Seasonal Adjustments in Economic and Financial Series at the Bank of Israel—Demonstration on the “Mortgage Performance” Series

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Abstract

“Seasonal adjustment” is a complex statistical procedure used to estimate the effect of the calendar on time series, and to deduct that effect from the series. Applying this procedure to time series data—economic and financial—helps in reaching more accurate conclusions regarding economic developments. The Information and Statistics Department at the Bank of Israel makes seasonal adjustments to many time series, and some of them are published on the Bank’s website.

Seasonally adjusted time series are used, among other things, as input for economic models and leading indicators of the business cycle and the state of the economy, and are an important element in the decision-making process by monetary policy makers.

This paper is intended to expand and deepen knowledge on the issue of seasonal adjustment, and to demonstrate the Bank of Israel’s implementation of it on the series of data on new mortgages taken out.

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1. Introduction

"Seasonal Adjustment"

Economists, researchers and policy makers at the Bank of Israel base their decisions and projections on the analysis of a large quantity of data, which represent various aspects of economic and financial activity in Israel and abroad. For the most part, the data are presented as time-series data, which reflect the development of activity over time. These time series are affected, inter alia, by the Gregorian and Jewish calendars. The effects of the Gregorian calendar include seasonality—variability that repeats itself in particular months or quarters of the year—and changes in the number of trading days in various months or quarters. The effects of the Jewish calendar are reflected in changes in the timing of the Jewish holidays, since those dates are not fixed on the Gregorian calendar, leading to changes in the number of trading days in the Gregorian calendar. By way of illustration, each month, the Central Bureau of Statistics (CBS) publishes the Consumer Price Index. This index tends to be higher in July and August each year, as well as during the Jewish holidays in the fall, when private consumption increases. Another example is the series of total Israeli tourist departures to abroad, which is published monthly by the CBS. This figure tends to be particularly high during July and August. In these examples, drawing conclusions regarding the inflation rate or the volume of Israeli tourist departures during those periods without accounting for the effects of the calendar could be misleading. Pertaining to all time series, in order to draw correct conclusions regarding economic developmentsfrom time-series data, adjustments must be made for the effects of the calendar (hereinafter: "seasonal adjustment").

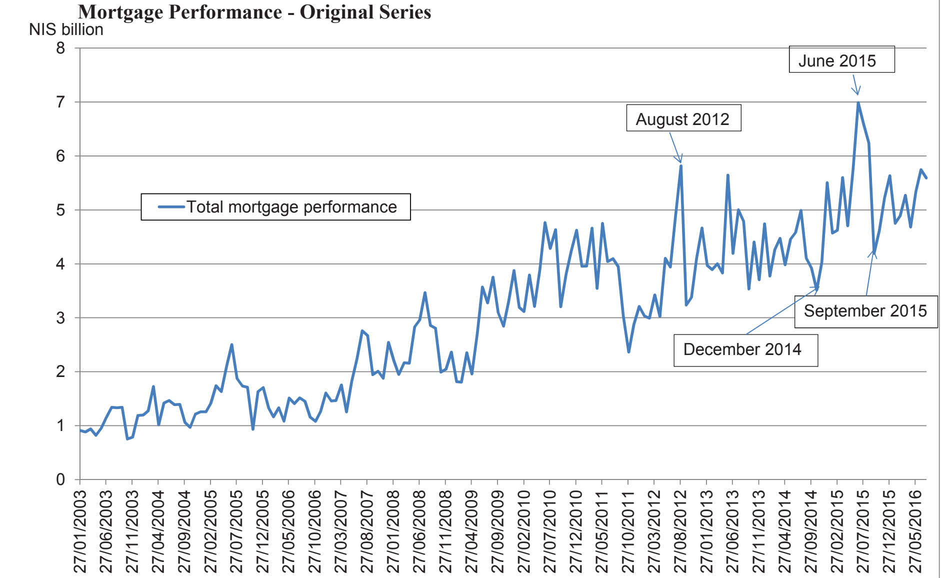
Seasonal adjustment is a complex statistical procedure, in which the seasonality component and other calendar effects in a time series are estimated and deducted from the series. The common method around the world for seasonal adjustment was developed at the US Census Bureau, and is referred to as X12-ARIMA[1]. This is the method used at the Bank of Israel, most government statistics bureaus, universities, and central banks worldwide.

