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Abstract

This paper examines the issue of Saudi Arabia's pre-1988 economic data, much of which was formerly based on the Islamic calendar, a 354-355 day calendar composed of 12 lunar months. The Kingdom went to a Gregorian-based 365-366 day solar calendar in 1988, but, with the exception of the national accounts data, little effort has been made to convert many of the pre-1988 economic series into their Gregorian equivalents. This is particularly the case with the monthly and quarterly money and banking data published by the Saudi Arabian Monetary Authority (SAMA). The paper identifies the problems caused by the lack of pre-1988 Gregorian-based data, explains the methodology used to convert the annual data, and gives an example of the application of this methodology. In addition, the paper describes how this methodology can be applied to monthly data – most importantly, the data for the monetary aggregates and their individual components, for which monthly Gregorian-based data back to 1964 has now been calculated. Finally, this paper suggests that one of the tools developed for the monthly data conversion (the monthly proportionality matrix) can be used with the US Census Bureau's X-13-ARIMA-SEATS seasonal adjustment program, which in turn can be used to produce seasonally adjusted data for many of the monthly series that SAMA produces.

**Keywords:** Economic Data, Economic Data Conversion, Hijra/Islamic Calendar, Seasonal Adjustment

**(JEL Classification):** C22, C53, E50

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## 1. Introduction

Prior to 1988, the Saudi Arabian government's fiscal year was based on the Hijra lunar calendar, and many of its economic and financial data series were published using this calendar.[1] To further complicate matters, the fiscal year started on the first day of the seventh month (Rajab) of the Hijra year, and ended on the last day (either day 29 or 30, depending on the timing of the new moon) of the sixth month (Jumada II) of the next Hijra year. Even more problematic is the fact that a Hijra lunar year is only 354-355 days long, versus the 365-366 days of the Gregorian calendar. Thus, the yearly totals for the various series were understated by around 3% from the corresponding Gregorian year, as were any growth rates calculated from these data.

The Hijra calendar was used for many of the Kingdom's economic data series, including the following:

- National Accounts (GDP)
- Money and Banking statistics, including the money supply and bank assets and liabilities
- Government Revenues and Expenditures

Other data series, including the balance of payments, the cost of living index, the wholesale price index, and most of the Kingdom's energy data have traditionally been kept on a Gregorian calendar basis.

Starting in 1988, the Saudi Ministry of Finance went to a fiscal year based on the Gregorian calendar, with the fiscal year starting on the 31st day of December and ending on the 30th of December of the following year. Thus,

[1] The Hijra calendar dates back to the year 622 AD, when the Prophet Mohammed (PBUH) and his followers migrated from Mecca to Medina and established the first Muslim community. The current Islamic year is 1439 AH, which began on 21 September 2017 and will end on 10 September 2018.

fiscal year 1988 started on December 31st 1987 and ended on December 30th 1988. The Ministry of Finance used a shortened transition year that began in March of 1986 and restated fiscal 1407/08 AH revenue and expenditure data for 1987.[2]

SAMA, which produces a large amount of monthly data (e.g., the monetary base and aggregates, monthly central and commercial bank balance sheet items, interest rates, etc.), switched to the Gregorian calendar in June of 1988. The last Hijra monthly statistics were for Shawwal of 1408, which ended on 14 June 1988, and the next monthly statistics were on the Gregorian basis, which ended on 30 June 1988. To the knowledge of the authors of this paper, neither SAMA nor the Ministry of Finance have restated any of their pre-1988 data; rather, SAMA publishes tables of both its own and the MOF annual data in Hijra format for fiscal 1407/08 AH directly above the data for 1988. The strong implication of this is that 1407/08 AH corresponds directly to 1987, as do earlier Hijra dates correspond to their earlier Gregorian counterparts.

The Central Department for Statistics (CDS, now known as the General Authority for Statistics) also switched to the Gregorian calendar in 1988 for all of its statistics; however, it did not restate the historical National Accounts data until 2003, when it released restated (and rebased) data back to 1968.

