

## Entries to Glossary of Forecasting Terms

### A

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ACF; Adaptive response rate; Additive model; AIC (Akaike's Information Criterion); Algorithm; Applicability; ARIMA models; ARMA model; Asymptotically unbiased estimator; Autocorrelated errors; Autocorrelation; Autocorrelation function; Autoregressive (AR) model.

### B

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Backcasting; Backward shift operator; Biased estimator; BIC (Bayesian Information Criterion); Box-Jenkins methodology; Box-Pierce test; Business cycle.

### C

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Census II; Central limit theorem; Chi-square test; Classical decomposition method; Coefficient of determination; Coefficient of variation; Confidence interval; Correlation coefficient; Correlation matrix; Correlogram; Covariance; Critical value; Crosscorrelation; Cumulative forecasting; Curve fitting; Cyclical data; Cyclical index.

### D

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Decomposition; Degrees of freedom (df); Delphi method; Dependent variable; Depression; Deseasonalized data; Diagnostic checking; Differencing; Double moving average; Dummy variable; Durbin-Watson statistic; Dynamic regression models.

### E

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Econometric model; Economic indicator; Elasticity; Endogenous variable; Error; Error cost function; Estimation; Ex ante forecast; Exogenous variable; Explanatory model; Explanatory variable; Exploratory forecasting; Exponential growth; Exponential smoothing; Ex post forecast.

### F,G

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F-test; Feedback; File; Filter; First difference; Forecast horizon; Forecasting; Forecast interval; Forecast variable; Fourier analysis; Function; Goodness of fit; Gross National Product (GNP).

### H

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Heteroscedasticity; Heuristic; Holdout set; Holt-Winters' exponential smoothing method; Holt's exponential smoothing method; Homoscedasticity; Horizontal or stationary data; Hypothesis testing.

### I

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Identification; Impulse response weights; Independent variable; Index numbers; Indicator variable; Integrated; Interactive forecasting; Intercept; Interdependence; Intervention analysis.

### L

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Lag; Lead; Leading indicator; Lead time; Least squares estimation; Likelihood; Ljung-Box test; Local regression; Loess; Logarithmic transformation; Logistic curve.

### M

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M-Competition; M3-IJF Competition; Macrodata; Matrix; Maximum likelihood estimation; Mean; Mean Absolute Percentage Error (MAPE); Mean Percentage Error (MPE); Mean Squared Error (MSE); Medial average; Median; Microdata; Mixed model; Model; Moving average; Multicollinearity; Multiple correlation coefficient; Multiple regression; Multiplicative model; Multivariate ARMA model.

### N

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Naïve forecast; Neural networks; Noise; Non-linear estimation; Non-linear forecasting; Non-stationary; Normal distribution.

### O

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Observation; Optimal parameter or weight value; Order selection criteria; Outlier.

### P

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P-value; Parameter; Parsimony; Partial autocorrelation; Partial correlation; Pattern; Pegels' classification; Polynomial; Polynomial fitting; Post-sample evaluation; Prediction interval; Probability; Product life cycle .

### Q,R

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Qualitative or technological forecasting; Quantitative forecasting; R-bar-squared ( $\bar{R}^2$ ); R-squared ( $R^2$ ); Randomness; Random sampling; Random walk; Regression; Regression coefficients; Regression with ARIMA errors; Regressor; Residual.

### S

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S-curve; Sample; Sampling distribution; Sampling error; Seasonal adjustment; Seasonal data; Seasonal difference; Seasonal exponential smoothing; Seasonal index; Seasonal variation; Serial correlation; Significance; Simple regression; Slope; Smoothing; Specification error; Spectral analysis; Spencer's weighted moving average; Standard deviation; Standard error; Standardize; State space modeling; Stationary; Statistic; STL decomposition.

### T

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t-test; Technological forecasting; Time series; Time series model; Tracking signal; Trading day; Transfer function; Transformation; Trend analysis; Turning point; Type of data.

### U,V,W,X

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Unbiasedness; Updated forecast; Validation; Variance; Vector ARMA model; Weight; White noise; Winters' exponential smoothing; X-11 decomposition; X-12-ARIMA decomposition .

## Glossary of Forecasting Terms

**ACF** : See Autocorrelation function. ↑.

**Adaptive response rate** : In many time series forecasting methods, a trade-off must be made between smoothing randomness and reacting quickly to changes in the basic pattern. Adaptive-response-rate forecasting uses a decision rule that instructs the forecasting methodology (such as exponential smoothing) to adapt more quickly when it appears that a change in pattern has occurred and to do more smoothing of randomness when it appears that no such change has occurred. ↑.

**Additive model** : A model in which the various terms are added together. See also Multiplicative model. ↑.

**AIC (Akaike's Information Criterion)** : The AIC provides a measure of the goodness-of-fit of a model which takes into account the number of terms in the model. It is commonly used with ARIMA models to determine the appropriate model order. The AIC is equal to twice the number of parameters in the model minus twice the log of the likelihood function. The theory behind the AIC was developed by Akaike and is based on entropy concepts. See Order selection criteria. ↑.

**Algorithm** : A systematic set of rules for solving a particular problem. The sets of rules used in applying many of the quantitative methods of forecasting are algorithms. ↑.

**Applicability** : Recently, applicability has gained recognition as an important criterion in selecting a forecasting method. Applicability refers to the ease with which a method can be applied to a given situation with a specific user of forecasting. Increased complexity of sophisticated forecasting methods often reduces applicability.. ↑.

**ARIMA models** : An abbreviation for **AutoRegressive Integrated Moving Average**. A time series which, when differenced, follows an ARMA model is known as an ARIMA model. It is a very broad class of time series models. See Autoregressive (AR) model, Differencing, Integrated, and Moving average. ⇒=○=↑.

**ARMA model** : This type of time series forecasting model can be autoregressive (AR) in form, moving average (MA) in form, or a combination of the two (ARMA). In an ARMA model, the series to be forecast is expressed as a function of both previous values of the series (autoregressive terms) and previous error values from forecasting (the moving average terms). ↑.

**Asymptotically unbiased estimator** : If the bias of an estimator approaches zero as the sample size increases, the estimator is called "asymptotically unbiased." The formula for mean squared error is a biased estimator of variance, but it is asymptotically unbiased. See Biased estimator. ↑.

**Autocorrelated errors** : When the error terms remaining after application of a forecasting method show autocorrelation, it indicates that the forecasting method

has not removed all of the pattern from the data. There are several hypothesis tests for autocorrelated errors. The Box-Pierce test and Ljung-Box test check whether a sequence of autocorrelations is significantly different from a sequence of zeros; the Durbin-Watson test checks only for first-order autocorrelations after fitting a regression model. See Regression with ARIMA errors and Dynamic regression models.  $\uparrow$ .

