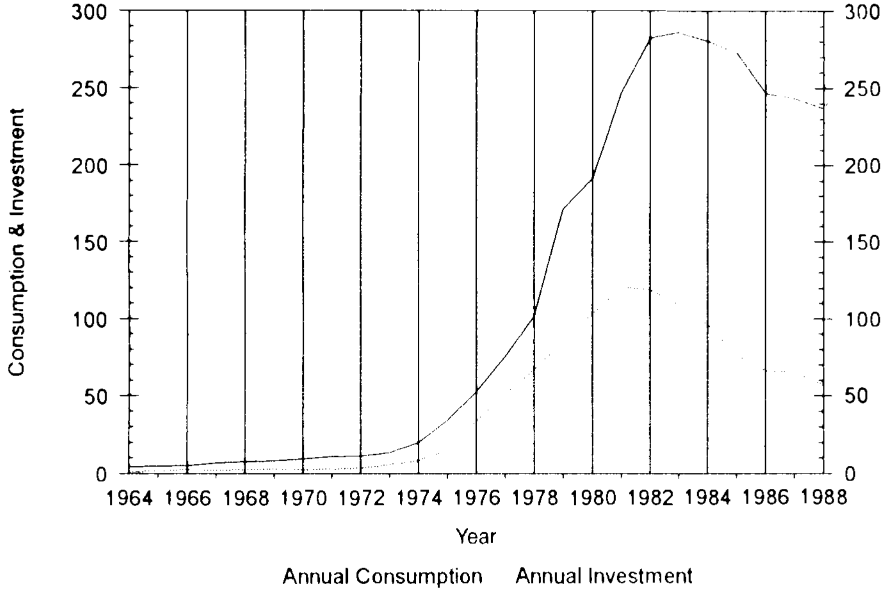

Fig. 3a. Annual fixed capital formation and total consumption of Saudi Arabia.

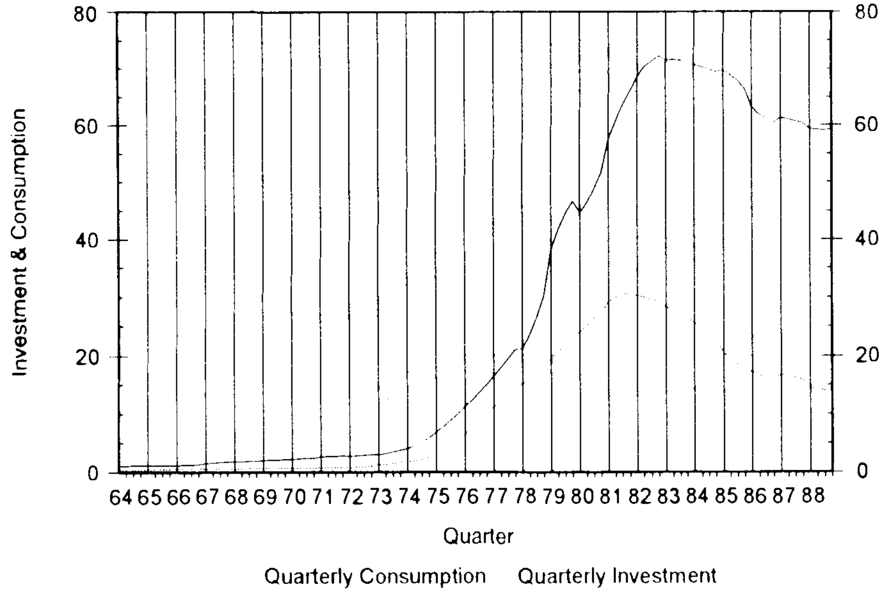

Fig. 3b. Quarterly fixed capital formation and total consumption of Saudi Arabia.