There are many time series used at the Bank of Israel, including series that are seasonally adjusted. The seasonally adjusted series are used, inter alia, as input for economic, econometric and statistical models and as leading indicators for the business cycle and the state of the economy. They are an important element in the decision-making process for monetary policy makers.

Many seasonally adjusted time series that are used by economists and researchers at the Bank originate with the CBS, such as real series from the National Accounts. The CBS developed a unique method[2] for seasonal adjustment, which is based on the X12-ARIMA method, and which it uses in adjusting many time series. This method differs slightly from the method used at the Bank of Israel and other institutions around the world. There are many time series that are adjusted at the Bank of Israel, some of which are published in the series database on the Bank of Israel's website[3].

[1] https://www.census.gov/en.html.
[2] Seasonal adjustment—Central Bureau of Statistics.
[3] Bank of Israel—Information and Statistics.

Figure 1
Mortgage Performance - Original Series



Demonstration on the "Mortgage Performance" Series

We demonstrate the seasonal adjustment procedure on a time series that includes data on the amounts of new loans for residential purchases provided by the banks to the public (hereinafter: mortgage performance). The series includes monthly data in billions of shekels for the period from January 2003 to July 2016. There are two objectives to the demonstration: a. to clarify the seasonal adjustment process, and b. to show how this process helps provide a proper economic analysis of the series.

In examining the original series in Figure 1, it is easy to distinguish the upward trend in the volume of mortgage performance throughout the period in general. However, due to volatility in the monthly performance data, some of which is particularly high, it is difficult to determine whether mortgage activity during certain sub-periods increases, is stable, declines, or shows a cyclical pattern. For instance, performance data in August 2012 and in June 2015 show a large decline in such activity. Therefore, even after the fact—when the analyst has data on the entire period—it is difficult to determine what the trend is in mortgage activity during a sub-period, such as the last period in the Figure. It is even more the case that in a real-time analysis—when the most recent data available to the analyst indicates a large fluctuation, such as in the months noted—it is difficult to determine whether the data show a change in activity and the start of a new trend, or whether it is a one-time outlier. More specifically, it is difficult to understand what part of the fluctuation in the monthly data is explained by the calendar effect and what part is explained by other effects. Below, we will see how and to what extent using the seasonal adjustment procedure on this series makes it possible for us to separate an outlier change and a change in activity trend, and to show the trends in this activity during sub-periods.

The rest of the work includes a theoretical explanation of the various components of an economic time series, an explanation of the seasonal adjustment procedure, and a demonstration of that procedure and of its significance through the series of the volume of new mortgages taken out.

2. Theoretical background

The calendar's effects on a time series are not observed. Therefore, they cannot be measured directly, but are estimated. These estimates are based, inter alia, on a number of assumptions regarding the theoretical components of the time series and the mutual relations between them, as described herein.

a. The time series and its components

Theoretically, it is customary to decompose the data in a time series at any point in time, t, into three unobserved components: seasonality (*S*), trend-cycle (*TC*), and irregularity (*I*).

$$O_t = f\,(TC_t, S_t, I_t)$$

Seasonality—The term refers to expected variations in the data that repeat each year in the same months or quarters of the Gregorian calendar.

Trend-cycle—The term refers to long-term behavior of the time series that is more "smooth" than the original series. The term "cycle" relates to data during a particular period, which are characterized by variation around the trend of the series—a pattern that repeats itself. For instance, the business cycle is comprised of periods of economic growth, during which the data in the GDP time series are above the GDP trend figure, and periods of slowdown, during which the series data are below the trend figure, alternatively. The trend-cycle is treated as one component due to the difficulty in separating its components.

Irregularity—This term includes the remainder of the series after deducting seasonality and trend-cycle from the original series. It is comprised of three parts. The first is the effects of the Jewish calendar due to the changing Gregorian dates of the Jewish holidays, particularly the autumn holidays in September-October, and the Passover holiday in March-April. The variable effect of the number of trading days in each month is similar. The second part is the effects of temporary events such as changes in regulation or the economic environment. The third part is the remainder caused by measurement and other errors.

b. Common models for decomposing time-series data

The multiplicative model—In this model, all of the components in the series are interdependent. In particular, the seasonality component is dependent on the series level component (trend-cycle):

$$O_t = TC_t \times S_t \times I_t$$

In this model, the trend-cycle component is in terms of the original time-series data, while the seasonality and irregularity components are multiples. This means that the effects of these components are proportional to the series level. For instance, a seasonality component of 1.2 means that this component adds 20 percent to the time series. This model is not appropriate for series in which there are negative or zero values.