**Autocorrelation** : This term is used to describe the correlation between values of the same time series at different time periods. It is similar to correlation but relates the series for different time lags. Thus there may be an autocorrelation for a time lag of 1, another autocorrelation for a time lag of 2, and so on.  $\uparrow$ .

**Autocorrelation function** : The pattern of autocorrelations for lags 1, 2,  $\dots$ , is known as the autocorrelation function or ACF. A plot of the ACF against the lag is known as the correlogram. It is frequently used to identify whether or not seasonality is present in a given time series (and the length of that seasonality), to identify appropriate time series models for specific situations, and to determine if data are stationary.  $\uparrow$ .

**Autoregressive (AR) model** : Autoregression is a form of regression, but instead of the variable to be forecast being related to other explanatory variables, it is related to past values of itself at varying time lags. Thus an autoregressive model would express the forecast as a function of previous values of that time series.  $\uparrow$ .

**Backcasting** : In applying quantitative forecasting techniques based on past errors, starting values are required so certain recursive calculations can be made. One way to obtain these is to apply the forecasting method to the series starting from the end and going to the beginning of the data. This procedure is called backcasting and provides a set of starting values for the errors that can then be used for applying that forecasting method to the standard sequence of starting from the data and forecasting through the end.  $\uparrow$ .

**Backward shift operator** : The letter  $B$  is used to denote a backward shift by one period. Thus  $B$  operating on  $X_t$  has the effect of shifting attention to  $X_{t-1}$ . Similarly  $BB$  or  $B^2$  is the same as shifting attention to two periods back. A first difference for a time series can be denoted  $(1 - B)X_t$ . A second-order difference is denoted  $(1 - B)^2X_t$  and a second difference would be denoted  $(1 - B^2)X_t$ . See Differencing.  $\uparrow$ .

**Biased estimator** : If a formula is defined to calculate a statistic (such as the mean) and the expected value of this statistic is not equal to the corresponding population parameter (e.g., the mean of the population), then the formula will be called a biased estimator. The usual formula for the sample mean is an unbiased estimator of the population mean, but the formula for MSE is a biased estimator of the variance. See Asymptotically unbiased estimator.  $\uparrow$ .

**BIC (Bayesian Information Criterion)** : Like the AIC, the BIC is an order selection criteria for ARIMA models. It was invented by Schwarz<sup>1</sup> (1978) and sometimes leads to less complex models than the AIC.  $\uparrow$ .

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<sup>1</sup>G. Schwarz (1978) Estimating the dimensions of a model, *Annals of Statistics*, **6**, 461–464.

**Box-Jenkins methodology** : George E. Box and Gwilym M. Jenkins have popularized the application of autoregressive / moving average models to time series forecasting problems. While this approach was originally developed in the 1930s, it did not become widely known until Box and Jenkins published a detailed description of it in book form in 1970.<sup>2</sup> The general methodology suggested by Box and Jenkins for applying ARIMA models to time series analysis, forecasting, and control has come to be known as the Box-Jenkins methodology for time series forecasting. ↑.

**Box-Pierce test** : This is a test for autocorrelated errors. The Box-Pierce  $Q$  statistic is computed as the weighted sum of squares of a sequence of autocorrelations. If the errors of the model are white noise, then the Box-Pierce statistic is distributed approximately as a chi-square distribution with  $h - m$  degrees of freedom where  $h$  is the number of lags used in the statistic and  $m$  is the number of fitted parameters. It is sometimes known as a “portmanteau test.” Another portmanteau test is the Ljung-Box test which is an improved version of the Box-Pierce test. ↑.

**Business cycle** : Periods of prosperity generally followed by periods of depression make up what is called the business cycle. Such cycles tend to vary in length and magnitude and are often dealt with as a separate subcomponent of the basic pattern contained in a time series. ↑.

**Census II** : The Census II method is a refinement of the classical decomposition method. It attempts to decompose a time series into seasonal, trend, cycle, and random components that can be analyzed separately. This method has been developed by using the empirical results obtained from its application at the United States Bureau of Census and elsewhere. The most widely used variant of the Census II method is X-11 decomposition. This has now been superseded by the X-12-ARIMA method. ↑.

**Central limit theorem** : Regardless of the shape of the population distribution, this theorem states that the sampling distribution of the mean of  $n$  independent sample values will approach the normal distribution as the sample size increases. In practice, when the sample size is sufficiently large (say greater than 30) this theorem is invoked. ↑.

**Chi-square test** : Given a standard normal population (i.e., normal distribution with mean zero and variance one) and  $n$  independently sampled values, the sum of the squares of these sampled values is called a chi-square value with  $n$  degrees of freedom. The complete set of such chi-square values is called a chi-square distribution. Several statistics have approximate chi-square distributions including the Box-Pierce statistic and the Ljung-Box statistic. Using these statistics, hypothesis tests can be conducted to see if the sample autocorrelations are significantly different from zero. See Sampling distribution. ↑.

**Classical decomposition method** : This algorithm seeks to decompose the underlying pattern of a time series into cyclical, seasonal, trend, and random sub-

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<sup>2</sup>G.E.P. Box and G.M. Jenkins (1970) *Time Series Analysis*, San Francisco: Holden-Day. Later editions were published in 1976 and 1994 (with G.C. Reinsel).

patterns. These subpatterns are then analyzed individually. See also Census II. ↑.

**Coefficient of determination** : See R-squared and R-bar-squared. ↑.

**Coefficient of variation** : This statistic is the ratio of the standard deviation to the mean, expressed as a percent. It is a measure of the relative dispersion of a data series. ↑.

**Confidence interval** : Based on statistical theory and probability distributions, a confidence interval, or set of confidence limits, can be established for population parameters such as the mean. For example, a 95% confidence interval will contain the true value of the population parameter with probability 95%. The term *confidence interval* is sometimes inappropriately applied to prediction interval. ↑.

**Correlation coefficient** : A standardized measure of the association or mutual dependence between two variables, say  $X$  and  $Y$ . Commonly designated as  $r$ , its values range from  $-1$  to  $+1$ , indicating strong negative relationship, through zero, to strong positive association. The correlation coefficient is the covariance between a pair of standardized variables. ↑.

**Correlation matrix** : Most computer programs designed to perform multiple regression analysis include the computation of the correlation coefficients between each pair of variables. The set of these correlation coefficients is often presented in the form of a matrix, referred to as the correlation matrix. ↑.

**Correlogram** : See Autocorrelation function. ↑.

**Covariance** : This is a measure of the joint variation between variables, say  $X$  and  $Y$ . The range of covariance values is unrestricted (large negative to large positive). However, if the  $X$  and  $Y$  variables are first standardized, then covariance is the same as correlation and the range of covariance (correlation) values is from  $-1$  to  $+1$ . ↑.

