Methodology of JCPPI:
Japan Commercial Property Price Index

August 2020

Real Estate and Construction Economy BureauMinistry of Land,
Infrastructure, Transport and Tourism

Contents

1. Outline of the Japan Commercial Property Price Index (JCPPI)

The Japan Commercial Property Price Index (JCPPI) is an index of prices for commercial property (commercial plots of land and buildings) nationwide that is calculated based on the data accumulated through the System to Provide Real Estate Transaction Price Data (*Land General Information System*) operated by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), and the quality of each property is adjusted by using the Hedonic Approach. For these reasons, the JCPPI serves as a constant quality property price index.

The commercial property data is categorized into seven types based on use and location: "Retail," "Office," "Warehouse," "Factory," "Apartment (entire building)," "Commercial Land," and "Industrial Land."

Table 1: Outline of the Japan Commercial Property Price Index

Index name (Use)	・Commercial property ・Land with structure ・Retail ・Office ・Warehouse ・Factory ・Apartment ・Land ・Commercial Land ・Industrial Land
Regions	・Nationwide (Japan) ・Metropolitan Areas (three major metropolitan areas/TMA, areas other than TMA, Tokyo including suburbs) ・Prefectures (Tokyo, Aichi, and Osaka) * The three major metropolitan areas include Tokyo including suburbs (Saitama, Chiba, Tokyo, and Kanagawa), Nagoya including suburbs (Gifu, Aichi, and Mie) and Osaka including suburbs (Kyoto, Osaka, and Hyogo)
Nature of transactions	・Transactions between private bodies. Excludes transactions with public bodies.
Term	・From April 2008 (from April 1984 for the indexes by prefecture)
Base year	・The calendar year 2010 is used as the base year (Arithmetic mean of 2010 equals 100)
Periodicity	・Nationwide (Japan), Metropolitan Areas: Quarterly ・Prefecture: Annually
Method of calculation	・Hedonic Approach (time dummy variable method)
Method of seasonal adjustment	・X-12-ARIMA Seasonal adjustment method
Data	・Transaction price by questionnaire ・Information on real estate interests in trust disclosed in a timely fashion by J-REIT funds
Lag between transaction period and publication	・Approximately three months (the preliminary index shall be updated for three months and then fixed)

2. Data Generation Process

The data used for compiling the JCPPI is the data accumulated through the System to Provide Real Estate Transaction Price Data (*Land General Information System*) operated by the MLIT ("Transaction Case Data" or TCD). In addition, the data, which is information on real estate interests in trust disclosed in a timely fashion by J-REIT funds ("J-REIT data"), is also used for establishing JCCPI.

(1) System to Provide Real Estate Transaction Price Data

The System to Provide Real Estate Transaction Price Data aims to enhance the credibility and transparency of the real estate market, thereby facilitating and vitalizing real estate transactions. Under this system, information on real estate prices in actual transactions, which is compiled based on the questionnaire targeting transaction parties, is provided to the general public.

This system was launched in some areas in FY2005, and since FY 2008 the survey has been conducted nationwide. Information such as the transaction price, time of the transaction, address, floor area, age, and nearby stations is accumulated for each transaction, and is published after processing for secrecy, on a quarterly basis, on the "Land General Information System" webpage[1)] on the MLIT website.

The prices in the TCD are those for land or land with structure that were determined in actual transactions. Transactions in the market involve various circumstances that trigger aggressive buying or delay of buying decisions or otherwise affect the course of transactions, and rights and interests are sometimes attached to the land and/or structure. The TCD is characterized as being generic and basic information that reflects all these factors.

(2) Data used for the JCPPI

The TCD is compiled in three steps, based on (i) information on changes in registry, (ii) questionnaire responses, and (iii) on-site surveys. The information that is actually published on the "Land General Information System" webpage is the information that has been processed for secrecy.

The JCPPI figures are based on the data from (i) information on changes in registry and (ii) questionnaire responses, while past figures are based on all data, and also include information from (iii) on-site surveys.

It should be noted that TCD is only created from real estate transactions as "real asset." The transaction information on real estate interests in trust is collected from the information disclosed in a timely fashion by J-REIT funds and added to our estimation.

[1)] https://www.land.mlit.go.jp/webland_english/servlet/MainServlet

(3) Definition of Area

The structure of property pricing and the change of the price in time series are likely to vary area by area. Thus, the national index should be built up from regional property indexes which are properly weighted for each region. The regional index should also be estimated from a suitable model that reflects the property pricing structure in each region.