Obviously, use of the unconverted Hijra data would result in serious distortions in any analytical procedure. However, any statistical inference that only used post-1987 Gregorian-based data would be seriously

[2] See the footnotes to Tables 5.1 and 5.2 in the SAMA Annual Report database and page 29 of the Annual Report for 1406/1407. Annual report tables are available at: http://www.sama.gov.sa/en-US/EconomicReports/Pages/YearlyStatistics.aspx

questioned, since there would only be 30 data points at a maximum. Thus, what is needed is a way to convert the Hijra-based data into a Gregorian base. The rest of this paper is divided as follows: section 2 provides a summary of a recommended methodology that can be used for the restatement of this Hijra data, section 3 restates the methodology for monthly Hijra data and section 4 describes an application of the methodology to the M3 monetary aggregate. Section 5 presents some possible applications of the Hijra adjustment methodology to seasonality problems. Section 6 and section 7 summarize the literature review and the conclusions of the paper, respectively.

## 2. Restatement Methodology for Annual Hijra Data[3]

Since the original data for many Saudi time series prior to 1987-1988 exist only on a Hijra basis, it is not possible to get a precise estimate of the actual value based on the corresponding Gregorian time period. However, an estimate can be made by calculating the proportion of each given Hijra time period that goes into the equivalent Gregorian time period and then multiplying that proportion by the corresponding Hijra value.

Although this methodology can be applied to monthly, quarterly, or annual data, it has so far been applied almost exclusively to annual data. The calculations of these proportions for historical annual data going back to 1964 are shown in Table 1. All Hijra/Gregorian dates in Table 1 are from

[3] The authors would like to thank Dr. Fred Joutz, Professor of Economics at Georgetown University and a Visiting Research Fellow at the King Abdullah Petroleum Studies and Research Center (KAPSARC), for his invaluable contributions to this section of the paper.

the internal Microsoft Excel calendar.[4] Hijra calendars are available on the Internet, but their quality can be variable. The Excel dating methodology corresponds quite closely to the dates that actually appeared in the official Umm al-Qura calendar.

