CHAPTER 9

What If the Disturbances Are Correlated?

9.0 What We Need to Know When We Finish This Chapter

This chapter deals with the possibility that the disturbances are correlated with each other. In this case, ordinary least squares (OLS) estimates are still unbiased. However, they're no longer best linear unbiased (BLU). In addition, the true variances of b and a are probably different from those given by the OLS variance formulas. In order to conduct inference, we can estimate their true variances. We can also attempt to get best linear unbiased estimators by *transforming* the data so that the transformed disturbances have the properties of chapter 5.

1. **Section 9.2:** When the disturbances are correlated, it's called *autocorrelation*.
2. **Section 9.2:** *Spatial autocorrelation* describes the situation where a correlation exists between the disturbances from observations that are near each other in spatial or social terms.
3. **Section 9.2:** *Serial correlation* describes the situation where a correlation exists between the disturbances from observations that are near each other in time. *Shocks* are the random components of activity that are unique to the time unit in which they occur.
4. **Section 9.2:** *Attenuation* describes the situation in which the correlations between observations get smaller as the observations get more distant from each other in geographic, social, or temporal terms.
5. **Section 9.3:** *The OLS estimators b and a remain unbiased for β and α regardless of what we assume for* $\text{COV}(\varepsilon_i, \varepsilon_j)$.
6. **Section 9.3:** The OLS estimators b and a are not BLU and their true variances are probably not estimated accurately by the OLS variance formulas.
7. **Section 9.4:** The *Newey-West variance estimators* for $\text{V}(b)$ and $\text{V}(a)$ are approximately accurate even if autocorrelation is present.
8. **Section 9.5:** In time-series data, first-order autocorrelation occurs when the disturbances of consecutive observations are correlated. More generally, autocorrelation of order k occurs when the disturbances of observations that are separated by $k - 1$ units of time are correlated.
9. **Section 9.5:** In time-series data, the variance of the autocorrelated disturbances is larger, and often a lot larger, than the variance of the underlying, uncorrelated shocks.
10. **Section 9.6:** *Generalized least squares* (GLS) provides BLU estimators for β and α by transforming the data so as to remove the autocorrelation. This requires either knowledge of or estimates of the relevant autocorrelation.
11. **Section 9.7:** Greek letters always represent parameters. Greek letters with carets over them represent estimators of the parameter represented by the Greek letter itself.

12. **Section 9.7:** The Durbin-Watson test is a common test for first-order autocorrelation in time-series data. It can be approximated as

$$\text{DW} \approx 2\left(1-\hat{\rho}\right),$$

where $\hat{\rho}$ is the estimated correlation between e_i and e_{i-1}.
13. **Section 9.8:** The GLS procedure of section 9.6 can usually be implemented in two steps. The first step estimates the required correlations, and the second step estimates OLS on the transformed data.
14. **Section 9.9:** If we have some form of autocorrelation other than first order, the specific procedures of sections 9.6 through 9.8 won't work. However, procedures that follow the same principles, tailored to the autocorrelation form that we're actually dealing with, will.
15. **Section 9.10:** The trick is not in inventing a new procedure to fit each variation in the assumptions. It is in reconceiving each population relationship so that it fits the one procedure that we've already established.