**Critical value** : In hypothesis testing, the critical value is the threshold for significance. A test statistic beyond the critical value gives a significant result. See Hypothesis testing and  $P$ -value. ↑.

**Crosscorrelation** : A standardized measure of association between one time series and the past, present, and future values of another time series. This statistic has the characteristics of a regular correlation coefficient and is used in the Box-Jenkins approach to fitting dynamic regression models. It is not covered in this book. ↑.

**Cumulative forecasting** : Instead of forecasting values for sequential time periods of equal length, users of forecasting often prefer to forecast the cumulative level of a variable over several periods. For example, one might forecast cumulative sales for the next 12 months, rather than forecast an individual value for each of these 12 months. ↑.

**Curve fitting** : One approach to forecasting is simply to fit some form of curve, perhaps a polynomial, to the historical time series data. Use of a linear trend is, in fact, a curve fitting method. Higher forms of curve fitting are also possible, and they frequently provide better results. ↑.

**Cyclical data** : See Business cycle. ↑.

**Cyclical index** : A cyclical index is a number, usually standardized around 100, that indicates the cyclical pattern of a given set of time series data. ↑.

**Decomposition** : See Classical decomposition method, Census II, and STL decomposition. ↑.

**Degrees of freedom (df)** : Given a sample of data and the computation of some statistic (e.g., the mean), the degrees of freedom are defined as the number of observations included in the formula minus the number of parameters estimated using the data. For example, the mean statistic for  $n$  sample data points has  $n$  d.f., but the variance formula has  $(n - 1)$  df because one parameter (the mean of  $X$ ) has to be estimated before the variance formula can be used. ↑.

**Delphi method** : This qualitative or technological approach seeks to use the judgment of experts systematically in arriving at a forecast of what future events will be or when they may occur. The approach uses a series of questionnaires to elicit responses from a panel of experts. ↑.

**Dependent variable** : See Forecast variable. ↑.

**Depression** : This term is used to describe that portion of the business cycle in which production and prices are at their lowest point, unemployment is highest, and general economic activity is low. ↑.

**Deseasonalized data** : See Seasonal adjustment. ↑.

**Diagnostic checking** : A step in time series model building where the estimated errors of a model are examined for independence, zero mean, constant variance, and so on. ↑.

**Differencing** : When a time series is non-stationary, it can often be made stationary by taking first differences of the series—that is, creating a new time series of successive differences ( $X_t - X_{t-1}$ ). If first differences do not convert the series to stationary form, then first differences of first differences can be created. This is called second-order differencing. A distinction is made between a second-order difference (just defined) and a second difference ( $X_t - X_{t-2}$ ). See Backward shift operator and Seasonal differencing. ↑.

**Double moving average** : When a moving average is taken of a series of data that already represents the result of a moving average, it is referred to as a double moving average. It results in additional smoothing or the removal of more randomness than an equal-length single moving average. ↑.

**Dummy variable** : Often referred to as a binary variable whose value is either 0 or 1, a dummy variable is frequently used to quantify qualitative events. For example, a strike/non-strike situation could be represented by a dummy variable. These variables are most commonly used in the application of multiple regression analysis. They are also known as *indicator variables*. ↑.

**Durbin-Watson statistic** : The Durbin-Watson (DW) statistic, named after its creators, tests the hypothesis that there is no autocorrelation of one time lag present in the errors obtained from forecasting. By comparing the computed value of the Durbin-Watson test with the appropriate values from the table of values of the DW statistic (Table F of Appendix III), the significance can be determined. See Autocorrelated errors. ↑.

**Dynamic regression models** : A dynamic regression model is a regression model which allows lagged values of the explanatory variable(s) to be included. The relationship between the forecast variable and the explanatory variable is modeled using a transfer function. A dynamic regression model is used to predict what will happen to the forecast variable if the explanatory variable changes. The errors from this model are usually described with an ARIMA model. Hence, a regression with ARIMA errors is a special case of a dynamic regression model. ↑.

**Econometric model** : An econometric model is a set of equations intended to be used simultaneously to capture the way in which endogenous and exogenous variables are interrelated. Using such a set of equations to forecast future values of key economic variables is known as econometric forecasting. The value of econometric forecasting is intimately connected to the value of the assumptions underlying the model equations. ↑.

**Economic indicator** : An economic indicator is a time series that has a reasonably stable relation (it lags, leads, or is coincident) to the average of the whole economy, or to some other time series of particular interest. Leading indicators are frequently used to identify turning points in the level of general economic activity. ↑.

**Elasticity** : This term is used to describe the amount of change in supply or demand when there is a 1% change in price. For a highly elastic product there would be a change greater than 1% in quantity with a 1% in price. The opposite is true for an inelastic product. ↑.

**Endogenous variable** : An endogenous variable is one whose value is determined within the system. For example, in an econometric model the market price of a product may be determined within the model, thus making that an endogenous variable. ↑.

**Error** : A forecast error is calculated by subtracting the forecast value from the actual value to give an error value for each forecast period. In forecasting, this term is commonly used as a synonym for residual. However, in regression with ARIMA errors and dynamic regression models, we draw a distinction between errors and residuals. An error is the difference between the forecast obtained from the regression part of the model and the actual value whereas the residual is obtained by subtracting the true forecast value from the actual value. ↑.

**Error cost function** : An error cost function states the cost of an error as a function of the size of the error. The most frequently used functional form for this is quadratic, which assumes that the effect of an error is proportional to the square of the error. ↑.

**Estimation** : Estimation consists of finding appropriate values for the parameters of an equation in such a way that some criterion will be optimized. The most commonly used criterion is that of mean squared error. Often, an iterative procedure is needed in order to determine those parameter values that minimize this criterion. ↑.

**Ex ante forecast** : A forecast that uses only information available at the time of the actual forecast. See Ex post forecast. ↑.

**Ex post forecast** : A forecast that uses some information beyond the time at which the actual forecast is prepared. See Ex ante forecast. ↑.

**Exogenous variable** : An exogenous variable is one whose value is determined outside of the model or system. For example, in an econometric model the gross national product might be an exogenous variable. In a multiple regression equation, the explanatory variables would be exogenous variables. ↑.

**Explanatory model** : This type of forecasting model assumes that the variable to be forecast is related to one or more other explanatory variables. Regression models, dynamic regression models, and multivariate ARMA models are the most common forecasting approaches of this type. ↑.

**Explanatory variable** : An explanatory variable is one whose values are determined outside of the system being modeled. An explanatory variable is used to predict values of a forecast variable. Explanatory variables are also called *independent variables* and *regressors*. ↑.