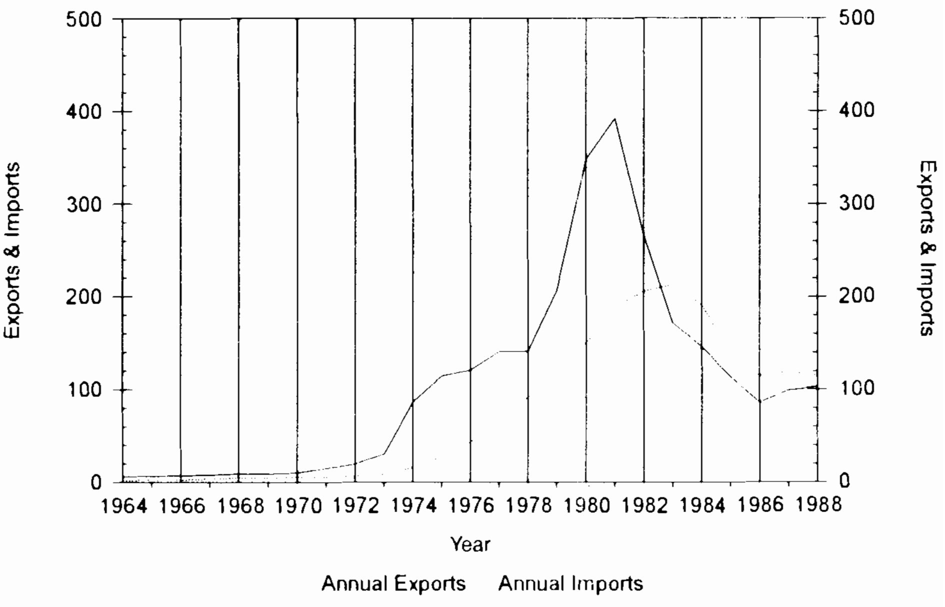

Fig. 2a. Annual exports and imports series of Saudi Arabia.

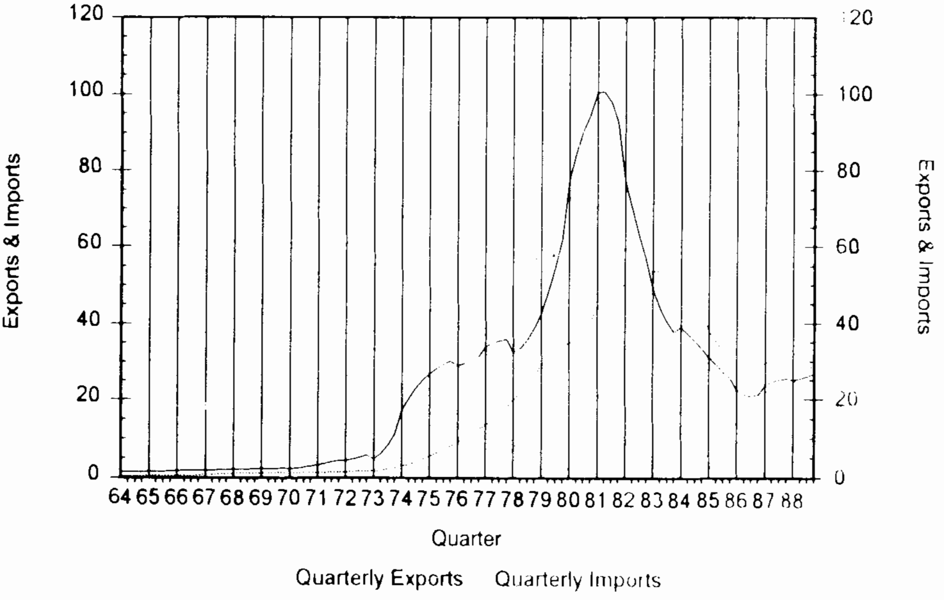

Fig. 2b. Quarterly exports and imports series of Saudi Arabia.