The additive model—In this model, the series components are not interdependent:

Here, all the components are in terms of the original series, and are not dependent on the series level. It is appropriate for series in which there are negative or zero values.

$$O_t = TC_t + S_t + I_t$$

The pseudo-additive model—In this model, the seasonality and irregularity components are dependent on the series level, but are not dependent on each other:

$$O_t = TC_t \text{ x } (S_t + I - 1)$$

This model is appropriate for series in which there are zero values in certain months or quarters each year, and positive values in other months or quarters. This decomposition is appropriate, for instance, for series in the tourism field.

Stage 1: Prior adjustment of the series for the Jewish holidays, outlier observations, trading days and other variables through a regression model.

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Stage 2: Examining the quality of the regression model's adjustment.

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Stage 3: The basic seasonal adjustment algorithm.

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Stage 4: Tests of the quality of the seasonal adjustment.

3. Seasonal adjustment according to the X12-ARIMA procedure

The X12-ARIMA procedure for seasonal adjustment, the use of which is currently widespread, is the result of a gradual development of adjustment methods since the middle of the previous century. In 1954, Julius Shiskin of the US Census Bureau developed a method called Census Method I. Between 1957 and 1965, this method was followed with the development of 11 experimental methods (X1, X2, etc.), the last of which was X11. Method X11 rapidly became the standard and accepted method for seasonal adjustment at that time. The method is based on an iterative estimation procedure of the time series components by way of moving averages.

In 1975, the method was significantly developed at Statistics Canada, in a version called X11-ARIMA. The most important improvement in this version was the ability to extend the series prior to seasonal adjustment, by adding forecasts for periods that are not included. This extension is implemented through ARIMA models for modeling time series, presented by Box and Jenkins[4] in 1970. Empirically, the use of

[4] Box, G. E. and G. M. Jenkins (1970), "Time Series Analysis: Forecasting and Control", San Fransisco: Holden Day.

forecasts leads to relatively small revisions, on average, in the seasonally adjusted series, particularly at the end of the series, where new monthly or quarterly observations are added to the time series.

In 1996, an improved version of the X11-ARIMA method was developed at the US Census Bureau, called X12-ARIMA. The most important improvement in this version is the ability to model and adjust the series to the effects of the calendar and to one-time events before implementing the basic seasonal adjustment algorithm.

The following is a general flowchart of the X12-ARIMA procedure, together with an explanation of the various stages in the procedure.

General outline of the X12-ARIMA procedure

- **Stage 1: Prior adjustment.** In this stage, an initial adjustment of the series is made to a number of effects—of the calendar and others—on the basis of the parameters estimated in a linear regression model. This stage comes before the main seasonal adjustment stage (Stage 3). In this stage, we also extend the series by forecasting its data for a number of periods forward on the basis of the adjusted model. The various calendar effects that can be adjusted at this stage of the procedure by including the relevant explanatory variables in the regression model are discussed below.

  The effect of the Jewish holidays—The series is adjusted to take into account the effect of the Jewish holidays beyond the monthly or quarterly effects of the Gregorian calendar, particularly the Passover and autumn holidays, which vary along the Gregorian calendar from year to year. For instance, the Passover holiday in 2013 took place partly in March and partly in April, while it fell entirely in April in 2014. The effect of the Jewish holidays is included in the regression model through an explanatory variable that answers the question of how many days of the Passover holiday take place in March and how many in April, as well as through an explanatory variable answering the question of how many days of the autumn holidays occur in September and how many in October. A variable counting the intermediate days of the holidays that occur in March, April, September and October can also be included.

  The effect of trading days—Each month, the composition of Sundays, Mondays, Tuesdays, Wednesdays, Thursdays, Fridays, Saturdays, holiday eves, and holidays is different. Each of the days of the week may occur four or five times per month, and the number may have an effect on the level of activity. For instance, the level of activity in a month with five Saturdays may be lower or higher than the level in a month with just four Saturdays. The series can also be adjusted for the effect of a leap year—containing a 29th day in February (such as 2016)—every fourth year, when there may be increased activity due to the extra day in that month.