**Exploratory forecasting** : The general class of technological forecasting methods that seek to predict long-run outcomes are known as exploratory approaches. These contrast with the normative approaches that seek to determine how best to achieve certain long-term results. ↑.

**Exponential growth** : If \$100 is invested in a bank at 10% compound interest, then the amount grows at an exponential rate. This is exponential growth. Similarly, populations grow exponentially if unchecked. In forecasting, many situations (e.g., sales, GNP) can be modeled as exponential functions. ↑.

**Exponential smoothing** : Exponential smoothing methods provide forecasts using weighted averages of past values of the data and forecast errors. They are commonly used in inventory control systems where many items are to be forecast and low cost is a primary concern. The simplest exponential smoothing method is single exponential smoothing (SES), suitable for data with no trend or seasonal patterns. For trended data, Holt's method is suitable and for seasonal data, Holt-Winters' method may be used. Pegels' classification provides a convenient structure in which to study and apply exponential smoothing methods. ↑.

**F-test** : In statistics the ratio of two mean squares (variances) can often be used to test the significance of some item of interest. For example, in regression the ratio of "mean square due to the regression" to "mean square due to error" can be used to test the overall significance of the regression model. By looking up an

$F$  table, the degree of significance of the computed  $F$  value can be determined. See Hypothesis testing. ↑.

**Feedback** : Feedback occurs when there is an interrelationship between two series such that past values of each series affect current values of the other series. If feedback occurs, a multivariate ARMA model must be used. ↑.

**File** : A file is a collection of data arranged in some order for future reference. When stored on a computer, files may represent actual computer programs for performing certain forecasting methods or simply historical data to be used by those computer programs. ↑.

**Filter** : The purpose of a filter, as developed in engineering, is to eliminate random variations (high or low frequencies) so that only the true pattern remains. As applied to time series forecasting, filters generally involve one or more parameters that are used to weight historical values of the series, or of the residuals of the series, in some optimal way that eliminates randomness. ↑.

**First difference** : See Differencing. ↑.

**Forecast horizon** : The forecast horizon is the length of time into the future for which forecasts are to be prepared. These generally vary from short-term forecasting horizons (less than three months) to long-term horizons (more than two years). ↑.

**Forecast interval** : See Prediction interval. ↑.

**Forecast variable** : A variable that is predicted by some other variable or variables is referred to as a forecast variable. The forecast variable is also called the *dependent variable* or *response variable*. ↑.

**Forecasting** : Forecasting is the prediction of values of a variable based on known past values of that variable or other related variables. Forecasts also may be based on expert judgments, which in turn are based on historical data and experience. ↑.

**Fourier analysis** : See Spectral analysis. ↑.

**Function** : A function is a statement of relationship between variables. Virtually all of the quantitative forecasting methods involve a functional relationship between the item to be forecast and either previous values of that item, previous error values, or other explanatory variables. ↑.

**Goodness of fit** : See AIC,  $R^2$ , mean absolute percentage error (MAPE), and mean squared error (MSE). ↑.

**Gross National Product (GNP)** : The most comprehensive measure of a nation's income is the gross national product. It includes the total output of goods and services for a specific economy over a specific period of time (usually one year). ↑.

**Heteroscedasticity** : This condition exists when the errors do not have a constant variance across an entire range of values. For example, if the residuals from a time series have increasing variance with increasing time, they would be said to exhibit heteroscedasticity. See Non-stationary and Homoscedasticity. ↑.

**Heuristic** : A heuristic is a set of steps or procedures that uses a trial-and-error approach to achieve some desired objective. The word comes from Greek, meaning to *discover or find*. ↑.

**Holdout set** : When assessing the performance of one or more models for making forecasts, a group of data is sometimes withheld from the end of the series. This is a holdout set and is not used in the parameter estimation of the models. The forecasts from each of the models can then be compared with this holdout set to allow genuine forecast assessment. See Post-sample evaluation. ↑.

**Holt-Winters' exponential smoothing method** : Winters extended Holt's exponential smoothing method by including an extra equation that is used to adjust the forecast to reflect seasonality. This form of exponential smoothing can thus account for data series that include both trend and seasonal elements. It uses three smoothing parameters controlling the level, trend, and seasonality. ↑.

**Holt's exponential smoothing method** : Holt's method is an extension of single exponential smoothing which allows for trends in the data. It uses two smoothing parameters, one of which is used to add a trend adjustment to the single smoothed value. It is sometimes also called double or linear exponential smoothing. ↑.

**Homoscedasticity** : This condition exists when the variance of a series is constant over the entire range of values of that series. It is the opposite of heteroscedasticity. When a series of residuals exhibits constant variance over the entire range of time periods, it is said to exhibit homoscedasticity. ↑.

**Horizontal or stationary data** : See Stationary. ↑.

**Hypothesis testing** : An approach commonly used in classical statistics is to formulate a hypothesis and test the statistical significance of a hypothesis. For example, a hypothesis might be that the errors from applying a time series method of forecasting are uncorrelated. The statistical test would then be set up to determine whether or not those residuals behave in a pattern that makes them significantly different (statistically) from uncorrelated variables. See *P*-value. ↑.

**Identification** : This is the step in time series model building (for ARMA and ARIMA approaches) where patterns in summary statistics such as autocorrelation functions, partial autocorrelation functions, and so on are related to potential models for the data. The intent is to identify, at least tentatively, an appropriate model so that the next steps in model-building—estimating parameters followed by diagnostic checking—can be pursued. (It should be noted that this definition and use of the word bears no relationship to the same word as used in the economics literature.) ↑.

**Impulse response weights** : If an input time series  $X$  exerts its influence on an output variable  $Y$  in a dynamic manner over the future time periods, then the set of weights defining this relationship is called the impulse response function. These weights are estimated as part of a dynamic regression model. ↑.

**Independent variable** : See Explanatory variable. ↑.

**Index numbers** : These numbers are frequently used as summary indicators of the level of economic activity and/or corporate performance. For example, the Federal Reserve Board Index of Industrial Production summarizes a number of variables that indicate the overall level of industrial production activity. Similar index numbers can be prepared for economic variables, as well as for corporate. ↑.

**Indicator variable** : See Dummy variable. ↑.

**Integrated** : This is often an element of time series models (the I in ARIMA models), where one or more of the differences of the time series are included in the model. The term comes from the fact that the original series may be recreated from a differenced series by a process of integration (involving a summation in the typical discrete environment). ↑.

**Interactive forecasting** : This term has been used to describe forecasting packages that allow the user to interact directly with the data and with the results of alternative forecasting methods. ↑.

**Intercept** : In simple regression the constant term is referred to as the intercept of the regression equation with the  $Y$ -axis. If the explanatory variable  $X$  is 0, then the value of the forecast variable will be the intercept value. ↑.

