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ARAŞTIRMA MAKALESİ RESEARCH ARTICLE

# The Calculation of Composite Calendar Regressors Including Moving Holidays in Türkiye

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## Abstract

The calendar effects are categorized into working days, trading days, leap years, moving holidays and fixed holidays. In order to analyze the calendar effects for short term statistics ten different composite calendar regressors were calculated. Theoretical averages were used instead of a specific date range to calculate long-term averages. This study explains how to calculate ten composite calendar regressors, including moving holidays such as Ramadan and Sacrifice Feast, which significantly impact economic activities in Türkiye. Furthermore, the consistency analysis of the composite calendar regressors over the periods was also mentioned. The calendar effects of the Industrial Production Index (IPI) time series are determined by reducing the number of observations backward as a case study. This study will make significant contributions to the literature and be beneficial for other countries where there are moving holidays according to the Lunar Calendar.

*Keywords: Composite Calendar Regressor, Türkiye, Lunar Calendar, Moving Holiday, Seasonal Adjustment*

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# Türkiye'de Hareketli Tatilleri İçeren Birleşik Takvim Regresörlerinin Hesaplanması


## Özet

Takvim etkileri, iş günü, ticaret günü, artık yıl, hareketli tatil (Hicri takvime bağlı tatiller) ve sabit tatil (Miladi takvime bağlı tatiller) gibi kategorilere ayrılır. Kısa dönemli istatistiklerdeki bu takvim etkilerini analiz etmek amacıyla on farklı birleşik takvim etkisi regresörleri oluşturulmuştur. Uzun dönem ortalamaların hesaplanmasında belirli bir tarih aralığı yerine teorik ortalamalar kullanılmaktadır. Bu çalışma Türkiye'de ekonomik aktiviteler üzerinde önemli etkisi olan Ramazan Bayramı ve Kurban Bayramı gibi dini tatillerin de kapsandığı on farklı birleşik takvim etkisinin nasıl elde edildiğini açıklamaktadır. Ayrıca çalışmada elde edilen birleşik takvim regresörlerinin dönemler içerisindeki tutarlılığının analiz sürecinden de bahsedilmiştir. Uygulama örneği olarak, Sanayi Üretim Endeksi (SUE) zaman serilerinin geriye doğru gözlem sayısı azaltma yöntemiyle takvim etkileri belirlenmiştir. Bu çalışmanın literatüre önemli katkılar sağlayacağı ve ay takvimine göre hareketli tatillerin olduğu diğer ülkeler için faydalı olacağı düşünülmektedir.


*Anahtar sözcükler: Birleşik Takvim Regresörü, Türkiye, Ay Takvimi, Hareketli Tatil, Mevsimsel Düzeltme*

## 1. Introduction

Seasonal movements observed in economic indicators can make it challenging to understand the actual trend of these series. For the series' general tendencies to be measured in a reliable way, they must be seasonally adjusted. However, adjusting the seasonal component only is not sufficient for this purpose. Another reason of short-term fluctuations in economic indicators is the "holidays," which occur in time series depending on the composition of the calendar in the month and year, are classified under the name of "*calendar day*" effects and differ from month to month and year to year (Atabek et al. 2009). Ignoring the possible effects of holidays, one of the deterministic components of the time series, on economic activities causes biased results in determining time series models. This situation causes erroneous evaluations of economic indicators. In particular, the effects of Ramadan (Eid al-Fitr) and Sacrifice (Eid-al-Adha) holidays, which are called moving holidays depending on the Lunar (Hijri) calendar, on the number of working days in a month can be tremendous and cause fluctuations in economic indicators. Therefore, it is essential to accurately estimate the effects of moving holidays to compare the monthly/quarterly and annual growth of economic time series.

There are many studies in the literature on calendar effects. Young (1965) put forward the pioneer study on this subject. Theoretical and applied studies on calendar effects include Cleveland and Devlin (1982), Hillmer et al. (1983), Bell and Hillmer (1983), Cano et al. (1996), Soukup and Findley (2000), Lin and Liu (2002), Shuja et al. (2007) can be cited as examples. On this subject, a detailed literature review on calendar effects was made by Ladiray (2006). However, the number of studies examining the effects of Lunar calendar holidays is limited. Bessa et al. (2009) examined the effect of Ramadan on sectors in Tunisia. On the other hand, Faye et al. (2019) compared the effects of Ramadan on prices in Morocco, Senegal, and Tunisia.

In Türkiye, a country with a large Muslim population, although moving holidays are based on the Lunar calendar, the country's official calendar is the Solar (Gregorian) calendar. Therefore, the calendar effects on the Turkish economy should be handled in more detail, mainly due to the moving holidays. The first study on this subject in terms of Türkiye belongs to Atuk and Ural (2002). This study examined the performances of X-12 ARIMA and TRAMO/SEATS seasonal adjustment methods on monetary aggregates, considering the calendar effects. Alper and Aruoba (2004) found that the deterministic part of seasonal effects is significant in monthly economic time series. According to the results of the Reg-ARIMA model in his study, Koçak (2009) revealed that moving holidays have a negative and significant effect on the Industrial Production Index (IPI). On the other hand, Atabek et al. (2009) analyzed calendar effects with production indicators within the framework of working days. This study introduced a regression variable created to eliminate calendar day effects. As a result, the importance of calendar-adjusted series in annual comparisons of industrial production index (IPI) was revealed. Bozok and Kanli (2013), in their study on the effect of bridge days on production indicators, found that half-day eve days and bridge days before and after moving holidays were significant on industrial production. Demirhan (2016) demonstrated the calendar and working day effect in detail for foreign trade statistics using daily data. Eyerci et al. (2021) examined the effect of Ramadan on prices and production by converting the Solar calendar to the Lunar calendar. In a similar study, Eyerci (2021) investigated the possible effect of Sacrifice Feast on red meat prices.

