

## CHAPTER 1

# Fundamental Concepts of Time-Series Econometrics

Many of the principles and properties that we studied in cross-section econometrics carry over when our data are collected over time. However, time-series data present important challenges that are not present with cross sections and that warrant detailed attention.

Random variables that are measured over time are often called "time series." We define the simplest kind of time series, "white noise," then we discuss how variables with more complex properties can be derived from an underlying white-noise variable. After studying basic kinds of time-series variables and the rules, or "time-series processes," that relate them to a white-noise variable, we then make the critical distinction between stationary and non-stationary time-series processes.

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## 1.1 Time Series and White Noise

### 1.1.1 Time-series processes

A *time series* is a sequence of observations on a variable taken at discrete intervals in time.<sup>1</sup> We index the time periods as 1, 2, ...,  $T$  and denote the set of observations as

$$(Y_1, Y_2, \dots, Y_T).$$

We often think of these observations as being a finite sample from a *time-series stochastic process* that began infinitely far back in time and will continue into the indefinite future:

$$\left\{ \overbrace{\dots, Y_{-2}, Y_{-1}}^{\text{pre-sample}}, \overbrace{Y_1, Y_2, \dots, Y_{T-1}, Y_T}^{\text{sample}}, \overbrace{Y_{T+1}, Y_{T+2}, \dots}^{\text{post-sample}} \right\}.$$

Each element of the time series is treated as a random variable with a probability distribution. As with the cross-section variables of our earlier analysis, we assume that the distributions of the individual elements of the series have parameters in common. For example,

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<sup>1</sup> The theory of discrete-time stochastic processes can be extended to continuous time, but we need not consider this here because econometricians typically have data only at discrete intervals.

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