Taking into consideration the need to secure a certain number of stable sample sizes, we have compiled the national level of the JCPPI from two sub-indexes: the index for the three major metropolitan areas, and the index for the areas other than three major metropolitan areas. For Tokyo including suburbs, we will calculate and publish five separate indexes - Retail, Office, Apartment, Commercial Land, and Industrial Land.

Table 2: Regional classification for the JCPPI

Prefecture	Region
Hokkaido	Area other than TMA
Aomori	
Iwate	
Miyagi	
Akita	
Yamagata	
Fukushima	
Ibaragi	
Tochigi	
Gunma	
Saitama	Three major metropolitan areas (Tokyo including suburbs)
Chiba	
Tokyo	
Kanagawa	
Niigata	Area other than TMA
Toyama	
Ishikawa	
Fukui	
Yamanashi	
Nagano	
Shizuoka	
Gifu	Three major metropolitan areas (Nagoya including suburbs)
Aichi	
Mie	

Prefecture	Region
Shiga	Area other than TMA
Kyoto	Three major metropolitan areas (Osaka including suburbs)
Osaka	
Hyogo	
Nara	Area other than TMA
Wakayama	
Tottori	
Shimane	
Okayama	
Hiroshima	
Yamaguchi	
Tokushima	
Kagawa	
Ehime	
Kochi	
Fukuoka	
Saga	
Nagasaki	
Kumamoto	
Oita	
Miyazaki	
Kagoshima	
Okinawa	

(4) Definition of Usage

The definition of usage for Land with Structure (Retail, Office, Warehouse, Factory, and Apartment) is shown in the table below under the following conditions.

From April 2014
- Category of land-use in the registry is "Building Land" where the transfer of ownership is properly registered.
- The type of transaction in the questionnaire is "transaction on land with structure"

Up to March 2014
- "Usage" as determined by on-site investigation is "Land for structure"

Table 3: Definition of Usage (Land with Structure)

Usage	Definition
Retail	From April 2014 ・ Properties whose "Main usage" in the questionnaire is not "Residential," but one of the following: (1) "Building type" is "Retail" on the building registry. (2) "Building type" is "Other" on the building registry and "Main usage" is "Retail" in the questionnaire. Up to March 2014 ・ The "Building usage" as determined by the on-site investigation describes the usage as follows: "Retail," "Commercial," "Shopping center," "Rented shop," "Restaurant," "Bank," "Financial institution," "Game center," "Movie theater," "Karaoke," "Club house," "Convenience store," "Studio," "Sports club," "Pachinko," "Bowling center," etc.
Office	From April 2014 ・ Properties whose "Main usage" in the questionnaire is not "Residential," but one of the following: (1) "Building type" is "Office" on the building registry. (2) "Building type" is "Other" on the building registry and "Main usage" is "Office" in the questionnaire. Up to March 2014 ・ The "Building usage" as determined by the on-site investigation describes the usage as follows: "Office," "R&D space," etc.
Warehouse	From April 2014 ・ Properties whose "Main usage" in the questionnaire is not "Residential," but one of the following: (1) "Building type" is "Warehouse" on the building registry. (2) "Building type" is "Other" on the building registry and "Main usage" is "Warehouse" in the questionnaire. Up to March 2014 ・ The "Building usage" as determined by the on-site investigation describes the usage as follows: "Warehouse," "Logistics."
Factory	From April 2014 ・ Properties whose "Main usage" in the questionnaire is not "Residential," but one of the following: (1) "Building type" is "Factory" on the building registry.

	(2) "Building type" is "Other" on the building registry and "Main usage" is "Factory" in the questionnaire. Up to March 2014 ・The "Building usage" as determined by the on-site investigation describes the usage as follows: "Factory."
Apartment	From April 2014 ・ Those properties which meet one of the following conditions. (1) "Building type" on the building registry is "Apartment." (2) "Main usage" in the questionnaire is "Residential" and their freehold ownership transfer cannot be identified in the building registry (because it is likely that the property was recently constructed). In addition, its floor-to-site area should be greater than 300% (because it is classified as a "Detached house" in the Japan Residential Property Price Index if the ratio is less than or equal to 300%) Up to March 2014 ・The "Building usage" as determined by the on-site investigation describes the usage as follows: "Apartment," "Second-hand apartment," "New apartment," etc.