In the studies examined in the literature, it has been observed that calendar effects regressors in time series models are examined separately for working days, trading days, public holidays, and moving holidays or by considering several common dates. This study explains how to obtain ten different composite calendar regressors, including moving holidays such as Ramadan Feast and Sacrifice Feast, which significantly impact on economic activities in Türkiye. Unlike other studies, this study used theoretical averages instead of a specific date range to calculate long-term averages while constructing the composite calendar regressors. The disadvantages of long-term averages obtained by using a specific date range, such as subjectivity and variability over time, are also mentioned in the study. By considering these issues, the usability of the more objective and fixed theoretical averages structure over time has been expressed as a new approach in the theoretical and applied framework. In addition, the analysis process of the consistency of the composite calendar regressors over the periods is also mentioned. For this purpose, the IPI - Manufacture of Food Products time series for the period 2010-01:2021-12 was used for the case study. Calendar effects were determined using datasets with different time spans obtained by decreasing the observations backward one at a time. The lack of options to analyze the effects of moving holidays depending on the Lunar calendar in the existing software used for seasonal and calendar adjustment studies has also been a source of motivation for producing composite calendar regressors for Türkiye.

## 2. Methodology

It is assumed that the calendar effect in an observed time series consists of two parts: the seasonal and non-seasonal parts. The seasonal part of the calendar effect consists of effects whose cycle is completed in a year (for example, March has 31 days each year). In contrast, the non-seasonal part consists of effects that have a cycle longer than one year (February has 29 days every four years, or the number of Saturday-Sunday in a given month varies over the years). According to the Seasonal Adjustment Guide[1] of the European Statistical System, only the non-seasonal part of the calendar effect should be adjusted from the relevant series during the calendar adjustment process.

In order to adjust for the non-seasonal part of the calendar effect, it is first necessary to estimate the seasonal part of the calendar effect. For this purpose, long-term monthly averages are estimated for each month. The number of days worked is then adjusted for the long-term monthly average estimated for each month. The date length of the long-term average used here should "sufficiently" cover the seasonal cycle of the relevant calendar effect. Therefore, this study used theoretical averages instead of a specific date range in calculating long-term averages. In order to better understand the reason for using theoretical averages, both the Lunar[2] calendar and the Solar[3] calendar cycle should be discussed in detail.

### 2.1. Lunar Calendar Effect

While a calendar year is 354.37 days on average in the Lunar calendar, a calendar year is 365.24 days in the Solar calendar. The Lunar year is 10-12 days shorter than the Solar year compared to the leap year in the two calendars. For this reason, Ramadan and Sacrifice holidays go back 10-12 days every year. The difference between the Lunar and Solar calendars is approximately one year in 33 years. To put it more clearly, once every 33 or 34 Lunar (32 or 33 Solar) years, the first day of the Lunar year (1 Muharram) coincides with one of the first ten days of January. In this case, the total number of days in the 34 Lunar year is 12048.58 (354.37 x 34 = 12048.58), while the total number of days in the 33 Solar years is 12052.92 (365.24 x 33 = 12052.92). According to this calculation, the difference (12052.92 - 12048.58 = 4.34) between the Lunar and Solar calendars has still not been eliminated. For this reason, it can be stated that considering 33 years or different year periods in calculating the average number of holidays for Ramadan and Sacrifice Feasts may cause bias. For example, in July 1982, there was a 3-day Ramadan holiday, and 33 years later, in July 2015, there was a 3-day Ramadan holiday. However, in August 1981, there were three days of Ramadan holiday, and 33 years later, in July 2014, there were three days of Ramadan holiday. While the first day of the Ramadan holiday was August 1, 1981, it was July 28, 2014. In this case, the Ramadan holidays coincide with a deviation of 4 days. In theory, this difference should be 4.34 days.

In light of this information, the long-term averages of the moving holidays within the Lunar calendar are calculated with a theoretical average rather than a specific calendar period. According to the Lunar calendar, it is a moving holiday for eight days (including eve days) every 354.37 days. For example, 0.70 (31 x 8 / 354.37 = 0.70) days of moving holidays fall on average in a year in January. Table 1 shows the number of moving holidays per month based on 32-year intervals.

[1] https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/KS-GQ-15-001
[2] https://en.wikipedia.org/wiki/Islamic_calendar
[3] https://en.wikipedia.org/wiki/Gregorian_calendar

**Table 1.** Total number of moving holidays per months

| | 1984-2015 | 1974-2005 | 1975-2006 | Theoretical Average * |
|---|---|---|---|---|
| January | 20 | 17 | 17 | 19.6 |
| February | 18 | 18 | 18 | 17.9 |
| March | 21 | 21 | 21 | 19.6 |
| April | 20 | 20 | 20 | 19.0 |
| May | 18 | 18 | 18 | 19.6 |
| June | 19 | 19 | 19 | 19.0 |
| July | 20 | 20 | 20 | 19.6 |
| August | 20 | 21 | 21 | 19.6 |
| September | 16 | 21 | 21 | 19.0 |
| October | 20 | 15 | 15 | 19.6 |
| November | 21 | 20 | 20 | 19.0 |
| December | 18 | 21 | 18 | 19.6 |
| **Total** | **231** | **231** | **228** | **230.9** |

**Note:*** The calculation of theoretical averages will be explained in the following sections.

As can be seen from the Table 1, the number of moving holidays per month varies for different 32-year time intervals, even if it is taken into account that the cycle of moving holidays is approximately 32 years. Therefore, the theoretical averages calculated according to the months for each holiday effect should be used to adjust for calendar effects.