**Table 1**
**Annual Conversion Factors for Hijra Fiscal Year Data**

| Year | ending Hijra fiscal year (see note) | Hijra fiscal year beginning date | ending date of Gregorian fiscal year | Hijra fiscal year ending date | # of days in Hijra year | # of days of beginning Hijra fiscal year | # of days of ending Hijra fiscal year | percent of beginning fiscal yr | percent of ending fiscal yr | sum |
|---|---|---|---|---|---|---|---|---|---|---|
| **1963** | 1383-1384 | 17/11/1963 | 31/12/1963 | 04/11/1964 | 354 | | | | | |
| **1964** | 1384-1385 | 05/11/1964 | 31/12/1964 | 24/10/1965 | 354 | 310 | 57 | 87.57% | 16.10% | 103.67% |
| **1965** | 1385-1386 | 25/10/1965 | 31/12/1965 | 14/10/1966 | 355 | 298 | 68 | 84.18% | 19.15% | 103.34% |
| **1966** | 1386-1387 | 15/10/1966 | 31/12/1966 | 03/10/1967 | 354 | 288 | 78 | 81.13% | 22.03% | 103.16% |
| **1967** | 1387-1388 | 04/10/1967 | 31/12/1967 | 22/09/1968 | 355 | 277 | 89 | 78.25% | 25.07% | 103.32% |
| **1968** | 1388-1389 | 23/09/1968 | 31/12/1968 | 11/09/1969 | 354 | 267 | 100 | 75.21% | 28.25% | 103.46% |
| **1969** | 1389-1390 | 12/09/1969 | 31/12/1969 | 31/08/1970 | 354 | 255 | 111 | 72.03% | 31.36% | 103.39% |
| **1970** | 1390-1391 | 01/09/1970 | 31/12/1970 | 20/08/1971 | 354 | 244 | 122 | 68.93% | 34.46% | 103.39% |
| **1971** | 1391-1392 | 21/08/1971 | 31/12/1971 | 09/08/1972 | 355 | 233 | 133 | 65.82% | 37.46% | 103.28% |
| **1972** | 1392-1393 | 10/08/1972 | 31/12/1972 | 29/07/1973 | 354 | 223 | 144 | 62.82% | 40.68% | 103.49% |
| **1973** | 1393-1394 | 30/07/1973 | 31/12/1973 | 19/07/1974 | 355 | 211 | 155 | 59.60% | 43.66% | 103.27% |
| **1974** | 1394-1395 | 20/07/1974 | 31/12/1974 | 09/07/1975 | 355 | 201 | 165 | 56.62% | 46.48% | 103.10% |
| **1975** | 1395-1396 | 10/07/1975 | 31/12/1975 | 27/06/1976 | 354 | 191 | 175 | 53.80% | 49.44% | 103.24% |
| **1976** | 1396-1397 | 28/06/1976 | 31/12/1976 | 16/06/1977 | 354 | 180 | 187 | 50.85% | 52.82% | 103.67% |
| **1977** | 1397-1398 | 17/06/1977 | 31/12/1977 | 05/06/1978 | 354 | 168 | 198 | 47.46% | 55.93% | 103.39% |
| **1978** | 1398-1399 | 06/06/1978 | 31/12/1978 | 26/05/1979 | 355 | 157 | 209 | 44.35% | 58.87% | 103.22% |
| **1979** | 1399-1400 | 27/05/1979 | 31/12/1979 | 14/05/1980 | 354 | 147 | 219 | 41.41% | 61.86% | 103.27% |
| **1980** | 1400-1401 | 15/05/1980 | 31/12/1980 | 04/05/1981 | 355 | 136 | 231 | 38.42% | 65.07% | 103.49% |
| **1981** | 1401-1402 | 05/05/1981 | 31/12/1981 | 23/04/1982 | 354 | 125 | 241 | 35.21% | 68.08% | 103.29% |
| **1982** | 1402-1403 | 24/04/1982 | 31/12/1982 | 13/04/1983 | 355 | 114 | 252 | 32.20% | 70.99% | 103.19% |
| **1983** | 1403-1404 | 14/04/1983 | 31/12/1983 | 01/04/1984 | 354 | 104 | 262 | 29.30% | 74.01% | 103.31% |
| **1984** | 1404-1405 | 02/04/1984 | 31/12/1984 | 21/03/1985 | 354 | 93 | 274 | 26.27% | 77.40% | 103.67% |
| **1985** | 1405-1406 | 22/03/1985 | 31/12/1985 | 10/03/1986 | 354 | 81 | 285 | 22.88% | 80.51% | 103.39% |
| **1986** | 1406-1407 | 11/03/1986 | 31/12/1986 | 28/02/1987 | 355 | 70 | 296 | 19.77% | 83.38% | 103.15% |
| **1987** | 1407-1408 | 01/03/1987 | 31/12/1987 | 17/02/1988 | 354 | 60 | 306 | 16.90% | 86.44% | 103.34% |

Note: The Hijra fiscal year began on 1 Rajab (month 7) and ended on 29 or 30 Jumada II (month 6).

Following is the calculation process for the year 1964, which includes portions of Hijra fiscal years 1383-1384 and 1384-1385. Note that each Gregorian year has two sets of Hijra fiscal years associated with it – the fiscal year at the beginning of the Gregorian year and the next fiscal year at the end.

[4] In order to obtain the Hijra equivalent to any Gregorian date, simply format the cell containing the Gregorian date as follows: Home - Format Cells – Category: Date – Locale: Arabic (Saudi Arabia) – Calendar type: Umm al-Qura – Type: (select the format style desired). The Hijra dates in this paper are in the day/month/year format.

The first step is to calculate the number of days between Jan. 1, 1964 and the end of Hijra fiscal year 1383-1384 (Nov. 4, 1964). This amounts to 310 days, or 87.57% of fiscal 1383-1384 (which was 354 days long).

The next step is to calculate the number of days between the beginning of the next fiscal year 1384-1385 (Nov. 5, 1964) and the end of 1964 (on Dec. 31). This amounts to 57 days, or 16.1% of fiscal 1384-1385 (which was also 354 days long).

The final step (not shown on Table 1) is to multiply the series' Hijra value for fiscal 1383-1384 by 0.8757 and the Hijra value for fiscal 1384-1385 by 0.161 and add the two results together. That gives us an estimated value for the year 1964. Note that, in the case of adjustments to annual data, the sum of the two proportions is always greater than 100%, reflecting the fact that Gregorian years are 365-366 days long, whereas the corresponding Hijra fiscal years are only 354 or 355 days long.