Usage for Land (Commercial Land and Industrial Land) is shown in the table below under the following conditions.

From April 2014
- Category of land-use in the registry is "Building Land" where the ownership transfer is properly registered.
- "Only land was transacted" in the questionnaire. However, the data is excluded if any of the following are true.
  - ✓ The building sold is to be demolished.
  - ✓ The registry suggested that there was a transaction involving both the land and building.
  - ✓ Some data on the building price, total floor space, or age of the building was found.

Up to March 2014
- Category of land-use in the registry is "Building Land" where the transfer of ownership is properly registered.
- Category of building land as determined by the on-site investigation is either "Vacant Land" or "Limited Proprietary Right of Land."

Table 4: Definition of Usage (Land)

Usage	Definition
Commercial Land	From April 2014 ・ The Land Use Zone identified by GIS is either "Neighborhood Commercial zone" or "Commercial zone." ・ If there is no Land Use Zone allocated, then it is one of the following: (1) "Main usage" on the questionnaire is either "Retail" or "Office" (2) "Main usage" on the questionnaire is "Other" and the "Category of land use" as determined by the on-site investigation is related to commercial use Up to March 2014 ・ The Land Use Zone as determined by the on-site investigation is either "Neighborhood Commercial zone" or "Commercial zone." ・ If there is no Land Use Zone allocated, the "Category of land use" as determined by the on-site investigation is related to commercial use.
Industrial Land	From April 2014 ・ The Land Use Zone identified by GIS is either "Quasi-industrial zone," "Industrial zone" or "Exclusively industrial zone." ・ If there is no Land Use Zone allocated, then it is one of the following: (1) "Main usage" on the questionnaire is either "Warehouse" or "Factory."

	(2) "Main usage" on the questionnaire is "Other" and the "Category of land use" as determined by the on-site investigation is related to industrial use. Up to March 2014 ・ The Land Use Zone as determined by the on-site investigation is either "Quasi-industrial zone," "Industrial zone," or "Exclusively industrial zone." ・ If there is no Land Use Zone allocated, the "Category of land use" as determined by the on-site investigation is related to industrial use

(5) Missing data and Outlier

<Handling of Missing data>

The data is excluded from our analysis if the following information is missing.

- Transaction price (total price)
- Transaction date
- Address
- Land area
- Total number of floors of the building (*only for land with structure)
- Year of construction (*only for land with structure)

<Handling of Outlier>

The data is excluded from our analysis as an outlier that meets one of the seven following "Rules." The reason for this exercise is that we would like to eliminate the outliers that have been created from errors either in the answers in the questionnaire or those that occurred while entering the data in the database. We made a final decision that took into consideration the data generation process as well as the distribution of the data.

- Rule 1: Transaction price (total) / Land area < JPY 1,700 per m^2
- Rule 2: Transaction price (total) / Land area < JPY 500 million per m^2
- Rule 3: Transaction price (total) < JPY 1 million
- Rule 4: Land area < $30m^2$
- Rule 5: Total floor area < $30m^2$ (*only for land with structure)
- Rule 6: Total floor area / Land area < 1% or > 2,500% (*only for land with structure)
- Rule 7: Building age as of transaction date > 80 years (*only for land with structure)

Note 1 – In Rule 1, we have set up this minimum land area, taking into account half of the minimum land size in the "Land Market Value Publication" produced by the MLIT.

Note 2 – In Rule 6, we have limited the maximum ratio, taking into account double the highest designated floor-to-area ratio (1,300%) after the ratio is de-regulated.

3. Calculation Model

The hedonic price method, in particular the time dummy variable method, was used to calculate the JCPPI. Furthermore, in order to minimize the necessity to revise time series data, the rolling window approach is applied.

(1) Outline of Commercial Property Price Index Calculation Method

The time dummy variable model of the hedonic regression method creates the price index to cover all targeted periods by estimating the price change ratio through time dummy parameters. The parameters are identified by the hedonic price function for discretional τ periods among the periods where t=0, 1, …, T.

$$\ln p_n^t = \beta_0 + \sum_{k=1}^{K} \beta_k z_{nk}^t + \sum_{t=1}^{T} \delta^t D^t + \varepsilon_n^t$$

p_n^t: Transaction price of property n in period t, β_0: Intercept

β_k: Parameters for attributes k of property n, z_{nk}^t: Attributes k of property n in period t

δ^t: Parameters for time dummy variables

D^t: Time dummy variables (equals "1" if the property is transacted in period t, otherwise "0")

ε_n^t: Error term

The table below describes an overview of the rolling window approach. Given the window length τ (where $1 < \tau < T$), the hedonic price function is estimated using data for each estimation window. As a result, the parameters for property attributes are allowed to vary over time (though they are fixed within τ periods).