## 2.2. Solar Calendar Effect

The approach suggested above for Lunar holidays can be similarly applied to holidays within the Solar calendar. Below, it is explained how the theoretical averages are calculated for the effect of days of the week, national holidays, and leap years within the scope of the Solar calendar. Since February is 29 days every four years, 28.25 days are included in the calculations.

### 2.2.1. Weekend-Sunday Effect

The cycle, as mentioned earlier, mainly affects the Saturday-Sunday distribution per month. From this point of view, the long-term average of the weekend or Sunday effect can be calculated as follows. If one of every seven days is a Sunday, for example, in January, an average of 4.43 (31 x 1/7 = 4.43) days is Sunday. With a similar approach, an average of 4.04 (28.2524 x 1/7 = 4.04) days in February is Sunday.

### 2.2.2. Fixed (National) Holidays

In Türkiye, there are seven national holidays within the scope of the Solar calendar, according to Law No. 2739 dated 27/5/1935, Law No. 2429 dated 17/3/1981, and Law No. 6752 dated 29/10/2016. These holidays are January 1, April 23, May 1, May 19, July 15, August 30, and October 29. October 29 holiday starts in the afternoon of October 28 and lasts for 1.5 days, while other national holidays are one day. National holidays take place on the same date yearly, depending on the Solar calendar. Due to these features, there is no shift like calendar events in the Lunar calendar. From this point of view, National holidays depending on the Solar calendar, can be evaluated within the scope of seasonality, not within the scope of the calendar effect. However, in the event that national holidays overlap (coinciding with the same date) with other Lunar or Solar calendar events, these effects should now be considered within the scope of the calendar effect. Due to the laws enacted on different dates in Türkiye, national and religious holidays and durations vary from 1936 to the present. These differences are shown in Table 2.

**Table 2.** National and Religious holidays between 1936 and 2027

| Holidays | 1936/January - 1981/March | 1981/April - 2009/April | 2009/May - 2017/June | 2017/July - 2027/December |
|---|---|---|---|---|
| **New Year** | 31 December (half-day), 1 January | 1 January | 1 January | 1 January |
| **National Sovereignty and Children's Day** | 22 April (half-day), 23 April | 23 April | 23 April | 23 April |
| **Labour and Solidarity Day** | 1 May | - | 1 May | 1 May |
| **Commemoration of Atatürk, Youth and Sports Day** | - | 19 May | 19 May | 19 May |
| **Democracy and National Unity Day** | - | - | - | 15 July |
| **Victory Day** | 30 August | 30 August | 30 August | 30 August |
| **Rebuplic Day** | 28 October (half-day), 29-30 October | 28 October (half-day), 29 October | 28 October (half-day), 29 October | 28 October (half-day), 29 October |
| **Ramadan Feast (Eid al-Fitr)** | 3 day | 3.5 day | 3.5 day | 3.5 day |
| **Sacrifice Feast (Eid al-Adha)** | 4 day | 4.5 day | 4.5 day | 4.5 day |

## 2.3. Composite Calendar Regressors

Calculating the composite calendar regressors is based on the number of days effectively worked. For this purpose, holiday effects are subtracted from the month's total number of working days. It is possible to group the calendar effects used in short-term statistics under the following four main headings:

- Weekend (Saturday-Sunday) or Sunday effect
- Fixed (national) holidays depending on the Solar calendar
- Moving (religious) holidays depending on the Lunar calendar (Ramadan and Sacrifice Feast)
- Leap year (February 29) effect

Ten composite calendar regressors were calculated using these four primary calendar effects with different combinations. (Table 3).

**Table 3.** Composite Calendar Regressors

| *No* | *Composite Calendar Regressor* |
|---|---|
| *1* | Exc. Saturday and Sunday |
| *2* | Exc. Sunday |
| *3* | Exc. Saturday, Sunday, fixed and moving holiday |
| *4* | Exc. Sunday, fixed and moving holiday |
| *5* | Exc. Saturday, Sunday and moving holiday |
| *6* | Exc. Sunday and moving holiday |
| *7* | Exc. Saturday, Sunday and fixed holiday |
| *8* | Exc. Sunday and fixed holiday |
| *9* | Exc. fixed and moving holiday |
| *10* | Exc. moving holiday |

One of the essential points to consider when calculating composite calendar regressors is that there are holidays that coincide with the same date. The effects of Ramadan and Sacrifice Feasts, national holidays, and the day of the week may coincide. For example, January 1 of any year can coincide with a fixed holiday, a Sunday, and the first day of the Ramadan Feast. In such cases, defining each calendar effect to different dummy variables will lead to the problem of over-weighting the relevant day in case of overlapping calendar effects. Therefore, composite calendar regressors were used to fix this problem.