**Interdependence** : If two or more variables are interdependent or mutually dependent, it indicates that their values move together in some specific manner. Thus a change in the value of one of the variables would correlate with a change in the value of the other variable. ↑.

**Intervention analysis** : This approach to forecasting is a special case of dynamic regression models. It facilitates determining the effects of unusual changes in the explanatory variables on the forecast variable. The most important characteristic of intervention analysis is that transient effects caused by such changes can be measured and their influence on the forecast variable can be predicted. ↑.

**Lag** : A difference in time between an observation and a previous observation. Thus  $Y_{t-k}$  lags  $Y_t$  by  $k$  periods. See also Lead. ↑.

**Lead** : A difference in time between an observation and a future observation. Thus  $Y_{t+k}$  leads  $Y_t$  by  $k$  periods. See also Lag, Lead time, and Leading indicator. ↑.

**Lead time** : This term refers to the time interval between two events, when one must precede the other. In many inventory and order entry systems, the lead time is the interval between the time when an order is placed and the time when it is actually delivered. ↑.

**Leading indicator** : An economic indicator whose peaks and troughs during the business cycle tend to occur sooner than those of the general economy. Turning points in such an indicator lead subsequent turning points in the general economy or some other economic series, thus signaling the likelihood of such a subsequent turning point. ↑.

**Least squares estimation** : This approach to estimating the parameter values in an equation minimizes the squares of the deviations that result from fitting that particular model. For example, if a trend line is being estimated to fit a data series, the method of least squares estimation could be used to minimize the mean squared error. This would give a line whose estimated values would minimize the sum of the squares of the actual deviations from that line for the historical data. ↑.

**Likelihood** : The probability that a certain empirical outcome will be observed, conditional on a certain prior outcome. This term is often used in connection with statistics that are maximum likelihood estimators for a population. ↑.

**Ljung-Box test** : This is a test for autocorrelated errors. It is an improved version of the Box-Pierce test. ↑.

**Local regression** : Local regression is a form of smoothing. A curve is estimated by applying linear regression to sections of the data. See Loess. ↑.

**Loess** : The most popular implementation of local regression. It also provides some protection against extreme observations by downweighting outliers. ↑.

**Logarithmic transformation** : This transformation is applied to remove exponential growth in a series. The transformed series consists of logarithms of the original series. ↑.

**Logistic curve** : This curve has the typical *S*-shape often associated with the product life cycle. It is frequently used in connection with long-term curve fitting as a technological method. ↑.

**M-Competition** : The M-Competition (Makridakis et al., 1982, 1984) compared the accuracies of about 20 different forecasting techniques across a sample of 111 time series. A subset of the methods was tested on 1001 series. The last 12 points of each series were held out and the remaining data were available for model fitting. The accuracy was assessed via the mean absolute percentage error (MAPE) on the holdout set. ↑.

**M3-IJF Competition** : The M3-IJF Competition was conducted in 1997 by the *International Journal of Forecasting*. It compared a range of forecasting techniques across a sample 3003 time series. The accuracy was assessed using a range of measures on a holdout set. ↑.

**Macrodata** : These type of data describes the behavior of macroeconomic variables such as GNP, inflation, the index of industrial production, and so on. Macroeconomics deals with the study of economics in terms of whole systems, usually at national or regional levels. ↑.

**Matrix** : In mathematical terminology a matrix is a rectangular array of elements arranged in rows and columns. There may be one or more rows and one or more columns in such a matrix. ↑.

**Maximum likelihood estimation** : The parameters in an equation can be estimated by maximizing the likelihood of the model given the data. For regression

models with normally distributed errors, maximum likelihood estimation is equivalent to least squares estimation. ↑.

**Mean** : The arithmetic average or mean for a group of items is defined as the sum of the values of the items divided by the number of items. It is frequently used as a measure of location for a frequency or probability distribution. ↑.

**Mean Absolute Percentage Error (MAPE)** : The mean absolute percentage error is the mean or average of the sum of all of the percentage errors for a given data set taken without regard to sign. (That is, their absolute values are summed and the average computed.) It is one measure of accuracy commonly used in quantitative methods of forecasting. ↑.

**Mean Percentage Error (MPE)** : Mean Percentage Error (MPE) The mean percentage error is the average of all of the percentage errors for a given data set. This average allows positive and negative percentage errors to cancel one another. Because of this, it is sometimes used as a measure of bias in the application of a forecasting method. ↑.

**Mean Squared Error (MSE)** : The mean squared error is a measure of accuracy computed by squaring the individual error for each item in a data set and then finding the average or mean value of the sum of those squares. The mean squared error gives greater weight to large errors than to small errors because the errors are squared before being summed. ↑.

**Medial average** : The middle number of a data set is the median. It can be found by arranging the items in the data set in ascending order and identifying the middle item. The medial average includes only those items grouped around the median value. For example, the highest and lowest value may be excluded from a medial average. ↑.

**Median** : Frequently used as a measure of location for a frequency or probability distribution, the median of a group of items is the value of the middle item when all the items are arranged in either ascending or descending order of magnitude. ↑.

**Microdata** : *Micro* comes from the Greek word meaning small. Microdata refers generally to data collected at the level of an individual organization or a company. Microeconomics refers to the study of such data as contrasted with macroeconomics, which deals generally with a regional or national level. ↑.

**Mixed model** : In time series analysis a process or model that combines moving average (MA) forms with autoregressive (AR) forms is frequently referred to as a mixed process. See ARMA models. ↑.

**Model** : A model is the symbolic representation of reality. In quantitative forecasting methods a specific model is used to represent the basic pattern contained in the data. This may be a regression model, which is explanatory in nature, or a time series model. ↑.

**Moving average** : There are two distinct meanings to this term. First, for a time series we can define the moving average of order  $K$  as the average (mean)

value of  $K$  consecutive observations. This can be used for smoothing (Chapter 3) or forecasting (Chapter 4). Second, in Box-Jenkins modeling the MA in ARIMA stands for moving average and means that the value of the time series at time  $t$  is influenced by a current error term and (possibly) weighted error terms in the past. See Chapter 7 for examples. ↑.

**Multicollinearity** : In multiple regression, computational problems arise if two or more explanatory variables are highly correlated with one another. The regression coefficients associated with those explanatory variables will be very unstable. In larger sets of explanatory variables, the condition of multicollinearity may not be easy to detect. If any linear combination of one subset of explanatory variables is nearly perfectly related to a linear combination of any other subset of explanatory variables, then a multicollinearity problem is present. See Chapter 6 for details. ↑.