Table 5: Overview of the calculation based on the rolling window approach (τ = 12)

	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	t = 6	t = 7	t = 8	t = 9	t = 10	t = 11	t = 12	t = 13	t = 14	…	t = T
Quarterly Index	0			δ1			δ2			δ3							
				0			δ2			δ3			δ4				
							0			δ3			δ4			…	
Monthly Index	0	δ1	δ2	δ3	δ4	δ5	δ6	δ7	δ8	δ9	δ10	δ11					
		0	δ2	δ3	δ4	δ5	δ6	δ7	δ8	δ9	δ10	δ11	δ12				
			0	δ3	δ4	δ5	δ6	δ7	δ8	δ9	δ10	δ11	δ12	δ13			
				0	δ4	δ5	δ6	δ7	δ8	δ9	δ10	δ11	δ12	δ13	δ14		
					0	δ5	δ6	δ7	δ8	δ9	δ10	δ11	δ12	δ13	δ14	…	

indicates the parameters of time dummy variables used in the computation of property price index.

For the initial τ periods ($t = 0, \ldots, \tau - 1$), the property price changes between the base period (0) and the reference periods (t) are obtained from the estimated parameters for time dummy variables as

shown below.

$$\ln(p^t/p^0) = \delta^t \quad \Leftrightarrow \quad p^t/p^0 = \exp(\delta^t)$$

For the preceding τ periods ($t = 1, \ldots, \tau$) and afterwards, property price changes at each reference period (t) from the previous period ($t-1$) are obtained from the estimated parameters for time dummy variables as shown below. This computation yields the price index for the entire periods (t=0, 1, …, T).

$$\ln(p^t/p^{t-1}) = \delta^t - \delta^{t-1} \quad \Leftrightarrow \quad p^t/p^{t-1} = \exp(\delta^t - \delta^{t-1})$$

We have set up the window length τ to secure sufficient sample size for this estimation in our calculation of the JCPPI as shown below.

- Nationwide and Metropolitan Area (Quarterly index): Two years
- Prefectures (Annual index): Five years

(2) Variable used for the individual model for each usage

The explanatory variables used for the JCPPI are shown in the table below.

It should be noted that both the building structure dummy and auction dummy have been used since April 2008 due to the availability of the data. For this reason, these dummies are included in the estimation of the JCPPI for Tokyo, Aichi, and Osaka after April 2008, and are linked to the index up to March 2008.

Table 6: Explanatory Variables for JCPPI

Category	Variables	Land with structure					Land	
		Retail	Office	Warehouse	Factory	Apartment	Commercial	Industrial
Building	Total floor area (*1)	○	○	○	○	○	—	—
	Age	○	○	○	○	○	—	—
	Building structure dummy (*2)	○	○	○	○	○	—	—
Location	Land area (*1)	○	○	○	○	○	○	○
	Distance from the nearest station (*1)	○	○	○	○	○	○	○
	Distance from the main station (*1)	○	○	○	○	○	○	○
	The number of railway stations available within 400 meters	○	○	—	—	—	○	—
	Distance from the nearest highway exit (*1)	—	—	○	○	—	—	○
	Distance from the nearest National Route (*1)	—	—	○	○	—	—	○
	Zoning dummy	○	○	○	○	○	○	○
	Administration area dummy	○	○	○	○	○	○	○
Other	Auction dummy (*2)	○	○	○	○	○	○	○
	Buyers dummy	○	○	○	○	○	○	○
	Sellers dummy	○	○	○	○	○	○	○
	Transaction date dummy	○	○	○	○	○	○	○

○: Used as a variable —: Not used

*1: We take a natural logarithm of the variables in the estimation of the regression models.

*2: Due to the availability of the data, we have not adopted these dummy variables as explanatory variable before March 2008.

(3) Definition of Explanatory Variables

The explanatory variables for the JCCPI have been generated as in the table shown below.

Table 6: Contents of explanatory variables.

