a. The researcher collects data on the average snowfall for each state and adds this regressor ($AverageSnow_i$) to the regressions given in Table 10.1.

b. The researcher collects data on the snowfall in each state for each year in the sample ($Snow_{it}$) and adds this regressor to the regressions.

10.8 Consider observations (Y_{it}, X_{it}) from the linear panel data model

$$Y_{it} = X_{it}\beta_1 + \alpha_i + \lambda_i t + u_{it},$$

where $t = 1, \ldots, T$; $i = 1, \ldots, N$; and $\alpha_i + \lambda_i t$ is an unobserved individual-specific time trend. How would you estimate β_1?

10.9 a. In the fixed effects regression model, are the fixed entity effects, α_i, consistently estimated as $n \longrightarrow \infty$ with T fixed? (*Hint:* Analyze the model with no X's: $Y_{it} = \alpha_i + u_{it}$.)

b. If n is large (say, $n = 2000$) but T is small (say, $T = 4$), do you think that the estimated values of α_i are approximately normally distributed? Why or why not? (*Hint:* Analyze the model $Y_{it} = \alpha_i + u_{it}$.)

10.10 In a study of the effect on earnings of education using panel data on annual earnings for a large number of workers, a researcher regresses earnings in a given year on age, education, union status, and the worker's earnings in the previous year using fixed effects regression. Will this regression give reliable estimates of the effects of the regressors (age, education, union status, and previous year's earnings) on earnings? Explain. (*Hint:* Check the fixed effects regression assumptions in Section 10.5.)

10.11 Let $\hat{\beta}_1^{DM}$ denote the entity-demeaned estimator given in Equation (10.22), and let $\hat{\beta}_1^{BA}$ denote the "before and after" estimator without an intercept, so that $\hat{\beta}_1^{BA} = \left[\sum_{i=1}^{n}(X_{i2} - X_{i1})(Y_{i2} - Y_{i1})\right]/\left[\sum_{i=1}^{n}(X_{i2} - X_{i1})^2\right]$. Show that, if $T = 2$, $\hat{\beta}_1^{DM} = \hat{\beta}_1^{BA}$. [*Hint:* Use the definition of $\widetilde{X}_{it}$ before Equation (10.22) to show that $\widetilde{X}_{i1} = -\frac{1}{2}(X_{i2} - X_{i1})$ and $\widetilde{X}_{i2} = \frac{1}{2}(X_{i2} - X_{i1})$.]

Empirical Exercises

E10.1 Some U.S. states have enacted laws that allow citizens to carry concealed weapons. These laws are known as "shall-issue" laws because they instruct local authorities to issue a concealed weapons permit to all applicants who are citizens, are mentally competent, and have not been convicted of a felony (some states have some additional restrictions). Proponents argue that if more people carry concealed weapons, crime will decline because criminals are deterred from attacking other people. Opponents argue that crime will increase because of accidental or spontaneous use of the weapon. In this exercise, you will analyze the effect of concealed weapons laws on violent crimes. On the textbook Web site **www.pearsonhighered.com/stock_watson** you will find a data file **Guns** that contains a balanced panel of data from 50 U.S. states plus the District of Columbia for the years 1977 through 1999.[3] A detailed description is given in **Guns_Description**, available on the Web site.

a. Estimate (1) a regression of $\ln(vio)$ against *shall* and (2) a regression of $\ln(vio)$ against *shall*, *incarc_rate*, *density*, *avginc*, *pop*, *pb1064*, *pw1064*, and *pm1029*.

  i. Interpret the coefficient on *shall* in regression (2). Is this estimate large or small in a "real-world" sense?

  ii. Does adding the control variables in regression (2) change the estimated effect of a shall-carry law in regression (1) as measured by statistical significance? As measured by the "real-world" significance of the estimated coefficient?

  iii. Suggest a variable that varies across states but plausibly varies little—or not at all—over time and that could cause omitted variable bias in regression (2).

b. Do the results change when you add fixed state effects? If so, which set of regression results is more credible and why?

c. Do the results change when you add fixed time effects? If so, which set of regression results is more credible and why?

d. Repeat the analysis using $\ln(rob)$ and $\ln(mur)$ in place of $\ln(vio)$.

e. In your view, what are the most important remaining threats to the internal validity of this regression analysis?

f. Based on your analysis, what conclusions would you draw about the effects of concealed-weapon laws on these crime rates?

E10.2 Traffic crashes are the leading cause of death for Americans between the ages of 5 and 32. Through various spending policies, the federal government has encouraged states to institute mandatory seat belt laws to reduce the

[3]These data were provided by Professor John Donohue of Stanford University and were used in his paper with Ian Ayres, "Shooting Down the 'More Guns Less Crime' Hypothesis," *Stanford Law Review*, 2003, 55: 1193–1312.

number of fatalities and serious injuries. In this exercise you will investigate how effective these laws are in increasing seat belt use and reducing fatalities. On the textbook Web site **www.pearsonhighered.com/stock_watson** you will find a data file Seatbelts that contains a panel of data from 50 U.S. states plus the District of Columbia for the years 1983 through 1997.[4] A detailed description is given in **Seatbelts_Description**, available on the Web site.

a. Estimate the effect of seat belt use on fatalities by regressing *FatalityRate* on *sb_useage*, *speed65*, *speed70*, *ba08*, *drinkage21*, ln(*income*), and *age*. Does the estimated regression suggest that increased seat belt use reduces fatalities?

b. Do the results change when you add state fixed effects? Provide an intuitive explanation for why the results changed.

c. Do the results change when you add time fixed effects plus state fixed effects?

d. Which regression specification—(a), (b), or (c)—is most reliable? Explain why.

e. Using the results in (c), discuss the size of the coefficient on *sb_useage*. Is it large? Small? How many lives would be saved if seat belt use increased from 52% to 90%?

f. There are two ways that mandatory seat belt laws are enforced: "Primary" enforcement means that a police officer can stop a car and ticket the driver if the officer observes an occupant not wearing a seat belt; "secondary" enforcement means that a police officer can write a ticket if an occupant is not wearing a seat belt, but must have another reason to stop the car. In the data set, *primary* is a binary variable for primary enforcement and *secondary* is a binary variable for secondary enforcement. Run a regression of *sb_useage* on *primary*, *secondary*, *speed65*, *speed70*, *ba08*, *drinkage21*, ln(*income*), and *age*, including fixed state and time effects in the regression. Does primary enforcement lead to more seat belt use? What about secondary enforcement?

g. In 2000, New Jersey changed from secondary enforcement to primary enforcement. Estimate the number of lives saved per year by making this change.

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[4]These data were provided by Professor Liran Einav of Stanford University and were used in his paper with Alma Cohen, "The Effects of Mandatory Seat Belt Laws on Driving Behavior and Traffic Fatalities," *The Review of Economics and Statistics*, 2003, 85(4): 828–843.