**Multiple correlation coefficient** : If a forecast variable  $Y$  is regressed against several explanatory variables  $X_1, X_2, \dots, X_k$ , then the estimated  $Y$  value is designated  $\hat{Y}$ . The correlation between  $\hat{Y}$  and  $Y$  is called the multiple correlation coefficient and is often designated  $R$ . It is customary to deal with this coefficient in squared form (i.e.,  $R^2$ ). See Multiple regression, R-squared, and R-bar-squared. ↑.

**Multiple regression** : The technique of multiple regression is an extension of simple regression. It allows for more than one explanatory variable to be included in predicting the value of a forecast variable. For forecasting purposes a multiple regression equation is often referred to as a causal orexplanatory model. ↑.

**Multiplicative model** : A model in which the various terms are multiplied together. See also Additive model. ↑.

**Multivariate ARMA model** : Multivariate ARMA models allow several time series which are mutually dependent to be forecast. Each of the series is forecast using a function of its own past, the past of each of the other series, and past errors. This is in contrast to dynamic regression models where there is only one forecast variable and it is assumed that the explanatory variables do not depend on the past of the forecast variable. See ARMA model. ↑.

**Naïve forecast** : Forecasts obtained with a minimal amount of effort and data manipulation and based solely on the most recent information available are frequently referred to as naïve forecasts. One such naïve method would be to use the most recent observation available as the future forecast. A slightly more sophisticated naïve method would be to adjust the most recent observation for seasonality. ↑.

**Neural networks** : Neural networks are based on simple mathematical models of the way brains are thought to work. They can be thought of as a network of neuron-like units organized in layers. When applied to time series, they provide a non-linear forecasting method. ↑.

**Noise** : The randomness often found in data series is frequently referred to as noise. This term comes from the field of engineering where a filter is used to eliminate noise so that the true pattern can be identified. ↑.

**Non-linear estimation** : If parameters have to be estimated for non-linear functions, then ordinary least squares estimation may not apply. Under these circumstances certain non-linear techniques exist for solving the problem. Minimizing the sum of squared residuals is one common criterion. Another is maximum likelihood estimation. Non-linear estimation is an iterative procedure and there is no guarantee that the final solution is the global minimum. ↑.

**Non-linear forecasting** : A time series model is non-linear if it cannot be written as a linear function of past observations, errors, and explanatory variables. Non-linear models are capable of reproducing some features in time series, such as chaotic behavior, which are not able to be captured using linear models. See Neural networks. ↑.

**Non-stationary** : A time series exhibits non-stationarity if the underlying generating process does not have a constant mean and/or a constant variance. In practice, a visual inspection of the plotted time series can help determine if either or both of these conditions exist, and the set of autocorrelations for the time series can be used to confirm the presence of non-stationarity or not. See Stationary. ↑.

**Normal distribution** : This is a probability distribution which is very widely used in statistical modeling. It is the distribution of many naturally occurring variables and the distribution of many statistics. It is represented by a bell-shaped curve. ↑.

**Observation** : An observation is the value of a specific event as expressed on some measurement scale by a single data value. In most forecasting applications a set of observations is used to provide the data to which the selected model is fit. ↑.

**Optimal parameter or weight value** : The optimal, final parameters or weights are those values that give the best performance for a given model applied to a specific set of data. It is those optimal parameters that are then used in forecasting. ↑.

**Order selection criteria** : For ARMA models of time series, it can be difficult to determine the order of the autoregressive and moving average components of the model. There are several order selection criteria to help make this decision, including the AIC and BIC. ↑.

**Outlier** : An outlier is a data value that is unusually large or small. Such outliers are sometimes removed from the data set before fitting a forecasting model so that unusually large deviations from the pattern will not affect the fitting of the model. ↑.

**P-value** : Used in hypothesis testing. The  $P$ -value is the probability of obtaining a result as extreme as the one calculated from the data, if the hypothesis to be demonstrated is not true. For example, an  $F$ -test is used to test whether the slope of a regression line is non-zero. In this case, the  $P$ -value is the probability of

obtaining an  $F$  value as large as that obtained if, in fact, the line has zero slope. It is customary to conclude that the result is significant if the  $P$ -value is smaller than 0.05, although this threshold is arbitrary.  $\uparrow$ .

**Parameter** : Characteristics of a population such as the mean or standard deviation are called parameters. These should be distinguished from the characteristics of a sample taken from a population, which are called statistics.  $\uparrow$ .

**Parsimony** : The concept of parsimony holds that as few parameters as possible should be used in fitting a model to a set of data. This concept is a basic premise of the Box-Jenkins approach to time series analysis.  $\uparrow$ .

**Partial autocorrelation** : This measure of correlation is used to identify the extent of relationship between current values of a variable with earlier values of that same variable (values for various time lags) while holding the effects of all other time lags constant. Thus, it is completely analogous to partial correlation but refers to a single variable.  $\uparrow$ .

**Partial correlation** : This statistic provides a measure of the association between a forecast variable and one or more explanatory variables when the effect of the relationship with other explanatory variables is held constant.  $\uparrow$ .

**Pattern** : The basic set of relationships and the underlying process over time is referred to as the pattern in the data.  $\uparrow$ .

**Pegels' classification** : Pegels has conveniently classified exponential smoothing method into a two-way table with three rows labeled  $A$  (no trend),  $B$  (linear trend), and  $C$  (multiplicative trend), and three columns labeled 1 (no seasonality), 2 (additive seasonality), and 3 (multiplicative seasonality). Cell A-1 represents simple exponential smoothing; cell B-1 represents Holt's two-parameter method; and cell B-3 represents Winters model.  $\uparrow$ .

**Polynomial** : In algebra a polynomial is an expression containing one or more terms, each of which consists of a coefficient and a variable(s) raised to some power. Thus  $a + bx$  is a linear polynomial  $a + bx + cx^2$  is a quadratic polynomial in  $x$ . A polynomial of order  $m$  includes terms involving powers of  $x$  up to  $x^m$ . Regression models often involve linear and higher order polynomials.  $\uparrow$ .

**Polynomial fitting** : It is possible to fit a polynomial of any number of terms to a set of data. If the number of terms (the order) equals the number of data observations, the fit can be made perfectly.  $\uparrow$ .

**Post-sample evaluation** : The evaluation of a forecasting model using data that were collected after the set of data on which the model was estimated is often referred to as a post-sample evaluation of the forecasting model. Ongoing tracking of the performance of a model is another example of this. See also holdout set.  $\uparrow$ .

**Prediction interval** : Based on statistical theory and probability distributions, a forecast interval, or set of forecast limits, can be established for a forecast. For example, a 95% prediction interval will contain the observation with probability 95%. These limits are based on the extent of variation of the data and the forecast

horizon. Sometimes the term confidence interval is inappropriately used instead of *prediction interval*. Prediction intervals are also known as *forecast intervals*. ↑.