## 3. Restatement Methodology for Monthly Hijra Data

The annual calculation methodology described above assumes that the series being adjusted is evenly distributed throughout the period, without any seasonal or other type of variation. However, the same adjustment methodology can be applied to quarterly or monthly data, with a considerable improvement in accuracy (since we no longer have to assume an even distribution of the data throughout the year). Fortunately, most of SAMA's money and banking data are on a monthly basis – Hijra months for pre-1988 data and Gregorian months for data after that. For instance, data on a Hijra monthly basis are available for the monetary base (back to 1976) and money stock variables (back to mid-1964).

However, the process becomes somewhat more complicated with monthly data. This is due to the variability in the time period for each Hijra month (29 or 30 days) versus Gregorian (28-31 days). This means that a single Hijra month could contain 1, 2, or 3 Gregorian months, and each Gregorian month could contain 1, 2, or 3 Hijra months. In contrast, each Hijra year can only contain two Gregorian years, and each Gregorian year almost always contains only two Hijra years.[5]

As an example of the calculations involved, Table 2 shows the proportions of each Hijra month in a given Gregorian month for the 1964-1965 period.

[5] There are three Hijra years in a single Gregorian year once every 32-33 Gregorian years. However, for the Hijra fiscal year, this last happened back in 1959 and would not have happened again until 1992, four years after the Kingdom switched to a 365-366 day fiscal year. Thus, calculations for the 1960-1988 period can always assume a two-year split.

**Table 2**
**Proportion of Hijra Months in Each Gregorian Month**
**1964-1965**

| Date | Hijra date | H1 | H2 | H3 | H4 | H5 | H6 | H7 | H8 | H9 | H10 | H11 | H12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19640131 | 13830917 | | | | | | | | 0.4516 | 0.5484 | | | |
| 19640229 | 13831016 | | | | | | | | | 0.4483 | 0.5517 | | |
| 19640331 | 13831118 | | | | | | | | | | 0.4194 | 0.5806 | |
| 19640430 | 13831218 | | | | | | | | | | | 0.4000 | 0.6000 |
| 19640531 | 13840120 | 0.6452 | | | | | | | | | | | 0.3548 |
| 19640630 | 13840220 | 0.3333 | 0.6667 | | | | | | | | | | |
| 19640731 | 13840322 | | 0.2903 | 0.7097 | | | | | | | | | |
| 19640831 | 13840423 | | | 0.2581 | 0.7419 | | | | | | | | |
| 19640930 | 13840524 | | | | 0.2000 | 0.8000 | | | | | | | |
| 19641031 | 13840625 | | | | | 0.1935 | 0.8065 | | | | | | |
| 19641130 | 13840726 | | | | | | 0.1333 | 0.8667 | | | | | |
| 19641231 | 13840827 | | | | | | | 0.1290 | 0.8710 | | | | |
| 19650131 | 13840929 | | | | | | | | 0.0645 | 0.9355 | | | |
| 19650228 | 13841027 | | | | | | | | | 0.0357 | 0.9643 | | |
| 19650331 | 13841129 | | | | | | | | | | 0.0645 | 0.9355 | |
| 19650430 | 13841229 | | | | | | | | | | | 0.0333 | 0.9667 |
| 19650531 | 13850201 | 0.9677 | 0.0323 | | | | | | | | | | |
| 19650630 | 13850302 | | 0.9333 | 0.0667 | | | | | | | | | |
| 19650731 | 13850403 | | | 0.9032 | 0.0968 | | | | | | | | |
| 19650831 | 13850504 | | | | 0.8710 | 0.1290 | | | | | | | |
| 19650930 | 13850605 | | | | | 0.8333 | 0.1667 | | | | | | |
| 19651031 | 13850707 | | | | | | 0.7742 | 0.2258 | | | | | |
| 19651130 | 13850807 | | | | | | | 0.7667 | 0.2333 | | | | |
| 19651231 | 13850909 | | | | | | | | 0.7097 | 0.2903 | | | |

The calculation of the proportions for the January 1964 value is as follows:

The first step is to find the equivalent Hijra date for the last day (31) in January 1964 (the date in the leftmost column, 19640131). Using the internal Excel Hijra calendar described above, we obtain the date of 17 Ramadan 1383, shown in the next column (yyyymmdd, or 13830917). Thus the weight assigned to the Ramadan proportion is 17/31, or 0.5484, the value in the H9 (Ramadan) column.