Composite calendar regressors are calculated monthly, quarterly, and annually. The equations used in the calculation of the monthly regressors are given below. Equations can be easily converted accordingly when quarterly or monthly regressors are needed.

$$R_{i,t} = Y_{i,t} - \tilde{Y}_{i,t} \tag{1}$$

$$Y_{i,t} = X_t - Z_{i,t} \tag{2}$$

$$\tilde{Y}_{i,t} = X_t - P_i X_t \tag{3}$$

- $i$ : composite calendar regressor in Table 3 ($i = 1,2,\dots,10$)
- $t$ : index of year-month between 1936-January:2027- December[4] ($1 \leq \mathrm{t} \leq 1104$[5])
- $R_{i,t}$ : composite calendar regressor *i* in the month *t*
- $Y_{i,t}$ : the number of working days in month *t* for the composite calendar regressor *i*
- $\tilde{Y}_{i,t}$ : the theoretical average of working day in month *t* for the composite calendar regressor *i*
- $X_t$ : the total number of days in the month *t*
- $Z_{i,t}$ : the total number of holidays in month *t* for the composite calendar regressor *i*

Composite calendar regressor *i* is calculated in month *t* by using Equation (1). In this equation, the theoretical average of working days ($\tilde{Y}_{i,t}$) is the difference between the total number of days in a month and the total number of number of holidays. In Equation (2), the number of working days for the composite calendar regressor *i* can be calculated by differencing the total number of days from the total number of holidays in the month *t*. The total number of days in months are as follows:

$$X_t = \begin{cases} 31, & mod(t,12) = 1 \\ 28.25, & mod(t,12) = 2 \\ 31, & mod(t,12) = 3 \\ 30, & mod(t,12) = 4 \\ 31, & mod(t,12) = 5 \\ 30, & mod(t,12) = 6 \\ 31, & mod(t,12) = 7 \\ 31, & mod(t,12) = 8 \\ 30, & mod(t,12) = 9 \\ 31, & mod(t,12) = 10 \\ 30, & mod(t,12) = 11 \\ 31, & mod(t,12) = 0 \end{cases} \tag{4}$$

[4] Data on the days of Ramadan and Sacrifice Feast holidays in Türkiye can be accessed on the Time Calculation page of the Presidency of Religious Affairs. The Presidency of Religious Affairs calculates religious days with Islamic and astronomical criteria determined by experts in the field at the International Hijri Calendar Union Congress (2016). The dates of religious days have been determined until 2027. As the data on the dates of religious days are updated, the composite calendar regressors are updated accordingly.

[5] It represents the total number of months between January 1936 and December 2027.

The probabilities required to calculate the long-term averages of the holidays are represented by $P_i$. These probabilities are weighted by the total number of days per month to obtain the number of month-specific holidays. Holiday probabilities for ten different composite calendar regressors specified in Table 3 are shown below.

$$P_i = \begin{cases} n_1, & i=1 \\ n_2, & i=2 \\ n_1 + (1-n_1)n_3 + (1-n_1)(1-n_3)m_t, & i=3 \\ n_2 + (1-n_2)n_3 + (1-n_2)(1-n_3)m_t, & i=4 \\ n_1 + (1-n_1)n_3, & i=5 \\ n_2 + (1-n_2)n_3, & i=6 \\ n_1 + (1-n_1)m_t, & i=7 \\ n_2 + (1-n_2)m_t, & i=8 \\ n_3 + (1-n_3)m_t, & i=9 \\ n_3, & i=10 \end{cases} \tag{5}$$

Here n and m represent holiday probabilities. n represents holidays whose cycle lasts longer than one year, and m refers to holidays whose cycle is completed within one year. $n_1$ and $n_2$ represent Lunar holidays and $n_3$ represent Solar calendar holidays. In other words, with the probability, $n_1 = 2/7$, shows the weekend holidays, and $n_2 = 1/7$ shows the Sunday holidays.

$$n_3 = \begin{cases} {}^{7}\!/_{354.37}, & t < 544^{6} \\ {}^{8}\!/_{354.37}, & t \geq 544 \end{cases} \tag{6}$$

$n_3$ represents the probability that half-day eve holidays were excluded before April 1981 but included after. The $(1 - n_{1,2,3})$ terms are used to avoid duplication when more than one calendar effect is defined together. Since there is a national holiday specific to each month, $m_t$ is calculated by considering the number of national holidays specified in Table 2.

[6] In March 1981, there were legal changes regarding the duration of national and religious holidays. Accordingly, May 19 (Commemoration of Atatürk - Youth and Sports Day) has been declared a public holiday. April 23 holiday (National Sovereignty and Children's Day) was changed to 1 day, while it was celebrated as a 1.5-day holiday starting in the afternoon of April 22. The October 29 holiday (Republic Day) was changed to 1.5 days, while it was celebrated as 2.5 days, starting from the afternoon of October 28. While the 1st January holiday (New Year's Day) was 1.5 days to start in the afternoon of December 31, it was changed to 1 day. The days before religious holidays have been declared half-day holidays since 1981. Therefore, the value of 544 corresponds to the common year-month (1981-April) index on which the changes made are reflected.

$$m_t = \begin{cases} {}^{1}/_{X_t}, & mod(t,12) = 1 \\ {}^{0}/_{X_t}, & mod(t,12) = 2 \\ {}^{0}/_{X_t}, & mod(t,12) = 3 \\ \begin{matrix} {}^{1,5}/_{X_t}, t < 544 \\ {}^{1}/_{X_t}, t \geq 544 \end{matrix}, & mod(t,12) = 4 \\ \begin{matrix} {}^{1}/_{X_t}, t < 881\text{[7]} \\ {}^{2}/_{X_t}, t \geq 881 \end{matrix}, & mod(t,12) = 5 \\ {}^{0}/_{X_t}, & mod(t,12) = 6 \\ \begin{matrix} {}^{0}/_{X_t}, t < 979\text{[8]} \\ {}^{1}/_{X_t}, t \geq 979 \end{matrix}, & mod(t,12) = 7 \\ {}^{1}/_{X_t}, & mod(t,12) = 8 \\ {}^{0}/_{X_t}, & mod(t,12) = 9 \\ \begin{matrix} {}^{2,5}/_{X_t}, t < 544 \\ {}^{1,5}/_{X_t}, t \geq 544 \end{matrix}, & mod(t,12) = 10 \\ {}^{0}/_{X_t}, & mod(t,12) = 11 \\ \begin{matrix} {}^{0,5}/_{X_t}, t < 544 \\ {}^{0}/_{X_t}, t \geq 544 \end{matrix}, & mod(t,12) = 0 \end{cases} \qquad (7)$$

The situations in Table 2 are considered both for the total number of holiday days ($Z_{i,t}$) specific to the relevant month and year in Equation (2) and the $P_i$ values reflecting the long-term averages of the holidays in Equation (1).