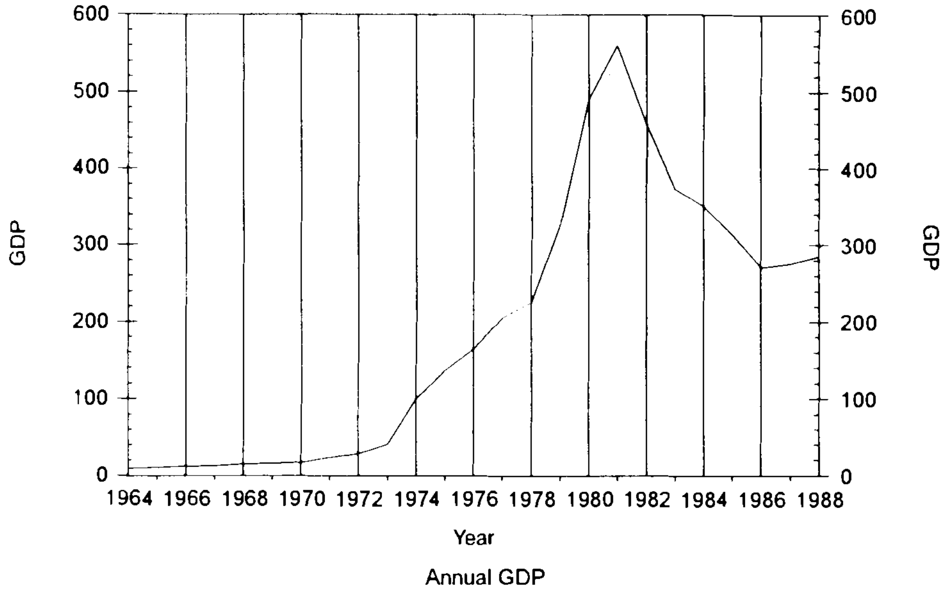

Fig. 1a. Annual GDP series by Saudi Arabia.

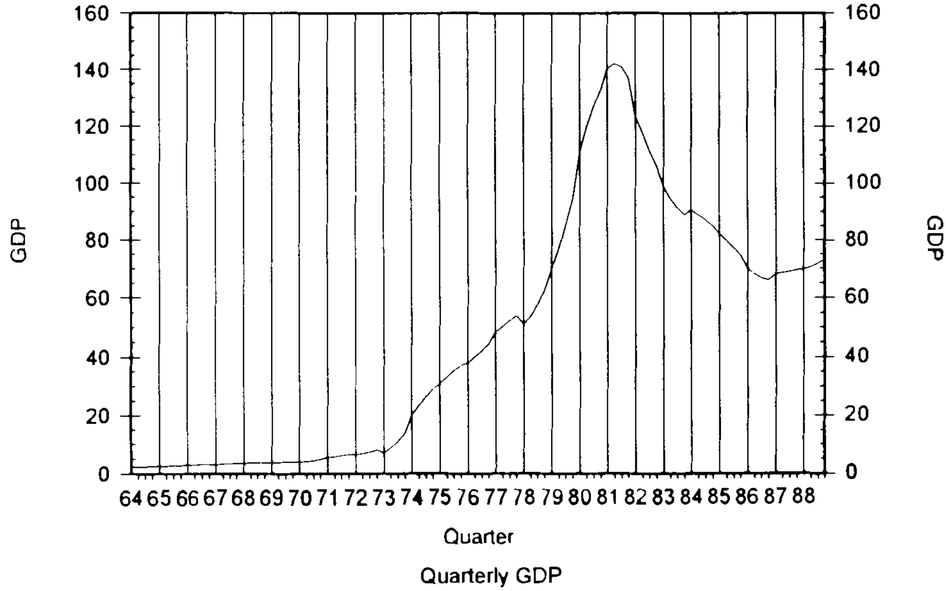

Fig. 1b. Quarterly GDP series of Saudi Arabia.

Equations (5) can be used to generate quarterly data. Note that for each quarter, the present year (t) has more weights than either the previous (t−1) or the later (t+1) years. For the first two quarters, year t− 1 has more weights than t+1, with weights reversed for the last two quarters. For all quarters, the present year has more weights than the former and the latter, with more weights for the present year in the second and third quarters when compared with the first and fourth quarters. Moreover, for each quarter, the weights sum to 0.25 so that quarterly figures sum to the value of the corresponding annual observation(5).