The previous month's weight is the number of January days remaining (31-17), or 14/31, the value in the H8 (Shaban) column.

Thus, the value for January 1984 is the weighted sum of the Shaban and Ramadan values. Ramadan receives a greater weight due to the greater number of days. Note that the two fractions add up to one (1).

## 4. Application of the Proposed Procedure to the M3 Monetary Aggregate

For the purpose of illustration, we have applied the above procedure to the M3 monetary aggregate. Table 3 shows the data on level and annual percentage change of the original and converted series on an annual base for the period from 1964 to 1987 (corresponding to the Hijra fiscal year 1384/85 up to 1407/08 AH). It also shows the correspondence (or lack thereof) of the Hijra and Gregorian dates with each other.

**Table 3**
**M3 Money Supply**
**Original Hijra Fiscal Year and Converted Gregorian Data**

| Hijra Fiscal Year | Equivalent Gregorian Date | Money Supply M3 | Growth Rate - Hijra M3 Data | Gregorian Year Ending Dec. 31 | Equivalent Hijra Date | Money Supply M3 Dec. 31 | Growth Rate Converted M3 Data |
|---|---|---|---|---|---|---|---|
| **1384/85** | **24/10/65** | 1,868.7 | | **1964** | **27/08/84** | 1,687.5 | |
| **1385/86** | **14/10/66** | 2,145.3 | 14.8% | **1965** | **09/09/85** | 1,864.7 | 10.5% |
| **1386/87** | **03/10/67** | 2,476.9 | 15.5% | **1966** | **19/09/86** | 2,206.0 | 18.3% |
| **1387/88** | **22/09/68** | 2,731.3 | 10.3% | **1967** | **30/09/87** | 2,635.2 | 19.5% |
| **1388/89** | **11/09/69** | 2,923.4 | 7.0% | **1968** | **12/10/88** | 2,817.3 | 6.9% |
| **1389/90** | **01/09/70** | 3,137.2 | 7.3% | **1969** | **22/10/89** | 2,992.2 | 6.2% |
| **1390/91** | **21/08/71** | 3,518.2 | 12.1% | **1970** | **03/11/90** | 3,146.4 | 5.2% |
| **1391/92** | **09/08/72** | 4,481.1 | 27.4% | **1971** | **14/11/91** | 3,798.7 | 20.7% |
| **1392/93** | **29/07/73** | 6,217.8 | 38.8% | **1972** | **26/11/92** | 5,080.3 | 33.7% |
| **1393/94** | **19/07/74** | 8,731.2 | 40.4% | **1973** | **07/12/93** | 6,921.9 | 36.2% |
| **1394/95** | **09/07/75** | 14,059.8 | 61.0% | **1974** | **18/12/94** | 10,243.0 | 48.0% |
| **1395/96** | **27/06/76** | 24,452.6 | 73.9% | **1975** | **28/12/95** | 17,937.9 | 75.1% |
| **1396/97** | **16/06/77** | 37,334.8 | 52.7% | **1976** | **10/01/97** | 30,274.9 | 68.8% |
| **1397/98** | **05/06/78** | 53,617.1 | 43.6% | **1977** | **21/01/98** | 45,281.8 | 49.6% |
| **1398/99** | **26/05/79** | 61,379.9 | 14.5% | **1978** | **02/02/99** | 58,732.5 | 29.7% |
| **1399/1400** | **14/05/80** | 74,788.5 | 21.8% | **1979** | **12/02/00** | 67,245.9 | 14.5% |
| **1400/01** | **04/05/81** | 94,380.2 | 26.2% | **1980** | **24/02/01** | 83,380.8 | 24.0% |
| **1401/02** | **23/04/82** | 119,444.7 | 26.6% | **1981** | **05/03/02** | 110,168.0 | 32.1% |
| **1402/03** | **13/04/83** | 134,398.1 | 12.5% | **1982** | **16/03/03** | 131,783.3 | 19.6% |
| **1403/04** | **01/04/84** | 143,947.5 | 7.1% | **1983** | **27/03/04** | 137,560.3 | 4.4% |
| **1404/05** | **21/03/85** | 148,896.3 | 3.4% | **1984** | **09/04/05** | 146,535.7 | 6.5% |
| **1405/06** | **10/03/86** | 150,239.7 | 0.9% | **1985** | **19/04/06** | 148,748.6 | 1.5% |
| **1406/07** | **28/02/87** | 163,735.7 | 9.0% | **1986** | **30/04/07** | 160,663.7 | 8.0% |
| **1407/08** | **17/02/88** | 164,359.6 | 0.4% | **1987** | **11/05/08** | 167,221.9 | 4.1% |
| | | CAGR | 21.5% | | | | 22.1% |