The calculation of the composite calendar regressor *"Exc. Saturday, Sunday, fixed and moving holiday"* (*i*=3) for the year 2022 is explained below as an example. In addition, the calculation of the theoretical average number of working days for July 2022 is explained as an example. This month was chosen because a fixed holiday coincides with the Feast of Sacrifice in July 2022. In order to obtain the monthly composite calendar regressors, first of all, a daily table should be prepared in which the days with and without holidays are determined. Accordingly, the daily table design for July 2022 is given in Table 4.

[7] It corresponds to the year-month (2009-May) index, which expresses the period when May 1 (Labor Day - Labor and Solidarity Day) was declared a national holiday again as of May 2009.

[8] It corresponds to the year-month (2017-July) index, which expresses the period when July 15 (Democracy and National Unity Day) was declared as a national holiday in May 2017.

**Table 4.** Daily Table Design of 2022 July

| | A | B | C | D | E = max(A,B,C,D) |
|---|---|---|---|---|---|
| Date | Sacrifice Feast | 15 July | Saturday | Sunday | Saturday, Sunday, Fixed and Moving Holidays |
| Friday,1.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Saturday,2.7.2022 | 0 | 0 | 1 | 0 | **1** |
| Sunday,3.7.2022 | 0 | 0 | 0 | 1 | **1** |
| Monday,4.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Tuesday,5.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Wednesday,6.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Thursday,7.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Friday,8.7.2022 | 0.5 | 0 | 0 | 0 | **0.5** |
| Saturday,9.7.2022 | 1 | 0 | 1 | 0 | **1** |
| Sunday,10.7.2022 | 1 | 0 | 0 | 1 | **1** |
| Monday,11.7.2022 | 1 | 0 | 0 | 0 | **1** |
| Tuesday,12.7.2022 | 1 | 0 | 0 | 0 | **1** |
| Wednesday,13.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Thursday,14.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Friday,15.7.2022 | 0 | 1 | 0 | 0 | **1** |
| Saturday,16.7.2022 | 0 | 0 | 1 | 0 | **1** |
| Sunday,17.7.2022 | 0 | 0 | 0 | 1 | **1** |
| Monday,18.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Tuesday,19.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Wednesday,20.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Thursday,21.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Friday,22.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Saturday,23.7.2022 | 0 | 0 | 1 | 0 | **1** |
| Sunday,24.7.2022 | 0 | 0 | 0 | 1 | **1** |
| Monday,25.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Tuesday,26.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Wednesday,27.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Thursday,28.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Friday,29.7.2022 | 0 | 0 | 0 | 0 | **0** |
| Saturday,30.7.2022 | 0 | 0 | 1 | 0 | **1** |
| Sunday,31.7.2022 | 0 | 0 | 0 | 1 | **1** |
| **Total** | **4.5** | **1** | **5** | **5** | **13.5** |

The table includes all fixed and moving holidays in July 2022. It takes 1 if the holiday exists on the relevant date and 0 otherwise. One day before the first day of Sacrifice Feast, a value of 0.5 is assigned since it is a half-day holiday. Column E in the table gives the combination of Saturday, Sunday, fixed (July 15 - Democracy and National Unity Day), and moving holidays (Sacrifice Feast) on the relevant date. Holidays coinciding with the same date are counted as one by taking the maximum value of the relevant date. Since there are no Ramadan Feast and other fixed holidays in July 2022, they are not included in the table. Then, the daily table is aggregated, and the monthly table is obtained. Table 5 shows the values of the other months, along with July.

**Table 5.** Creation of the Composite Calendar Regressor 3 (for monthly data)

| | A | B | C = A-B | D | E = C-D |
|---|---|---|---|---|---|
| 2022 | Total number of days | Total number of Saturday-Sunday, fixed and moving holidays | Number of days worked | Theoretical average number of working days | Composite Calendar Regressor (i=3) |
| | $X_t$ | $Z_{i,t}$ | $Y_{i,t} = X_t - Z_{i,t}$ | $\tilde{Y}_{i,t} = X_t - P_i X_t$ | $R_{i,t} = Y_{i,t} - \tilde{Y}_{i,t}$ |
| January | 31 | 10 | 21 | 20.94 | 0.06 |
| February | 28.25 | 8 | 20 | 19.72 | 0.28 |
| March | 31 | 8 | 23 | 21.64 | 1.36 |
| April | 30 | 9 | 21 | 20.25 | 0.75 |
| May | 31 | 13 | 18 | 20.25 | -2.25 |
| June | 30 | 8 | 22 | 20.94 | 1.06 |
| **July** | **31** | **13.5** | **17.5** | **20.94** | **-3.44** |
| August | 31 | 9 | 22 | 20.94 | 1.06 |
| September | 30 | 8 | 22 | 20.94 | 1.06 |
| October | 31 | 10.5 | 20.5 | 20.60 | -0.10 |
| November | 30 | 8 | 22 | 20.94 | 1.06 |
| December | 31 | 9 | 22 | 21.64 | 0.36 |