Section IV
Statistical Properties of the Generated Series

Equation (5) is applied to the annual GCC national income accounts to generate quarterly data. The annual data are taken from the International Monetary Fund, International Financial Statistics Tape. For each country, the sample covers the period shown in Table 1. The annual observations are used to generate quarterly observations starting from the first quarter of the following year and ending with the last quarter of the before-the-last-year, since the first year is used as the Y_{t-1} and the last year is used as the Y_{t+1}* (for details see Table 1).

To start analyzing the generated quarterly series, we first note that for each variable, quarterly data do indeed sum to the annual observations. More importantly, since the same 'transformation' is applied to the components of the GDP, the resulting quarterly series preserve the 'adding-up' property of the national income account. That is, the quarterly figure of the GDP can be obtained by summing the quarterly figures of exports, government consumption, fixed capital formation, imports, private consumption, and changes in stock.

We graph both the (original) annual data and the generated quarterly series for Saudi Arabia(6). Figures (1-3) show the graph of GDP (Figs. 1-3 are based on data of International Financial Statistics Tape, May 1993), exports and (absolute values of)

* Annual data and generated quarterly figures are not reported here for conservation of space. They can be made available from the author upon request.

(5) Goldstein and Khan [5] stated that multiplication of quarterly figures by 4 expresses the interpolated series at annual rates. However, it is obvious that it is the sum, rather than the multiplication that expresses the quarters in annual rates, since each quarter has different weights in the annual observations. Multiplication by 4 expresses quarterly data at annual rates only if the present year t has a weight equal to 0.25.

(6) We report the graphs and statistics for the Saudi Arabia series only to conserve on space. Similar tests have been conducted for other GCC countries and showed the same results. Graphs and tests that are not reported in this paper can be obtained from the author upon request.

Integrating and solving the resulting three simultaneous equations for a,b and c in terms of Y_{t-1}, Y_t, and Y_{t+1} so that the quadratic passes through the three annual observations give:

$$\begin{aligned} a &= 0.5\, Y_{t+1} - 1.0\, Y_t + 0.5\, Y_{t-1} \\ b &= -\,1.0\, Y_{t+1} + 3.0\, Y_t - 2.0\, Y_{t-1} \\ c &= 0.333\, Y_{t+1} - 1.167\, Y_t + 1.833\, Y_{t-1} \end{aligned} \tag{3}$$

Quarterly figures within any year can then be approximated by dividing a year interval into equal sub-intervals; that is dividing a year in four quarters each of length 0.25, and then approximating each sub-interval (quarter) using (3). This means evaluating the integrals[4]:

$$\begin{aligned} &\text{First Quarter } (Q_1): \int_{1.00}^{1.25} (ax^2 + bx + c)\, dx, \\ &\text{Second Quarter } (Q_2): \int_{1.25}^{1.50} (ax^2 + bx + c)\, dx, \\ &\text{Third Quarter } (Q_3): \int_{1.50}^{1.75} (ax^2 + bx + c)\, dx, \\ &\text{Fourth Quarter } (Q_4): \int_{1.75}^{2.00} (ax^2 + bx + c)\, dx. \end{aligned} \tag{4}$$

which, upon integration and substitutions for a,b, and c from (3), give the following fundamental equations for interpolating annual observations into quarterly figures:

$$\begin{aligned} Q_1 &= -\,0.0391\, Y_{t+1} + 0.2344\, Y_t + 0.0547\, Y_{t-1} \\ Q_2 &= -\,0.0234\, Y_{t+1} + 0.2656\, Y_t + 0.0078\, Y_{t-1} \\ Q_3 &= -\,0.0078\, Y_{t+1} + 0.2656\, Y_t - 0.0234\, Y_{t-1} \\ Q_4 &= -\,0.0547\, Y_{t+1} + 0.2344\, Y_t - 0.0391\, Y_{t-1} \end{aligned} \tag{5}$$