  The effect of outlier observations—Outlier observations may have an over-effect on the estimation of seasonality factors. These effects are included in the model by adding dummy variables for dates with observations that seem to be outliers. The procedure also contains an automatic method for identifying outlier observations and including them in the model.

  Other variables that may have an effect on the estimates of seasonality factors—For instance, an analysis of the Consumer Price Index series may relate to the fact that there were a number of months in which the shekel depreciated significantly, and the depreciation had an effect on the prices of imported goods during those months. Even though this effect is not seasonal, it may be identified as such and skew the seasonality factors for those months. The series can be adjusted for this effect.

- **Stage 2: Examining the quality of the regression model's adjustment:** The procedure's output includes examinations of the quality of the regression model's adjustment, including of the statistical significance of the explanatory variables. Based on these results, variables can be input into the model and extracted from it.
- **Stage 3: The basic seasonal adjustment algorithm:** This is the main stage in the seasonal adjustment procedure. This stage is mainly based on filtering the series through moving averages with odd length values (so that each side will have the same number of observations). In the first stage, an initial estimate is made of the trend-cycle component using a moving average with a length of 13, which is close to a year. After reducing the trend-cycle by subtracting from the additive model or dividing from the multiplicative model, an initial estimate of the seasonality component is made by filtering each month separately. The algorithm includes many stages, most of which are various filterings of the series. At the end, the algorithm generates estimates of the cycle-trend component, the seasonality component, and the irregularity component, as well as a seasonally adjusted series. At this stage, the user determines the various parameters, and controls, inter alia, the length of the moving averages in some of the algorithm stages.
- **Stage 4: Tests of the quality of the seasonal adjustment:** The procedure output shows adjustment tests of the seasonal adjustment. Based on these tests, the adjustment parameters can be revised through trial and error, and we can go back to the stage of adjusting the series in advance and inserting parameter changes.

4. Demonstration of the series of new mortgages taken out from banks (mortgage performance)

We demonstrate the seasonal adjustment procedure on a time series that includes data on the amounts of new loans for residential purchases provided by the banks to the public (hereinafter: mortgage performance). The series includes monthly data in billions of shekels for the period from January 2003 to July 2016. There are two objectives to the demonstration: a. to clarify the seasonal adjustment process, and b. to show how this process helps provide a proper economic analysis of the series.

In examining the original series in Figure 1, it is easy to distinguish the upward trend in the volume of mortgage performance throughout the period in general. However, due to volatility in the monthly performance data, some of which is particularly high, it is difficult to determine whether mortgage activity during certain sub-periods increases, is stable, declines, or shows a cyclical pattern. For instance, performance data in August 2012 and in June 2015 show a large decline in such activity. Therefore, even after the fact—when the analyst has data on the entire period—it is difficult to determine what the trend is in mortgage activity during a sub-period, such as the last period in the Figure. It is even more the case that in a real-time analysis—when the most recent data available to the analyst indicates a large fluctuation, such as in the months noted—it is difficult to determine whether the data show a change in activity and the start of a new trend, or whether it is a one-time outlier. More specifically, it is difficult to understand what part of the fluctuation in the monthly data is explained by the calendar effect and what part is explained by other effects. Below, we will see how and to what extent using the seasonal adjustment procedure on this series makes it possible for us to separate an outlier change and a change in activity trend, and to show the trends in this activity during sub-periods.

In order to gain an initial impression of the seasonal structure of this series, Figure 22 shows the same data from the original series, only for the years 2008–2016 (for display clarity purposes). Each year is presented with a different line.