Column B in Table 5 consists of the number of Saturday-Sunday days and the sum of fixed and moving holidays excluding Saturday-Sunday. In other words, fixed and moving holidays that coincide with Saturday and Sunday are combined. In calculating probability of the theoretical average number of working days for July 2022, Equation (5) was used.

$$P_{i=3} = n_1 + (1 - n_1)n_3 + (1 - n_1)(1 - n_3)m_t$$

In the equation, $n_1 = 2/7$ indicates the probability of Saturday-Sunday holiday, and $n_3 = 8/354.37$ (Equation 6) indicates the probability of a moving holiday. $m_t$ (Equation 7) is the fixed holiday probability in July. Therefore, its value in July 2022 is obtained with $m_t = 1/X_t$. The theoretical average number of days for July 2022 is obtained using this information.

$$P_{i=3} = \frac{2}{7} + \left((1 - \frac{2}{7})(\frac{8}{354.37})\right) + \left(\left(1 - \frac{2}{7}\right)\left(1 - \frac{8}{354.37}\right)\right)\left(\frac{1}{31}\right) = 0.32436078877$$

The theoretical average number of working days is obtained using the holiday probability obtained for the composite calendar regressor no. 3 (column D).

$$\tilde{Y}_{3,2022-7} = X_{2022-7} - P_3 X_{2022-7} = 31 - 0.32436078877 * 31 = 20.9448155479$$

In order to obtain composite calendar regressor (column E) subtract the theoretical average number of working days ($\tilde{Y}_{3,2022-7}$) from the number of days worked ($Y_{3,2022-7}$).

$$R_{3,2022-7} = Y_{3,2022-7} - \tilde{Y}_{3,2022-7} = 17.5 - 20.94 = -3.44$$

## 3. Case Study

In the seasonal and calendar adjustment process of short-term statistics, the model, filters, outliers, and appropriate calendar variables are determined each year following the release of the data for the last period, and parameters and factors are re-estimated in each newsletter period throughout the year. In this direction, calendar effects are also reviewed annually. At this stage, first of all, the statistical and sectoral significance of the calendar effect is examined. Then, the determined significant calendar effect is compared with the previous year, and its consistency is checked. Thus, revisions due to calendar effects are kept at a minimum as much as possible. In order to determine whether the relevant time series has the same calendar effect in the past periods, the data is analyzed with the backward reduction method during the analysis phase. For this, data sets with different observation numbers are produced by decreasing the time series backward one by one (month-quarter) for a total of 2-5 years. Then, the significance of ten different composite calendar regressors for each data set is tested with Reg-ARIMA models.

As a case study, monthly time series (2010-01:2021-12) was used for the Industrial Production Index (IPI)-Manufacture of food products (NACE Rev. 2 - C10). The composite calendar regressor will be determined by the backward reduction of the number of time series observations. In this direction, ten different composite calendar

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regressors will be tested with datasets of different lengths, reducing observations one by one for two years (24 months) backward from the last observation period (2021-12). The datasets mentioned here consist of time series obtained by excluding the last time series period at each observation reduction. Table 6 shows the design plan for the period covered by the time series and the number of observations it contains. Thus, each composite calendar regressor will be tested in 24 different time spans.

**Table 6.** Backward Observation Reduction Design of Time Series

| No of time span | Period | Number of Observations |
|---|---|---|
| 1 | 2010-01:2021-12 | 144 |
| 2 | 2010-01:2021-11 | 143 |
| 3 | 2010-01:2021-10 | 142 |
| … | … | … |
| 22 | 2010-01:2021-03 | 123 |
| 23 | 2010-01:2021-02 | 122 |
| 24 | 2010-01:2021-01 | 121 |

The t-statistics of the parameter estimates of the composite calendar regressors are used to determine the calendar effect. Using the t statistics, the calendar effect is decided with essential statistical criteria and graphical tools. The graph of the t statistics of the composite calendar regressors obtained is given below (Figure 1).