(4) For more discussions, see Jeffrey [8], pp. 644-646.

highly questionable[2]. Further difficulties are associated with the concept of national income accounts. That is, there is no guarantee that quarterly data of a flow variable such as GDP would sum to annual observations unless we impose restrictions on regression estimates. These restrictions are "definitive" and could not be tested by available data. If such restrictions are not valid, estimates will be based and the prediction of quarterly data may not be reliable. Furthermore, the basic property that the GDP is the sum of its components is not necessarily preserved in regression methods, since each component is interpolated by a totally independent regression. For all these reasons, we rely on numerical methods to generate quarterly sereis for the GCC economies. The advantage of these methods is that they do not require the use of additional variable nor do they use it. Such a desirable property does not transmit errors in used variables to the generated data. The method is based on what is known as the Simpson's (parabolic) rule in numerical integration and was used in Goldstein and Khan [5]. The next section illustrates the method in details.

The method

Let Y represent a variable whose observations are available at an annual base and we want to generate its quarterly data. The task is to approximate the graph of Y = f(x) between points at which the values of Y are known. That is, we want to approximate the graph of Y between any two annual points. If we represent f(x) by a quadratic function [3] on the form:

$$Y = ax^2 + bx + c \tag{1}$$

then for any three consecutive annual observations (at years 0,1 and 2) of Y, the approximation of the graph of Y takes the form:

$$\begin{aligned} \int_0^1 (ax^2 + bx + c)\, dx &= Y_{t-1} \\ \int_1^2 (ax^2 + bx + c)\, dx &= Y_t \\ \int_2^3 (ax^2 + bx + c)\, dx &= Y_{t+1} \end{aligned} \tag{2}$$

(2) For more discussions on regression methods, see Chow and Lin [2], Maddala [3] pp. 201-207, and Greene [4] pp. 273-277.

(3) A quadratic function gives all desirable properties of approximation. A lower order polynomial (a trapezoidal rule) gives straight line; whereas a higher order requires more data and (for a 3rd order polynomial) does not improve on the approximation, see Hamming [6], pp. 246-248. If the consecutive observations are collinear, then the quadratic degenerates to a linear function and the parabolic region becomes a trapezoid. See Salas and Hile [7], p. 457.

With the exception of Qatar, the coverage of national income accounts is identical in every country. As of May, 1993, all of the GCC countries have not published official data since 1989. It is well known that the GCC countries do not publish quarterly data on national accounts. This means that the number of available observations are so limited as to make it impossible to conduct a statistically reliable analysis. For Bahrain, there are only 14 observations; for Kuwait, there are 28 observations; for Saudi Arabia, there are 27 observations and for the UAE, there are 18 observations. It is clear that such a limited number of observations cast doubt on any statistical analysis. Therefore, the enhancement of the number of observations, while maintaining the structure of the original data, will be beneficial. This is the task which we take up in the next section.

Section III
Alternative Methods of Interpolation

There exists a number of methods to generate quarterly data from annual observations. In general, these methods can be classified into those which require and use the existence of relevant time series at quarter and annual frequencies and those which depend on numerical methods. The first type is generally based upon regression techniques. To illustrate the idea, suppose that we want to generate quarterly series for a variable Y whose observations are available at annual base only. Suppose further that Y is known to be related to a set of n variables $x = (x_1, x_2, \ldots, x_n)$ whose observations are available at both annual and quarter bases. The idea here is to use the annual series to estimate a regression of Y on x and then use the estimated coefficients to 'predict' the quarterly series of the dependent variable Y. Although this method seems straightforward, two difficulties make it impractical for most developing countries. The first is that the structure of the error term of the annual observation regression may be so complicated (due to measurements error, omitted variables, ... etc.) as to make estimates' reliability at stake. The second, and more important, difficulty is that the selection of the x's are ad-hoc and based totally on data availability rather than on theory. In fact, the question of how to select the x's is usually 'bypassed' and any variable that is correlated with Y and available at a quarter base will do. Moreover, researchers are sometimes constrained by the unavailability of any reasonably correlated x's at a quarter base. This fact is what hinders us from experimenting with regression methods to generate quarterly data for the GCC countries. For example, the only reasonably usable variable that is available at quarterly base in Saudi Arabia is the money stock.