**Probability** : The probability of an event is expressed as a number from 0 through 1. An impossible event has probability zero. A certain event has probability 1. Classical probability is defined in terms of long-run relative frequency—in a long series of identical trials the relative frequency of occurrence of the event approaches a fixed value called the probability of the event. In Bayesian analysis, probability is defined more subjectively as the encoding of my knowledge about that event. It is the degree of plausibility of the event given all that I know at this time, and is expressed as a number between 0 and 1. ↑.

**Product life cycle** : The concept of the product life cycle is particularly useful in forecasting and analyzing historical data. It presumes that demand for a product follows an S-shaped curve growing slowly in the early stages, achieving rapid and sustained growth in the middle stages, and slowing again in the mature stage. See *S-curve*. ↑.

**Qualitative or technological forecasting** : Qualitative or technological methods of forecasting are appropriate when the assumption of constancy is invalid (the pattern contained in past data cannot be assumed to continue into the future), when information about the past cannot be obtained, or when the forecast is about unlikely or unexpected events in the future. ↑.

**Quantitative forecasting** : Quantitative forecasting methods can be applied when information about the past is available, if that information can be quantified and if the pattern included in past information can be assumed to continue into the future. ↑.

**R-bar-squared ( $\bar{R}^2$ )** : Since the computation of  $R^2$  does not involve the degrees of freedom for either  $SS$  (sum of squares of deviations due to the regression or the  $SS$  of deviations in the original  $Y$  data, a corrected  $R^2$  is defined and designated  $\bar{R}^2$  (*R-bar squared*). See *R-squared*. This statistic can be interpreted as the proportion of variance in  $Y$  that can be explained by the explanatory variables. ↑.

**R-squared ( $R^2$ )** : In regression the square of the correlation between  $Y$  (the forecast variable) and  $\hat{Y}$  (the estimated  $Y$  value based on the set of explanatory variables) is denoted  $R^2$ . This statistic is often called the coefficient of determination. See *R-bar-squared*. ↑.

**Random sampling** : This statistical sampling method involves selecting a sample from a population in such a way that every unit within that population has the same probability of being selected as any other unit. ↑.

**Random walk** : A random walk is a time series model which states that each observation is equal to the previous observation plus some random error. Therefore, the change between observations is white noise. ↑.

**Randomness** : The noise or random fluctuations in a data series are frequently described as the randomness of that data series. ↑.

**Regression** : A term “regression” dates back to Sir Francis Galton and his work with the heights of siblings in different generations. The heights of children of exceptionally tall (or short) parents “regress” to the mean of the population. Regression analysis today means any modeling of a forecast variable  $Y$  as a function of a set of explanatory variables  $X_1$  through  $X_k$ . See Simple regression and Multiple regression. ↑.

**Regression coefficients** : In regression, a forecast variable  $Y$  is modeled as a function of explanatory variables  $X_1$  through  $X_k$ . The regression coefficients are the multipliers of the explanatory variables. The estimates of these regression coefficients can be used to understand the importance of each explanatory variable (as it relates to  $Y$ ) and the interrelatedness among the explanatory variables (as they relate to  $Y$ ). See Regression. ↑.

**Regression with ARIMA errors** : In standard regression modeling, it is assumed that the errors are uncorrelated. However, it is common with time series to find that this assumption is not true. When there are autocorrelated errors, the correlation in the errors may be modeled by an ARIMA model. This combination of a regression model and an ARIMA model for the errors is discussed in Section 8/1. See also Dynamic regression models. ↑.

**Regressor** : See Explanatory variable. ↑.

**Residual** : It is calculated by subtracting the forecast value from the observed value to give a residual or error value for each forecast period. In forecasting this term is commonly used as a synonym for error, although in some cases we distinguish the two. ↑.

**S-curve** : An  $S$ -curve is most frequently used to represent the product life cycle. Several different mathematical forms, such as the logistics curve, can be used to fit an  $S$ -curve to actual observed data. ↑.

**Sample** : A sample is a finite or limited number of observations or data values selected from a universe or population of such data values. ↑.

**Sampling distribution** : The distribution of a statistic from a finite sample. If many such samples were able to be taken, the collection of possible values of the statistic would follow its sampling distribution. ↑.

**Sampling error** : The sampling error is an indication of the magnitude of difference between the true values of a population parameter and the estimated value of that parameter based on a sample. ↑.

**Seasonal adjustment** : Seasonal adjustment is the process of removing seasonality from time series data. It is often done after time series decomposition. Seasonal adjustment facilitates the comparison of month-to-month changes. It is used in dealing with such data as unemployment statistics, economic indicators, or product sales. ↑.

**Seasonal data** : See Type of data. ↑.

**Seasonal difference** : In order to achieve a stationary series before applying the Box-Jenkins methodology to time series forecasting, the first or second differences of the data must often be taken. A seasonal difference refers to a difference that is taken between seasonal values that are separated by one complete season. Thus, if monthly data are used with an annual seasonal pattern, a seasonal difference would simply compute the difference for values separated by 12 months rather than using the first difference, which is for values adjacent to one another in a series. See Differencing. ↑.

**Seasonal exponential smoothing** : See Holt-Winters' exponential smoothing. ↑.

**Seasonal index** : A seasonal index is a number that indicates the seasonality for a given time period. For example, a seasonal index for observed values in July would indicate the way in which that July value is affected by the seasonal pattern in the data. Seasonal indices are used in seasonal adjustment. ↑.

**Seasonal variation** : The change that seasonal factors cause in a data series is frequently called seasonal variation. ↑.

**Serial correlation** : See Autocorrelation. ↑.

**Significance** : See Hypothesis testing. ↑.

**Simple regression** : Simple regression is a special case of multiple regression involving a single explanatory variable. As with multiple linear regression it assumes a linear relationship between the explanatory variable and the forecast variable. The relationship is estimated using the method of least squares and a set of observed values. ↑.

**Slope** : The slope of a curve at a given point indicates the amount of change in the forecast variable for a one-unit change in the explanatory variable. In simple regression the coefficient of the explanatory variable indicates the slope of the regression line. ↑.

**Smoothing** : Estimating a smooth trend, usually by taking weighted averages of observations. The term *smoothed* is used because such averages tend to reduce randomness by allowing positive and negative random effects to partially offset each other. ↑.

**Specification error** : A type of error often caused either by the incorrect choice of a functional form of a forecasting model or the failure to include important variables in that functional form or model. ↑.

**Spectral analysis** : The decomposition of a time series into a set of sine-waves (or cosine-waves) with differing amplitudes, frequencies, and phase angles, is variously known as spectral analysis, harmonic analysis, Fourier analysis, and so on. Each method has specific features but in general they all look for periodicities in the data. Spectral analysis is not covered in this book. ↑.

