UNIVERSITY OF BRISTOL

EXAMINATION FOR DEGREES IN THE SCHOOL OF ECONOMICS, FINANCE AND MANAGEMENT

January 20XX

EFIM20011

ECONOMETRICS

Time allowed: TWO hours and THIRTY minutes

Answer ALL questions

30 marks are allocated to Section A. 35 marks are allocated to Section B. 35 marks are allocated to Section C.

Justify all your answers. Non programmable calculators may be used, but candidates **must** show the basis of all calculations.

TURN OVER

Section A. [30 marks]

Answer all of the following 6 questions. Each question is worth **5 marks**. Give concise justifications for all your answers.

1. Let Q denote the quantile function for the distribution of full time wages in the UK. The quantile ratio $\frac{Q(90\%)}{Q(10\%)}$ is equal to 2.9. Explain what this ratio means and interpret its value. **[5 marks]**

2. We want to test the null hypothesis $H_0 : b = 0$ against the alternative $b \neq 0$ in the linear model $Y = a + bX + U$. The corresponding p-value is equal to 0.06 in our large iid sample. Explain what the p-value is. Conclude on the significance of b. **[5 marks]**

3. Consider the OLS regression of Y on X (and a constant). Consider another OLS regression of Y on X and W (and a constant). Both regressions use the same iid sample of size n. Write down the expression of the sum of squared errors for each of these two regressions. At the OLS estimates, which of these two sums of squared errors will be the lowest? **[5 marks]**

4. Consider the linear model $Y = a + bX + U$, where $E(U|X) = 0$. Using a large iid sample, we regress Y on X (and a constant) by OLS. Let Z be a valid instrument for X in the linear model. We conduct a 2SLS regression of Y on X (and a constant) using Z as an instrument for X. Would these two regressions (OLS and 2SLS) yield different estimated values for the parameter b? **[5 marks]**

5. Consider the linear model $Y = a + bX + cW + U$ where X is endogenous, W is exogenous and W is correlated with X. Can we use W as an instrument for X in this model? **[5 marks]**

6. What is the difference between a sharp and a fuzzy regression discontinuity design (RDD)? Illustrate using an example of a sharp RDD and an example of a fuzzy RDD. **[5 marks]**

Section B. [35 marks]

We want to study the effect of a policy on an outcome. To this end we have a large iid sample with n observations of the outcome Y and the policy variable X.

We start with the following linear regression model: $Y = a + bX + U$, where U is an error term. This model will be referred to as model (1).

Let $\widehat{a}$ and $\widehat{b}$ respectively denote the OLS estimators of a and b.

1. Derive the first-order conditions for the OLS estimation and solve them to get the expressions of $\widehat{a}$ and $\widehat{b}$. **[5 marks]**

2. Show that the predicted error $\widehat{U}$ from this OLS regression is not correlated with X. Show that $\widehat{U}$ is also not correlated with the predicted outcome $\widehat{Y}$. **[6 marks]**

3. If $\widehat{b} = 0.98$ and the estimated standard error of $\widehat{b}$ is 0.52, can we conclude that b is different from 0 at the 5% significance level? **[4 marks]**

From now on, X will be a binary variable. If individual i has received the policy treatment we have $X_i = 1$ and if individual i has not been treated we have $X_i = 0$.

4. If the exogeneity assumption $E(U|X) = 0$ holds in model (1), use this model to find the expressions of the conditional expectations $E(Y|X = 1)$ and $E(Y|X = 0)$. Then show that a consistent estimator for b can be obtained by comparing the average outcomes of the treated with that of the non treated. **[6 marks]**

From now on, we assume that the exogeneity assumption does not hold in model (1). We suggest a regression discontinuity approach and introduce the continuous variable W which is such that $X = 1$ if $W > 500$ and $X = 0$ if $W \leq 500$.

We now consider the model: $Y = \alpha + \beta X + \gamma W + V$, where V is an error term. This model will be referred to as model (2).

5. Write down the first-order conditions for the OLS estimation of model (2). **[4 marks]**

6. What is the main assumption we need to make in order to identify the causal effect of the policy X on Y using an OLS regression of model (2)? Write down this assumption formally and explain what it means. **[5 marks]**

7. If the discontinuity were not sharp but fuzzy (i.e. if the position of W with respect to 500 influenced but did not fully determine the treatment), suggest an instrumental variable for X and present the validity conditions for this instrument. **[5 marks]**

Section C. [35 marks]

This section is based on a 1995 article by Harmon and Walker. We want to estimate the wage returns to years of schooling in the UK and consider the following linear model:

$$W = a + bX + cS + U,$$

where W denotes an individual's log-wage (the logarithm of his wage), X denotes age, S is the number of years the individual spent in education (primary, secundary or higher education), U is an error term and a, b and c are parameters. This model will be referred to as model (A).

We have a large iid sample of more than 30,000 individuals. An OLS regression of model (A) gives an estimate of c equal to 0.061 with a standard error of 0.001.

1. If the exogeneity assumption holds in model (A), can we conclude with a 95% confidence level that there are positive wage returns to education? **[4 marks]**

2. Explain why education S may not be exogenous in model (A). **[4 marks]**

To identify the returns to education, Harmon and Walker suggested an instrumetal variable strategy which exploits changes in the school leaving age over time. Before 1947, individuals could not leave school before they turned 14 years old. In 1947, the school leaving age was raised from 14 to 15 and in 1973 it was further raised from 15 to 16. In our data sample, there are individuals from different cohorts, some of whom were in school when the leaving age was 14 (before 1947), others when the leaving age was 15 (between 1947 and 1973) or 16 (from 1973 onwards). Harmon and Walker then constructed two dummy variables:

- Z_1 is equal to 1 if the individual turned 14 between 1947 and 1973 (when the school leaving age was 15) and is equal to 0 otherwise.

- Z_2 is equal to 1 if the individual turned 14 after 1973 (when the school leaving age was 16) and is equal to 0 otherwise.

They then suggest to use Z_1 and Z_2 as instruments for S in model (A).

3. Why would they not also use a third instrument equal to 1 if the individual turned 14 before 1947 and equal to 0 otherwise? **[2 marks]**

4. Present the two stages of the 2SLS estimation of model (A) using Z_1 and Z_2 as instruments for S. **[5 marks]**

5. Present and discuss the validity conditions for this 2SLS estimation. **[8 marks]**

The 2SLS estimation of model (A) using Z_1 and Z_2 as instruments for S gives an estimate of c equal to 0.153, with a standard error of 0.015.

6. If we assume that Z_1 and Z_2 are valid instruments, what can we say about the exogeneity or endogeneity of S in model (A)? **[4 marks]**

7. Can there be an ability bias in the OLS estimation? **[3 marks]**

8. Discuss whether this instrumental variable strategy may only be producing a LATE. (Hint: would the education of individuals from wealthy and highly-educated background vary because of a change in the school leaving age?) **[5 marks]**

END OF EXAM