Any attempt to predict quarterly GNP data from the money supply alone will be accounts. Although some of the GCC countries have rich national databases when compared to other developing countries, these databases still do not permit the conduct of reliable statistical and econometric analyses. This paper makes available both officially published annual series and constructed quarterly time series. It is hoped that this endeavor will facilitate the conduct of more meaningful and reliable applied econometric research.

The paper is organized as follows: The next section presents an overview of the GCC national income accounts. Section III briefly discusses alternative methods of interpolating annual observations into quarterly data[1] and presents the method to be used in the interpolation. Section IV evaluates statistical properties of the generated series. Section V concludes the paper. The Appendix contains both annual (officially published) and quarterly (constructed) time series.

Section II
An Overview of the GCC National Income Accounts

As mentioned in the introduction of this paper, some of the GCC countries, notably Kuwait, Saudi Arabia and Oman, have rich national income accounts data when compared to developing countries. Table 1 shows the status of the national income accounts in the GCC countries.

Table 1. Summary of the status of the GCC national income accounts as of May 1993

Country	Starting	PC	GC	IV	X	M	CS	GDP
Bahrain	1975 to	1988	1989	1989	1988	1988	1988	1989
Kuwait	1962 to	1989	1989	1989	1989	1989	1989	1989
Oman*	1967 to	1989	1989	1989	1989	1989	NA	1989
Qatar**	1966 to	NA	NA	NA	1986	1989	NA	1989
Saudi Arabia	1963 to	1989	1989	1989	1989	1989	1989	1989
UAE	1972 to	1989	1989	1989	1989	1989	1989	1989

Notes: PC is private consumption; GC is government consumption; IV is gross fixed capital formation; X is exports; M is imports; CS is changes in stocks; and GDP is gross domestic product.

* Oman does not publish changes in stocks as a component of the GDP.

** Qatar publishes a stand-alone figure on the GDP without details on its components. The exports and imports figures are the foreign trade figures.

Source: Based on information from the International Monetary Fund, International Financial Statistics Tape, May 1992 release.

(1) Throughout this paper, "interpolation", "distribution", and "generation" will be used interchangeably to mean the same thing: construction of quarterly figures from annual observations.

J. King Saud Univ., Vol. 7, *Admin. Sci.* (2), pp. 107-118 (1415 A.H./1995)

On the Construction of Quarterly Time Series for the Gulf Cooperation Council Economies

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(Received on 19/4/1414; accepted for publication on 1/10/1414 A.H.)

Abstract. This paper evaluates the appropriateness of interpolating annual observations into quarterly data using the parabolic (Simpson's) rule in numerical integration. The rule is applied to construct quarterly time series for national income accounts of the Gulf Cooperation Council (GCC) countries. Statistical and graphical examinations of the resulting quarterly time series indicate that the generated series are at least as reliable as the officially published data. Both annual and quarterly time series of national income accounts are reported.

Introduction

Applied researchers usually face the problem of data availability. Aside from confidentiality and nonexistence of certain data, an equally severe problem in time series regressions and analyses arises when researchers have to sacrifice some observations on certain variables due to limitations on the availability of other variables at appropriate frequency. In spite of the fact that most economic time series are "manufactured products", to use the phrase of Milton Friedman [1], most developing countries have a very limited database that hinders the reliability, if not the conduct, of applied researches.

The purpose of this paper is to evaluate the appropriateness of a certain method of distributing annual observations into quarterly data. The method is applied to construct quarterly time series for the Gulf Cooperation Council (GCC) national income