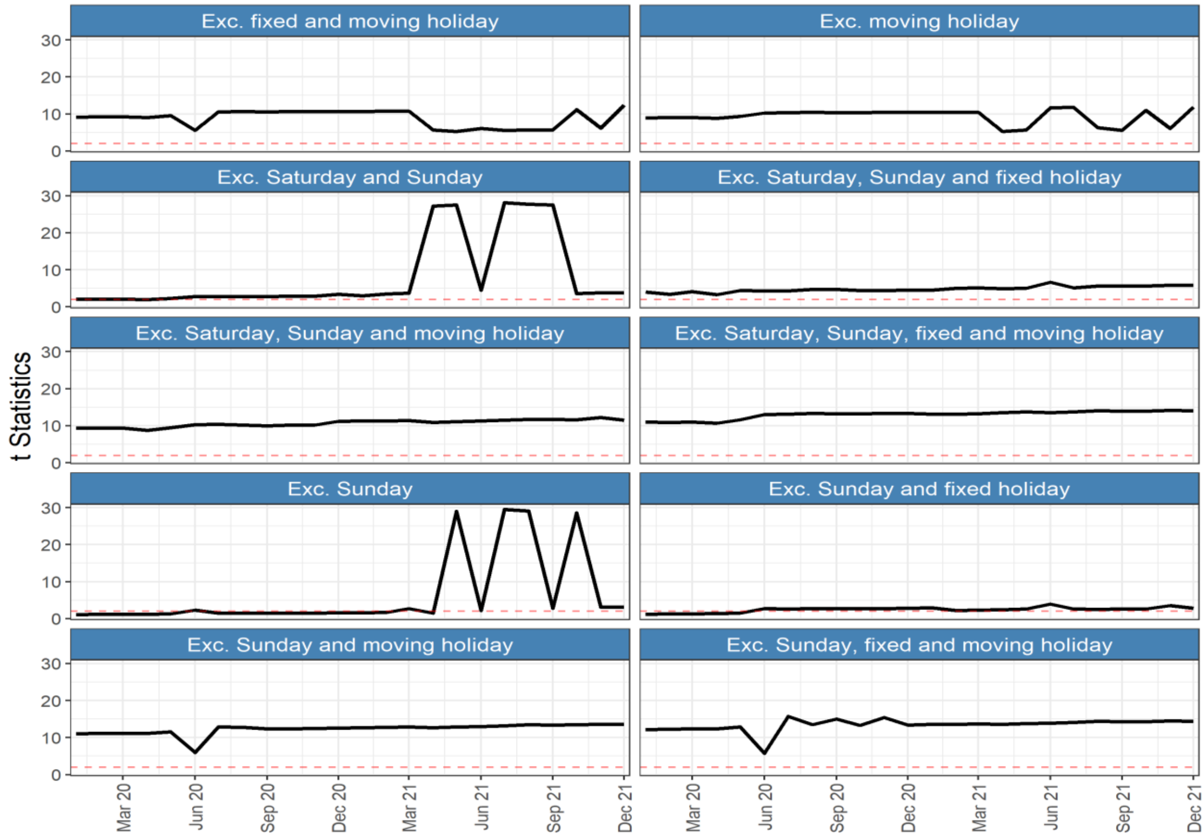


**Figure 1.** t-stats of Composite Calendar Regressors

The t statistics were interpreted according to the critical value of 1.96 at the α=0.05 significance level. The red dashed lines in Figure 1 represent the 1.96 threshold value. According to the figure, some regressors proceed in a fixed line above the threshold value, while others follow a volatile path quite close to the threshold value. From this point of view, we can quickly eliminate regressors with a volatile and inconsistent structure in the first stage. Accordingly, the t statistics of the regressors *"Exc. Saturday, Sunday, fixed and moving holiday"* and *"Exc. Saturday, Sunday and moving holiday"* seem more consistent than the others. Summary statistics were calculated to examine the analysis with numerical data (Table 7).

**Table 7.** Summary Statistics of t-stats

| Composite Calendar Regressor | Number of time spans | Mean of t-stat | Std.Dev. of t-stat | Min of t-stat | Max of t-stat | Number of time spans with t-stat > 2 | Number of time spans with maximum t- stat |
|---|---|---|---|---|---|---|---|
| Exc. Sunday, fixed and moving holiday | 24 | 13.44 | 1.88 | 5.79 | 15.73 | 24 | 16 |
| Exc. Saturday, Sunday, fixed and moving holiday | 24 | 13.00 | 1.10 | 10.67 | 14.13 | 24 | 2 |
| Exc. Sunday, moving holiday | 24 | 12.28 | 1.57 | 5.98 | 13.56 | 24 | 0 |
| Exc. Saturday, Sunday and moving holiday | 24 | 10.68 | 0.95 | 8.76 | 12.21 | 24 | 0 |
| Exc. moving holiday | 24 | 9.36 | 2.04 | 5.29 | 11.84 | 24 | 0 |
| Exc. fixed and moving holiday | 24 | 8.82 | 2.35 | 5.31 | 12.41 | 24 | 0 |
| Exc. Saturday and Sunday | 24 | 8.13 | 10.25 | 1.97 | 28.10 | 23 | 2 |
| Exc. Sunday | 24 | 6.34 | 10.38 | 1.10 | 29.53 | 10 | 4 |
| Exc. Saturday, Sunday and fixed holiday | 24 | 4.83 | 0.79 | 3.30 | 6.67 | 24 | 0 |
| Exc. Sunday and fixed holiday | 24 | 2.46 | 0.68 | 1.24 | 3.91 | 19 | 0 |

According to the summary statistics, the regressor "*Exc. Sunday, fixed and moving holiday*" has the highest significance regarding the mean value of the t statistics. In addition, this regressor has significant t statistics in all time spans and the highest t statistics in 16 of the time spans. Although it is seen as the most significant regressor, its inconsistency in the past periods should also be considered. Considering the mean of t statistics among the regressors selected according to Figure 1, *"Exc. Saturday, Sunday, fixed and moving holiday"* and *"Exc. Saturday, Sunday and moving holiday"* can be preferred. On the other hand, when the standard deviations are compared, it is seen that the regressor "*Exc. Saturday, Sunday and moving holiday*" has less volatility than *"Exc. Saturday, Sunday, fixed and moving holiday"*. When we evaluate the situation from a sectoral point of view, it is known that fixed holidays significantly impact the food manufacturing sector in Türkiye. According to all these evaluations, the "*Exc. Saturday, Sunday, fixed and moving holiday*" regressor for the IPI - Manufacture of Food Products time series was preferred because it includes all effective holidays. This preference is also compatible with the composite calendar regressor for the previous year.

In order to emphasize the importance of calendar effects, a forecast analysis was also carried out for the selected "Industrial Production Index (IPI)-Manufacture of food products (NACE Rev. 2 - C10)" time series in this paper. In this context, the period (2010-01:2020-12) was considered for the the C10 index time series and was estimated for the period (2021-01:2021:12) with and without "*Exc. Saturday, Sunday, fixed and moving holiday*" calendar effect. Information about the models is given in the Table 8. In both models, (0,1,1)(0,1,1) Airline model and (2020-4) TC outlier were considered so the effects that may arise from the model and the outlier were fixed.