Figure 2
Mortgage Performance - Original Series by Year

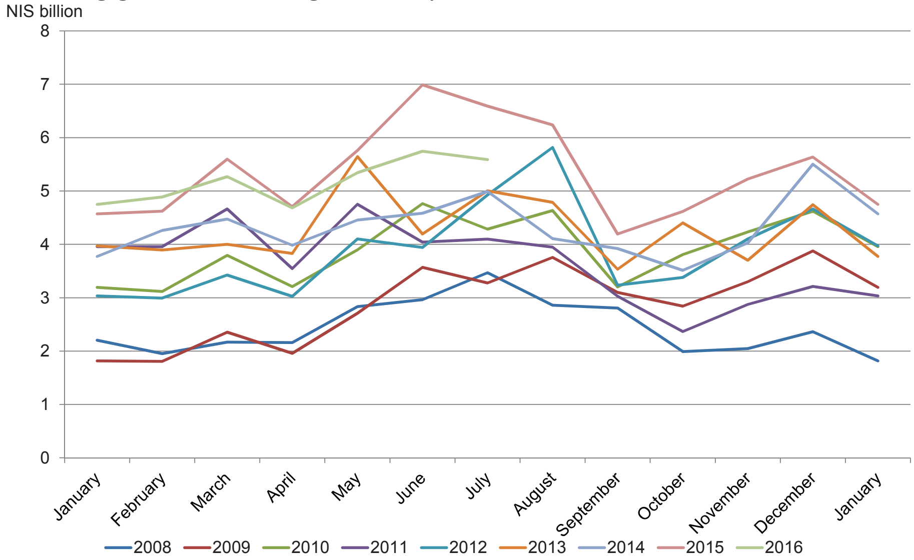


Figure 2 shows that the series has a clear seasonal structure. In particular, there is a marked increase in mortgage performance activity during the summer months. We can also distinguish high levels of activity in March and December compared to the months next to them.

Stage 1: Prior adjustment of the series for the Jewish holidays, outlier observations, trading days and other variables through a regression model.

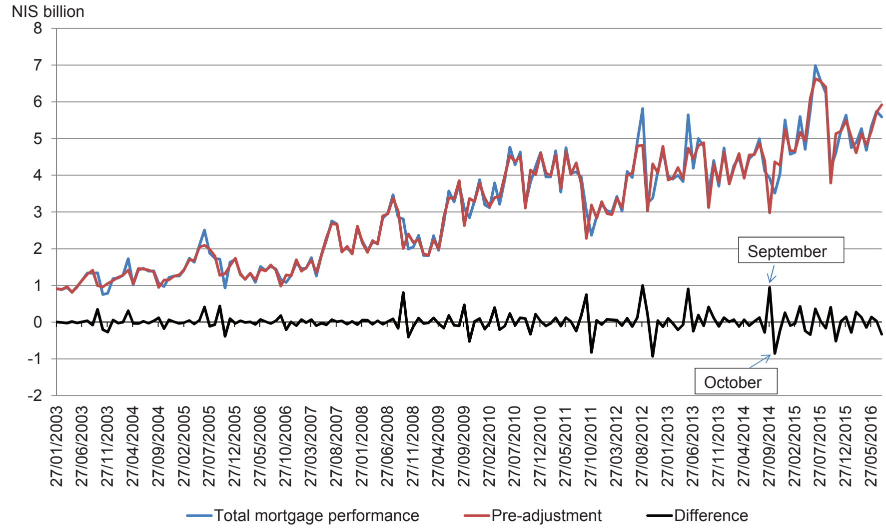
In the first stage, we adjust the series, through a linear regression model, for the effects of the Passover and autumn holidays, the amount of trading days, and outlier observations. Figure 3 shows the series pre-adjusted for these effects.

Figure 3 shows that the pre-adjustments in respect of the Jewish holidays, trading days and outliers are mostly relatively small. Thus, we can distinguish that many of the adjustments are made in the months bordering March and April, and September and October, and that the adjustments in respect of the holiday effects are in opposing directions. For instance, in 2014, the adjustment in September was upward, and in October it was downward.

Stage 2: Examining the quality of the regression model's adjustment.

In examining the indices for the adjustment quality of the regression model, we find that the model is in line with the data, and that the explanatory variables are statistically significant.