When analyzing these data, it is important to realize that the money supply data released by SAMA are stock data – i.e., they are a snapshot of commercial banks' balance sheets at a particular point in time. This also characterizes many of the time series published by SAMA, including bank loans, government deposits, etc. All items on the SAMA balance sheet are stock figures. This means that, in converting the Hijra data into Gregorian equivalents, it is imperative to come as closely as possible to matching the timing of the "snapshot". In this respect, the availability of monthly data for the various time series proves to be invaluable for economic researchers.

This can be seen clearly in Table 3 on the previous page. The years in the left-most column identify the beginning and ending years in the given Hijra fiscal year. For instance, Hijra fiscal year 1384/85 ended on the last day (the 29th, in this case) of the sixth month (Jumadah II) of 1385. The M3 value for this date was SAR 1,868.7 million. From its position in the table, the Gregorian year would appear to be 1964; if this is the case, the number should be the stock value of M3 on December 31, 1964. However, the actual Gregorian date associated with 29/6/1385 is October 24, 1965, almost 10 months later!

If we want to more accurately approximate the actual M3 value, we need to pick the monthly Hijra value(s) that are more closely associated with Dec. 31, 1964. This date corresponds to 27 Shaban 1384, so we select the monthly values associated with Rajab and Shaban, weight them accordingly for the 31 days of December (the Rajab value of 1655.7 is weighted 4/31, or 0.129, and the Shaban value of 1692.2 is weighted 27/31, or 0.871). The resulting value (1687.5) is clearly a closer approximation of the actual M3 money supply on Dec. 31 than is the value of 1868.7, which was 10 months in the future.

As can be expected, given the wide gap between the implied and actual dates, the original Hijra data differ greatly from their converted Gregorian counterparts, and the annual growth rates for any given year diverge as well. The compound annual growth rates (CAGR) over the period are about three percent higher for the converted Gregorian series (22.1%/21.5%) reflecting about 11 days per year difference, on average. Common sense would indicate that the quality of any statistical inferences drawn from the converted data become much higher than those using data produced by simply using the Hijra data unaltered. This feature has been tested and used in SAMA's Research Department.

## 5. Possible Applications of the Hijra Adjustment Factors to Seasonality Problems

Note that the coefficients in Table 2 (page 9) add up to 1 summing horizontally. In effect, the 12 Hijra columns become Hijra dummy variables, which represent the movement of the Hijra calendar through the Gregorian year. This movement has a substantial impact on the seasonal patterns in the various economic indicators measured by SAMA – for instance, the demand for money has a distinct seasonal pattern that depends both on the Gregorian calendar (due to weather, school schedules, and the arrival and departure of expatriate workers) and the Hijra calendar (due to the months of Ramadan and the Hajj and the preparation leading up the holidays). Although this interaction of different seasonal factors is undoubtedly present in every country with a large proportion of Muslims, it is particularly prevalent in Saudi Arabia, especially during the Hajj, when the country's population (and economy) swells by over two million Hajjis and their associated spending.

SAMA's General Department of Research and Statistics has collected Hijra monthly data for the monetary aggregates and their various components, going back to Muharram 1384 (corresponding to June 1964). We have converted these data to their Gregorian equivalent, using the monthly procedure described above, combined them with the Gregorian data from 1988 to the present, and analyzed the combined series for the presence of Hijra seasonality. A preliminary analysis of these data, using the Hijra dummies that have been developed, along with conventional 0-1 Gregorian month dummies, indicates the strong presence of both Hijra and Gregorian seasonality in most of the monetary aggregate components from June 1964 to the current time.