Category	Variables	Contents	Note	Unit
Price	Price	Transaction price (total)		JPY
Building	Total floor area	Total floor area of entire building		m^2
	Age	Transaction date recorded in the registry minus year of construction		Year
	Building structure dummy	Categorized into "Reinforced Steel Concrete," "Steel Concrete," "Steel," "Light-Steel," "Concrete block," "Wood," or "Other." "1" if it belongs to the category, otherwise "0." The same rule applies to the dummy variable.		(0, 1)
Location	Land area	Total land area on which the building is located		m^2
	Distance from the nearest station	Linear distance from the nearest station to the subject property	Note 1	meter
	Distance from the main station	Linear distance from the main stations to the subject property: Shinjuku Station for Tokyo including suburbs and the nearest station in the prefectural capital city for the other areas.	Note 1	meter
	The number of railway stations available within 400 meters	The number of railway stations available within 400 meters (assuming 5-minute walk) from the subject property. If the railway line is different, the station is included in the number even if the station name is same.	Note 1	stations
	Distance from the nearest highway exit	Linear distance from the nearest highway exit to the subject property.	Note 1	meter
	Distance from the nearest National Route	Linear distance from the nearest National Route to the subject property.	Note 1	meter
	Zoning dummy	We have four dummies in Land Use Zones: "Commercial," "Industrial," "Residential," and "No designation." 1: Neighborhood commercial zone, Commercial zone 2: Quasi-industrial zone, Industrial zone, Exclusively industrial zone 3: Category Ⅰ exclusively low-rise residential zone, Category Ⅰ mid/high-rise oriented residential zone, Category Ⅱ exclusively low-rise residential zone, Category Ⅱ mid/high-rise oriented residential zone, Category Ⅰ residential zone, Category Ⅱ residential zone, Quasi-residential zone	Note 1 Note 2	(0, 1)
	Administration area dummy	We made dummies for the different administration areas. ・Each of the Tokyo 23 Wards ・Each of the prefectural capital cities ・Each of the other prefectures		(0, 1)
Other	Auction dummy	The dummy shows it is transacted by auction.		(0, 1)
	Buyers dummy	The dummy shows the buyer is a private corporation.		(0, 1)

	Sellers dummy	The dummy shows the seller is a private corporation.		(0, 1)
	Transaction date dummy	The dummy shows the quarter or year in which the transaction happened (the day recorded in the registry)		(0, 1)

Note 1) We have measured the information on location by GIS using its geographical coordinates. The MLIT has provided the following data in their "National Land Numerical Information" that we referenced.

- Rail line time-series data
- Expressway time-series data
- Emergency Transportation Road
- Designated Area data

Note2) We used the data from Transaction Case Data up to March 2014 and measured the data by GIS for the transactions after April 2014.

(4) Method of Aggregation

When aggregating indexes in each strata (such as aggregating each regional index into a nationwide index, or aggregating each property type index into a composite index), the fixed base Fisher formula is used. The calendar year 2010 is used as the base period.

The fixed base Fisher index is computed as a geometric mean of the fixed base Laspeyres index and the fixed base Paasche index.

An overview of the computation method is described below.

The fixed base Laspeyres index ($I^{0t}_{Laspeyres}$) and Paasche index ($I^{0t}_{Paasche}$) are computed from the equations below, denoting price (p), quantities (q), and items/groups (i) in the base period (0) and the reference period (t).

$$I^{0t}_{Laspeyres} = \frac{\sum_{i=1}^{n} p_i^t q_i^0}{\sum_{i=1}^{n} p_i^0 q_i^0}$$

$$I^{0t}_{Paasche} = \frac{\sum_{i=1}^{n} p_i^t q_i^t}{\sum_{i=1}^{n} p_i^0 q_i^t}$$

Next, the fixed base Fisher index (I^{0t}_{Fisher}) is computed as a geometric mean of Laspeyres and Paasche.

$$I^{0t}_{Fisher} = \left(I^{0t}_{Laspeyres} \times I^{0t}_{Paasche}\right)^{1/2}$$

The indexes computed as described above are the Japan Commercial Property Price Index (JCPPI).

(5) Methods of Seasonal Adjustment

The time series data of the Commercial Property Price Index released quarterly are likely to have seasonality that could increase or decrease the index value depending on the season and the month. Therefore, it seems necessary to remove the seasonal effect inherent in the time series data.

As shown in the equation below, time series data are usually decomposed into: Tt (the trend component at time t); Ct (the cyclical component at time t); St (the seasonal component at time t); and It (the irregular (or error) component at time t.

