1. (a) Rewrite $Y_i = \beta_1(X_i + X_i^2) + u_i$ and estimate by OLS.
   (b) Simply omit X_i^2, do OLS of Y_i on X_i instead. Results in $\hat{\beta}_1 = \sum X_i Y_i / \sum X_i^2$.

2. [15 marks]

   Are the following statements true or false? Provide a short explanation.
   (Note: you will not receive any credit without providing a correct explanation.)

   (a) True.
   (b) False. The cdf of probit is not closed form. The cdf of logit is closed form.
   (c) False. Bias does not need to be a function of sample size. Example: $\hat{\beta}_1 = 5$ has a bias that does not go away.

3. (a) OVB or selection: parents' with strong preferences for their girls' education may be more likely to send their kids to girls high school.
   (b) Overestimate.
   (c) Relevance: $E[X_i Z_i] \neq 0$. Exogeneity: $E[u_i Z_i] = 0$. Only relevance can be tested.
   (d) Location choice is not random. Not fully convincing.

4. [20 marks]

   (a) [2.5 marks] Positive effect of beer tax, not intuitive.
   (b) [2.5 marks] Added state fixed effects. Coefficient turns negative, more intuitive. Omitted state effects must have played important role.
   (c) [2.5 marks] Added time fixed effects. Coefficient does not change much. Omitted time fixed effect not important.
   (d) [2.5 marks] Added control variables. Coefficient becomes smaller in size, loses statistical significance. Added controls play important role.
   (e) [5 marks]
      (i) culture of drinking and driving, road quality, vintage of autos on roads
      (ii) improvements in auto safety across time, federal laws
      (iii) change in other alcohol taxes

      The first two can be take care of using panel data.
   (f) [5 marks] Column (5): strict laws not effective. Column (6): allowing for flexible age specification does not change anything. Column (7): Merely using two years of data is misleading.

5. (a) [5 marks] Need to assume that $E[v_i Z_i] = 0$. Plugging equation (2) into equation (1), it is easy to see that the coefficient $\pi\beta_1$ is being estimated.

   (b) [5 marks] $r_i := \beta_1(X_i - \hat{X}_i) + u_i$.

   (c) [15 marks]

$$\begin{aligned} E[\hat{X}_i r_i] &= E[\hat{X}_i(X_i - \hat{X}_i)] = E[\hat{\pi}Z_i(\pi Z_i + v_i - \hat{\pi}Z_i)] \\ &= E[\hat{\pi}Z_i\,(\pi - \hat{\pi})\,Z_i + v_i)] \\ &= E[\hat{\pi}(\pi - \hat{\pi})Z_i^2] \\ &= \pi(\pi - \pi)E[Z_i^2] = 0, \end{aligned}$$

   because $\hat{\pi}$ is an unbiased estimator of π.