The major problem with using this approach is the assumption that these seasonal factors remain invariant over time. However, there is strong evidence that changes in the Kingdom's economy have created changes in the seasonal patterns over the years. Fortunately, there are statistical techniques that can be applied to detect and remove these seasonal patterns. SAMA's Economic Research Department is currently examining the suitability of a program that combines several promising approaches – the US Census Bureau's X-13 ARIMA/SEATS seasonal adjustment program contained in the EViews econometric analysis system used by SAMA. This program has the capability of handling the problems caused by moving seasonality patterns such as the Hijra calendar; our initial research indicates that it will be possible to generate seasonal factors for most of SAMA's monthly indicators that will reflect these moving patterns and produce seasonally adjusted data that are "cleansed" of both Hijra and Gregorian seasonality. Future reports will feature the results in this area.

## 6. Literature Review of Seasonal Adjustment Procedures

An extensive review of the literature failed to reveal any academic or applied research on the subject of data conversion methodology from a Hijra to a Gregorian basis. However, there were many articles on the subject of the impact of religious holidays (primarily Christian) on the seasonal patterns of economic data. More importantly, as noted below, there were several articles about Hijra seasonality, its impact on data series, and the appropriate methodology to identify the presence of such seasonality and adjust the data accordingly. Since this will the subject of future research, we have broadened our literature review below to include this topic.

Currently, about forty calendars are used in the world, mainly for determining religious dates, according to a recent estimate. Such calendars fall into three types of lunisolar, solar and lunar. All countries of the world mostly follow the Gregorian calendar; with specific settlements for each country on its working days and holidays accordingly (Riazuddin and Khan (2005)). However, religious calendars all have specific occasions that need to be factored in for economic aggregate data. For instance, the Easter holidays celebrated by most western countries move noticeably within a four week interval in late March through late April. It is quite apparent that the Islamic Hijra calendar, with its holy months of Ramadan and Dhul Hijja, definitely produces seasonal patterns in its economic data. Furthermore, the timing of these seasonal patterns can be precisely projected and moves predictably through the Gregorian calendar, which has its own patterns.

For developed countries, several articles have been written to identify seasonal patterns of Gregorian calendar impacts (Shiskin and Musgrave (1967), Gomez and Maravall (1996), Pfeffermann and Fisher (1980), Hillmer and Tiao (1982), Dagum (1983,1985), Huot et al (1986), Ladiray

and Quenneville (2001), Planas and Depoutot (2002)). However, less attention has been paid to the examination of the methodology involved with detecting and forecasting the effects of the Islamic calendar in economic time series data.

A few attempts have been made to analyze the impact of the Islamic calendar, in terms of the Ramadan and Hijra holidays. These articles include Riazuddin and Khan (2005), Rehomme et al (2008), Bukhari et al (2011), Almudhaf (2012) and Halari et al (2013). In addition, several articles have shown that Ramadan has a significant impact on prices in Muslim countries (Seyyed, et al (2005), EM Yucel (2005),Odabasi and Argan (2009), Lee and Hamzah (2004), Białkowski, et al (2012), Al-Khazali (2014) and Gavriilidis et al (2016)).

## 7. Conclusion

It is clear that the methodology described above has been indeed useful for economic researchers in expanding the Kingdom's national income and product accounts to include the earlier years, when the accounts were kept using the Islamic calendar. It is also clear that this methodology can be extended to monthly (and quarterly) data, with equally good results. Given the prevalence of monthly data produced by SAMA and the extensive pre-1988 history that is available, this methodology should prove to be crucial in improving the quality of the Monetary Authority's research efforts. As part of this research project, monthly Gregorian calendar-based data going back to 1964 are now available for the Kingdom's money supply and its various components.

Furthermore, the development of the monthly proportionality matrix, which maps the movement of the Hijra calendar through the Gregorian year, allows for the impact of the Islamic holidays to be accurately reflected in the annual seasonal patterns and makes the introduction of seasonally adjusted data series possible. The importance of this development should not be minimized – the lack of seasonally adjusted data has been a drawback to the analytical and modeling efforts within the economic research departments in both the government and the private sector.

Such data will also be extremely beneficial in developing short-term forecasting models utilizing time series forecasting. In fact, the Census X-13-ARIMA-SEATS forecasting program within the EViews econometric analysis system is capable of doing short-term projections simultaneously with the development of seasonal adjustment factors for SAMA's monthly data. This capability will greatly enhance the economic research analysis and forecasting activities.

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