**Table 8.** Summary Statistics of models with calendar and without calendar for C10 series

| | *With Calendar* | *Without Calendar* |
|---|---|---|
| *Arima model* | (0,1,1)(0,1,1) | (0,1,1)(0,1,1) |
| *Log* | Yes | Yes |
| *Theta* | coef= -0.5198 | coef= -0.7754 |
| | t-stat:-6.50 P-value:0.000 | t-stat:-13.16 P-value:0.000 |
| *BTheta* | coef= -0.295 | coef= -0.3139 |
| | t-stat:-3.31 P-value:0.001 | t-stat:-3.36 P-value:0.001 |
| *Calendar Effect* | Exc. Saturday, Sunday, fixed and moving holiday | None |
| | coef= 0.0278 | |
| | t-stat:13.40 P-value:0.000 | |
| *Outlier* | TC (4-2020) | TC (4-2020) |
| | coef= -0.1580 | coef= -0.1812 |
| | t-stat:-4.38 P-value:0.000 | t-stat:-3.57 P-value:0.0005 |
| *AIC* | 681.37 | 778.81 |
| *BIC* | -6.33 | -5.54 |

In order to compare forecast values for (2021-01:2021:12) period with and without calendar effect with the level values for the original time series, firstly annual growth rates (Year over Year -YoY) were calculated (Fig.2). Our expectation in annual growth rates graphs is that the with calendar model will obtain results close to the original series, especially during moving holiday periods. In 2021 Ramadan Feast was on May 13-15 and Sacrifice Feast was on July 20 - 23. When the relevant periods are examined graphically, we can say that the annual growth rates of the calendar effect model follow the direction in the original series and produce results close to the real annual growth rates. However, the annual growth rate of the without calendar model doesn't reflects this situation, especially in the May and July period, and differs from the original data.

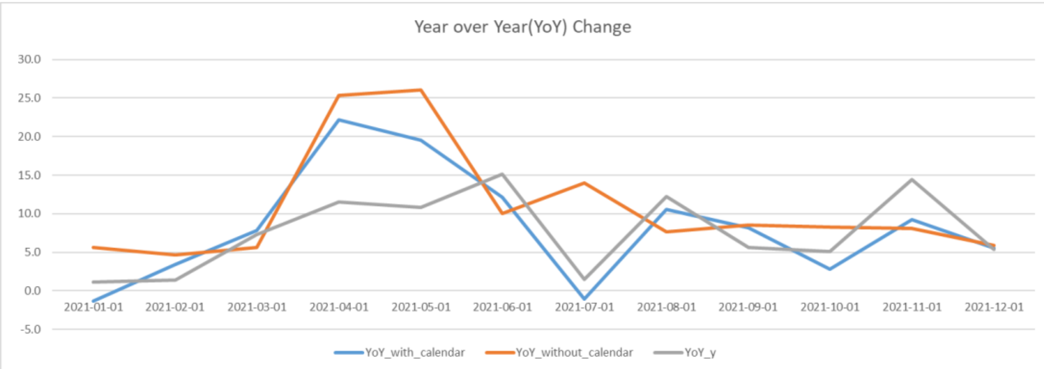


**Figure 2.** Year over Year (YoY) change with calendar, without calendar and original series

In the paper, a study was also conducted on the absolute revisions of the with calendar and without calendar model (Table 9). The table contains the Root Mean Square Revision (RMSR) results of the growth rates for monthly, annual and level values with and without calendar. According to these results, the model containing the calendar effect was found to be more successful because the revisions of the calendar results were smaller than without calendar model.

**Table 9.** Root Mean Square Revision (RMSR) results with and without calendar added

| | Calendar Added | Without Calendar |
|---|---|---|
| *MoM* | 5.02 | 8.13 |
| *YoY* | 4.60 | 7.72 |
| *Level* | 4.16 | 7.12 |

## 3. Conclusion

This study discusses how the composite calendar regressors are constructed, how the calendar effect is analyzed, and how the statistically significant calendar effect is determined. Using a specific date range in the generation of composite calendar regressors will only reflect the effect for that period. Instead, using theoretical averages is considered a more consistent and reliable way to obtain long-term averages. The usability of the more objective and invariant theoretical averages structure is expressed in this study as a new approach within the theoretical and practical framework. In this direction, ten composite calendar regressors were calculated with different combinations using the effects of the weekend (Saturday-Sunday) or Sunday, a Solar calendar based on fixed (national) holidays, a Lunar calendar based on moving (religious) holidays, and Leap year (February 29).

The significance of the composite calendar regressors for the IPI - Manufacture of Food Products sector was analyzed at different time spans with the method of backward reduction. When both numerical statistics and graphics were evaluated for this sector, the most suitable composite calendar regressor was tried to be preferred. While making this choice was also considered whether the calendar effect had a consistent structure in different time spans. Especially from a sectoral perspective, since working days or holiday durations in the sectors do not vary much, it is expected that the calendar effects will not have volatile structure. Therefore, when deciding on the composite calendar regressor, it is essential to interpret it in terms of the sector as well as its statistical significance.

One of the main purposes of time series analysis is to predict the future (forecasting) based on the past values of the relevant time series. In order to emphasize the importance of the calendar effect for forecasting the time series, a forecast analysis was also carried out for the selected time series with and without calendar effect. The monthly and annual growth rates and RMSR values of these prediction values were calculated and it was determined that the model containing the calendar effect was more successful in prediction because the revisions of the calendar results were smaller than without calendar model.

As a result, it is thought that the approach of calculation and analysis of composite calendar regressors will be a guide for other countries such as Türkiye, where there are moving holidays according to the Lunar calendar, and will contribute to the literature.

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