4. Partialling out (OPTIONAL)

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The idea of partialling out and the formal result known as the Frisch-Waugh-Lovell (FWL) theorem are key to understanding linear regression coefficients in cross-section applications, and determining the order p of an AR (p) process in time-series applications. More specifically, partialling out is the idea behind the partial autocorrelation function (pacf) of a time series. This is another way of characterizing the **dependence** structure of a times series, complementary to the autocorrelation function (acf). We will first describe the general idea, and then explain how it applies to the autoregressive process. This discussion gives us an opportunity to revisit the regression model and least squares estimation principle.

Recall the simple linear regression model of a random variable Y, called the outcome, and another random variable X, called the regressor. The idea is to use the **joint** distribution of the random pair (X, Y) in order to predict or characterize the values of Y in terms of the values of X. The conditional distribution, say the conditional pdf $f_{Y|X}(y|x) = \frac{f_{XY}(x,y)}{f_X(x)}$, completely describes the distribution of the outcome Y for each fixed value of X. The regression function $\mathbf{E}[Y|X]$ gives the conditional mean summary of this conditional distribution.

The linear regression model is:

$$\mathbf{E}[Y|X] = \beta_0 + \beta_1 X, \qquad \text{for some } \beta_0, \beta_1 \in \mathbb{R}.$$

This is a model because we assume that the conditional expectation of Y given X is linear in X. in general, the regression function $\mathbf{E}[Y|X]$ can be any measurable (i.e., possibly nonlinear or discontinuous) function of X. The linear model is convenient because it has only two parameters β_0, β_1.The question that we ask here is how to interpret the regression coefficient β_1? The purpose of the regression function is to predict the value of Y given the value of X. In the case where the regression function is linear, the coefficient β_1 tells us how the conditional expectation of Y changes if we increase the value of X by one unit.

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