**Spencer's weighted moving average** : The Spencer's weighted moving average is an approach to computing a moving average that will compensate for a cubic trend in the data. It consists of two averages, one for 15 periods and the other for 21 periods. Both have been used widely in many decomposition methods. ↑.

**Standard deviation** : A summary statistic (parameter) for a sample (population). It is usually denoted  $s$  ( $\sigma$ ) for a sample (population), and is the square root of variance. The standard deviation is a measure of the spread in the data (population). For many data sets, about 95% of the observations will be within approximately two standard deviations of the mean.  $\uparrow$ .

**Standard error** : Given a population distribution (say a normal distribution), a sampling plan (say a simple independent random sampling plan), and a specific statistic (say the mean), then the sampling distribution of the mean is a probability distribution with an expected value, a standard deviation, and various other properties. The standard deviation of the sampling distribution of a statistic is called the standard error of that statistic.  $\uparrow$ .

**Standardize** : Given a sample set of values for  $X$ , where the mean is  $\bar{X}$  and the standard deviation is  $S$ , the  $i$ th value in the set,  $X_i$ , is standardized by subtracting the mean and dividing by the standard deviation. The standardized values are often designated by the letter  $Z$ .  $\uparrow$ .

**State space modeling** : State space models are a matrix representation for univariate and multivariate time series. Many time series models can be written in “state space” form. It provides a convenient structure to handle computations for a wide variety of time series models. There are also some forecasting methods which use the state space model directly. Computations for state space models are carried out using the Kalman recursion equations or Kalman filter. Consequently, state space models are sometimes known as a “Kalman filter” model.  $\uparrow$ .

**Stationary** : If the underlying generating process for a time series is based on a constant mean and a constant variance, then the time series is stationary. More formally, a series is stationary if its statistical properties are independent of the particular time period during which it is observed. See Non-stationary.  $\uparrow$ .

**Statistic** : Given a sample consisting of  $n$  values, a statistic is any summary number that captures a property of the sample data. For example, the mean is a statistic, and so are the variance, the skewness, the median, the standard deviation, etc. For a pair of variables sampled jointly the correlation coefficient is a statistic and so is the covariance. The values of a statistic vary from sample to sample, and the complete set of values is called the sampling distribution of the statistic.  $\uparrow$ .

**STL decomposition** : The STL decomposition method was proposed by William Cleveland and others in 1990 as an alternative to the Census II methods of time series decomposition. The name “STL” is an acronym for “A Seasonal-Trend decomposition procedure based on Loess.” See also Loess.  $\uparrow$ .

**$t$ -test** : The  $t$ -test is a statistical hypothesis test used extensively in regression analysis to test if the individual coefficients are significantly different from 0. It is computed as the ratio of the coefficient to the standard error of that coefficient.  $\uparrow$ .

**Technological forecasting** : See Qualitative forecasting.  $\uparrow$ .

**Time series** : An ordered sequence of values of a variable observed at equally spaced time intervals is referred to as a time series.  $\uparrow$ .

**Time series model** : A time series model is a function that relates the value of a time series to previous values of that time series, its errors, or other related time series. See ARIMA. ↑.

**Tracking signal** : Since quantitative methods of forecasting assume the continuation of some historical pattern into the future, it is often useful to develop some measure that can be used to determine when the basic pattern has changed. A tracking signal is the most common such measure. One frequently used tracking signal involves computing the cumulative error over time and setting limits so that when the cumulative error goes outside those limits, the forecaster can be notified and a new model can be considered. ↑.

**Trading day** : A trading day is an active day. In many business time series the number of business days in a month or some other specified period of time may vary. Frequently trading-day adjustments must be made to reflect the fact that every January (or similar period) may not include the same number of trading days. ↑.

**Transfer function** : A transfer function is part of a dynamic regression model and describes how a change in the explanatory variable is transferred to the forecast variable. ↑.

**Transformation** : Transformation involves changing the scale of measurement in variable(s). For example, data can be transformed from a linear to a logarithmic scale, or from a linear to a square root scale. Transformations play two roles: (1) in time series they are used to achieve a series which is stationary in variance and (2) in regression they are used to make the relationship linear or to improve the fit of the model. ↑.

**Trend analysis** : Trend analysis (or trend-line analysis) is a special form of simple regression in which time is the explanatory variable. ↑.

**Turning point** : Any time a data pattern changes direction it can be described as having reached a turning point. For seasonal patterns these turning points are usually very predictable and can be handled by many different forecasting methods because the length of a complete season remains constant. In many cyclical data patterns the length of the cycle varies as does its magnitude. Here the identification of turning points is a particularly difficult and important task. ↑.

**Type of data** : In many forecasting methods, such as decomposition, data are classified as having one or more subpatterns. These include a seasonal pattern, a trend pattern, and a cyclical pattern. Frequently, when forecasters refer to the type of data they mean the specific forms of subpatterns that are included in that data. ↑.

**Unbiasedness** : A statistic is referred to as an unbiased estimator of a population parameter if the sampling distribution of the statistic has a mean equal to the parameter being estimated. See Biased estimator and Asymptotically unbiased estimator. ↑.

**Updated forecast** : Revisions of original forecasts in light of data that subsequently become available after the time period in which the original forecasts were made are often referred to as updated forecasts. This concept is analogous to posterior distributions, although the updating is often much more subjective than in Bayesian analysis and the calculation of posterior distributions. ↑.

**Validation** : The process of testing the degree to which a model is useful for making forecasts. The sample data are often split into two segments, one being used to estimate the parameters of the model, and the other being used as a holdout set to test the forecasts made by the model. There are many variations on this process of validation. ↑.

**Variance** : A summary statistic (parameter) for a sample (population). It is usually denoted  $S^2$  ( $\sigma^2$ ). It is the average of squared deviations from the mean. ↑.

**Vector ARMA model** : See Multivariate ARMA model. ↑.

**Weight** : The term *weight* indicates the relative importance given to an individual item included in forecasting. In the method of moving averages all of those past values included in the moving average are given equal weight. In more sophisticated methods of time series analysis, the problem of model identification involves determining the most appropriate values of those weights. ↑.

**White noise** : When there is no pattern whatsoever in the data series, it is said to represent white noise. ↑.

**Winters' exponential smoothing** : See Holt-Winters' exponential smoothing method. ↑.

**X-11 decomposition** : The X-11 method for time series decomposition is one of the series of methods which is part of the Census II family developed at the United States Bureau of the Census. It was developed in 1967 and was improved in the X-11-ARIMA method. It has now been superseded by the X-12-ARIMA method. ↑.

**X-12-ARIMA decomposition** : The latest method for time series decomposition from the Census II family is X-12-ARIMA. It is an enhancement of the X-11 method. ↑.

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