Figure 3
Mortgage Performance - The Series After Adjustment for Holidays, Trading Days and Outliers



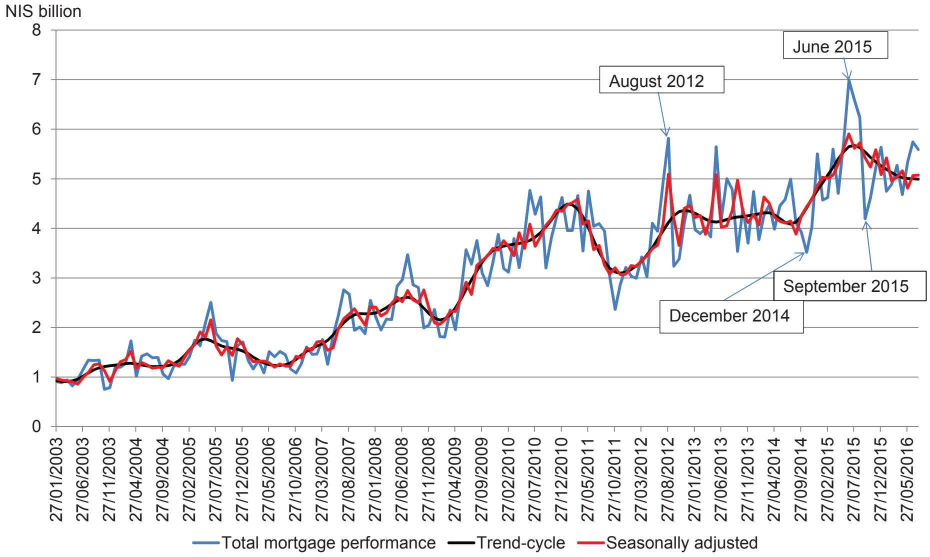
Stage 3: The basic seasonal adjustment algorithm.

The next stage in the procedure, the main part of which is smoothing the series through moving averages, generates estimates of the three components of the series and a seasonally adjusted series. Figure 4 shows the seasonality component estimated from the series—a separate line for each year—and Figure 5 shows the seasonally adjusted series and the trend-cycle series.

Figure 4
Mortgage Performance - Seasonality Component by Year

Figure 4 indicates a high level of seasonality in May, June, July and August, and a low level of seasonality in September. The seasonality ranges between plus 30 percent and minus 30 percent (0.7 to 1.3). This range shows that the seasonality component in mortgage performance is significant, and in order to properly analyze this activity, we must seasonally adjust the series.

Figure 5
Mortgage Performance—Trend-cycle, Seasonally Adjusted Series, and Original Series



The trend-cycle series is generally used in long-term analyses of economic activity, the purpose of which is to identify general directions or trends in developments over time, and cyclicality (periods of economic growth or contraction) around this trend. The cycle-trend analysis in Figure 5 shows a strong and continued increase in the volume of mortgage performance throughout the period in general, from about NIS 1 billion in 2003 to a level five times higher in 2016. This trend is consistent with the expanded activity in the housing market, and with the upward trend of home prices during the reviewed period.

As opposed to the original series, the trend-cycle series makes it possible to also distinguish the direction of the development of mortgage activity during sub-periods. For instance, we can clearly see a decline in mortgage performance in 2011, apparently due to the social protests, the increase in the Bank of Israel monetary interest rate, and the new limitations imposed by the Supervisor of Banks in May of that year on the variable-rate portion of mortgages as a share of mortgages issued by a bank as a macroprudential measure.[5] We can also see stabilization, and perhaps even a slight decline, in mortgage performance between March 2014 and September 2014, and a slowdown in the months thereafter, apparently due to the government's declaration of the "Zero VAT" plan in March of that year, due to which the housing market entered a waiting pattern for the implementation of that plan, and perhaps due to the effects of Operation Protective Edge.[6]

5 As per the Bank of Israel Annual Report for 2011.
6 As per the Bank of Israel Annual Report for 2014.

The seasonally adjusted series in Figure 5 is less “smooth” than the trend-cycle series, but more “smooth” than the original series. An analysis of the seasonally adjusted series shows a picture similar to that of the trend analysis. The seasonally adjusted series makes it possible to answer the question of what the change is in the monthly data in the series that is not affected by the calendar. For instance, in August 2012, a significant part of the increase in the performance data is not explained by the calendar effects, and it therefore does reflect an increase in mortgage activity. In contrast, it seems that in December 214, June and September 2015, the main part of the change in the data is explained by the calendar effects, and therefore does not reflect a change in mortgage activity.

The seasonally adjusted series is also used in a short-term analysis, and makes it possible to know in real time the extent to which the most recent data available represents a change in activity. For instance, in the seasonally adjusted series in Figure 5—as opposed to the original series—it is easy to distinguish the decline in mortgage performance in mid-2016, which continues the trend that began back in 2015.