Seasonal adjustment is generally carried out by removing the seasonal (S) and irregular (I) components from data series based on moving averages.

$$Yt = Tt + Ct + St + It$$

The decomposition of time series data can be achieved in the following way: (1) It is possible to remove the seasonal and irregular components by determining the seasonal fluctuation cycle of the time series data (Yt) and applying an appropriate moving average to the fluctuation cycle (for example, if the seasonal fluctuation cycle is four quarters, take a four-quarter moving average to smooth out the highs and lows observed among the periods); and (2) If the moving-average smoothing method in (1) was successful, the trend (T) and cyclical (C) components should remain in the time series. The cyclical (C) component can be obtained by removing the trend (T) component by utilizing data graphs and other materials.

For the Commercial Property Price Index, the X-12-ARIMA seasonal adjustment method developed by the US Census Bureau was employed. X-12-ARIMA is based on the X-11 method which was commonly used for seasonal adjustment in the past.

The Commercial Property Price index without seasonal adjustment has also been published.

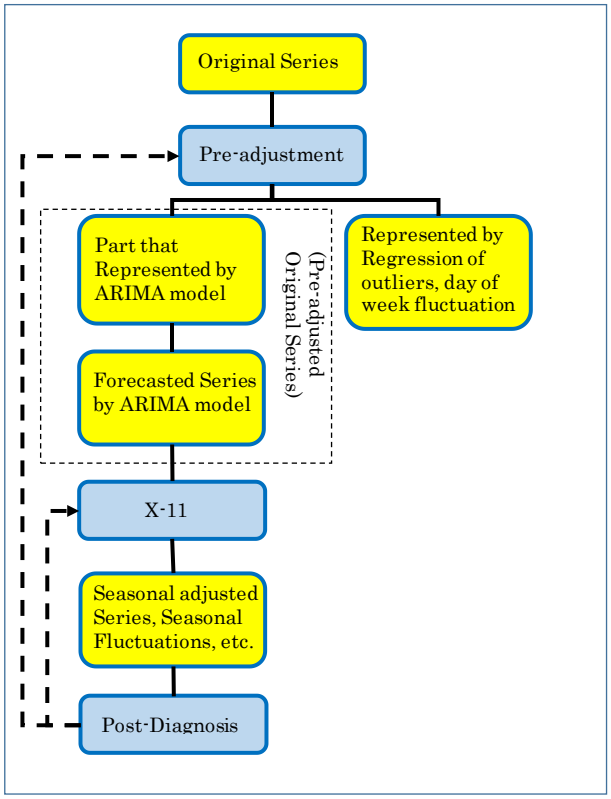
1) X-11 seasonal adjustment method

The X-11 seasonal adjustment method is a technique developed by the US Census Bureau in 1965. It repeatedly applies moving averages to an original time series in order to decompose it. Its seasonal component should be separated from the trend and irregular components. The X-11 procedure involves centered moving averages, for which each moving average is centered at the middle of the values being averaged. In terms of some latest values in a time series, however, there are not enough future values to calculate their centered moving averages. For those latest values, backward moving averages, which utilize values up to the newest value for calculating its average, are used instead. When another value of the most recent period is added to the time series in the future, the previously calculated averages of the latest values could be revised significantly.

2) X-12-ARIMA seasonal adjustment method

X-12-ARIMA was developed by the US Census Bureau to improve the X-11 and to adjust outliers and calendar effects. X-12-ARIMA uses the REGARIMA model that divides an original time series into the following two parts: (a) a portion that can be represented by a regression analysis of calendar effects and outliers; and (b) the remaining part that can be explained by the ARIMA model (Auto-Regressive Integrated Moving Average Model). Then, by making use of Item (b) above, the REGARIMA model generates a pre-adjusted original series that complements the original data with out-of-range values. Then, X-12-ARIMA makes seasonal adjustment to the pre-adjusted original series using the X-11 seasonal adjustment method. In this process, centered moving averages can be calculated for all values, including the most recent value, and outliers and calendar effects can be also adjusted. In addition, because X-12-ARIMA requires the analyst to carefully consider which model to represent the original series, it provides a post-diagnosis function to examine seasonally adjusted values. The figure below shows the process of seasonal adjustment by the X-12-ARIMA model.

Figure　Seasonal Adjustment Process by X-12-ARIMA



Source: Bank of Japan, "X-12-ARIMA Manual," Feb. 1997.