Agricultural and Resource Economics

Ph.D. Qualifying Examination – Applied Microeconometrics

Tuesday, July 10, 2018

Instructions:

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2) There are six questions on six pages. You must answer all six questions.
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4) Show all your work on the paper provided.
5) Leave one-inch margins and only write on one side of each sheet.
6) Do not place your name on any of your answer pages.
7) Clearly number each sheet with the question and page number in the upper right corner.
8) Submit your exam unstapled ordered by question number and page number.
9) If you need clarification about a question or believe there is a typographical error, raise your hand and the exam invigilator will assist you.
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1. Answer the following questions about consumer demand:

A. Suppose that a consumer can purchase 3 goods $\{x_1, x_2, x_3\}$ at strictly positive prices. Let ω_i denote the budget share of good *i*; ε_i denote the expenditure elasticity of good *i*; and η_{ij} denote the Marshallian price elasticity of good *i* with respect to the price of good *j*. You know the following information:

$$\begin{aligned}
\omega_1 &= 0.4 \\
\varepsilon_1 &= 1.8 \\
\varepsilon_2 &= 0.4 \\
\eta_{12} &= 0.6 \\
\eta_{21} &= 0.8
\end{aligned}$$

If consumer preferences satisfy a locally non-satiated rational preference ordering, what are the values of η_{22}, η_{23}, and η_{32}?

B. A researcher estimates the following regression equation with one thousand observations:

$$q_i = \alpha + \gamma m + \beta_i p_i + \beta_i p_i + \beta_i p_i + \varepsilon$$

where q_i denotes quantity demanded of good *i*, p_i denotes the price of good *i*, and *m* denotes total expenditure. Prices have been normalized so that $\overline{q_i}$, the mean of q_i, equals unity ($\overline{q_i} = 1$). These normalized prices are $\overline{p_i} = 4$, $\overline{p_j} = 3$, and $\overline{p_k} = 2$.

They report the following coefficient estimates and covariance matrix.

$$\begin{aligned}
\alpha &= \ \ 0.5 \\
\gamma &= \ \ 0.006 \\
\beta_i &= -0.2 \\
\beta_j &= \ \ 0.4 \\
\beta_k &= \ \ 0.10
\end{aligned}$$

$$\Omega = \left|\begin{array}{lllll}
.21 & .000017 & .000008 & .009 & .012 \\
 & .00008 & .000003 & .000001 & .000001 \\
 & & .03 & .0007 & .0011 \\
 & & & .0004 & .0001 \\
 & & & & .0007
\end{array}\right|$$

a. Propose a statistical test of the equality of β_j and β_k that only uses the information reported by the researcher. Clearly define the null hypothesis, the test statistic, and its distribution.
b. Using the test defined in (a), calculate the value of the test statistic. Can you reject at the null hypothesis of equality β_j and β_k at the five percent significance level?
c. Construct the demand elasticity of good *i* with respect to the price of good *j*, η_{ij}. Do the same for the demand elasticity of good *i* with respect to the price of good *k*, η_{ik}.
d. Propose a statistical test of the equality of η_{ij} and η_{ik} at the sample means of prices and quantities that only uses the information reported by the researcher. Clearly define the null hypothesis, the test statistic, and its distribution.
e. Using the test defined in (a), calculate the value of the test statistic. Can you reject at the null hypothesis of equality of η_{ij} and η_{ik} at the sample means of prices and quantities at the five percent significance level?

2. Suppose there is an economy with two consumer types: type A with population N_A and type B with population N_B. Both consumer types can allocate their resources to the purchases of two goods: an infinitely divisible general consumption good denoted $C \in R_+$ with price $p_C = 1$ (the numeraire) and a dichotomous *state-good* denoted $X \in \{0,1\}$ with price p_X (notice, the state-good **cannot** assume all integer values; it is either consumed, $X = 1$, or not consumed, $X = 0$). Type A consumers only receive utility from consumption of C, while type B consumers receive utility from both C and X. Utility depends on the consumption state $S \in \{0,1\}$ with $prob(S = 1) = q > 0$. Consumers purchase goods before the consumption state is realized.

Let the utility of type A consumer with disposable income m_A be:

$$U_A(C, X; S) = \left(\frac{2}{4}\right)^S \ln(C)$$

A. What is the expected utility of type A consumers before the consumption state is realized?
B. Suppose the government can implement the following program: type A consumers pay a tax of t before the consumption state is realized and the government uses this revenue to reduce the probability $S = 1$ so that $prob(S = 1|t) = q/2$. What is the expected utility of type A consumers as a result of this government program?
C. If type A consumers maximize their expected utility, derive an expression for the maximum value of t they would be willing to accept to implement the policy described above?
D. If type A consumers have pre-tax disposable income of \$60,000 and $q = 0.10$, what is the consumer's maximum willingness to pay to see the government program implemented?

Let the utility of type B consumers with income m_B be:

$$U_B(C, X; S) = \left(\frac{2 + X}{4}\right)^S \ln(C)$$

E. What is the expected utility of type B consumers before the consumption state is realized if X is unavailable for purchase?
F. What is the expected utility of type B consumers before the consumption state is realized if X is purchased at price p_X?
G. If type B consumers maximize their expected utility, derive an expression for the maximum value of p_X they would be willing to pay to purchase X.
H. If type B consumers also have pre-tax disposable income of \$60,000, $q = 0.10$, and the government has not implemented a tax on type A consumers to reduce q, what is the maximum price p_X they would be willing to pay to purchase X?

Suppose, the consumption of X affects the likelihood that each state arises so that $prob(S = 1|X) = \frac{q}{2-X}$.

I. If the government maximizes a social welfare function that is the sum of individual expected utilities and could ban the consumption of X, would it choose to do so? Would doing so be Pareto optimal? Would it be Pareto improving relative to the free-market outcome?
J. Is the following statement true, false, or unknown: "Given the utility and state probability functions defined above, if $\{N_A > N_B;\ m_A = m_B = \$60{,}000;\ q = 0.10\}$, then it is possible for type A and type B consumers to agree to an arrangement whereby type B consumers voluntarily set X=0."
K. In one or two sentences, identify a contemporary economic phenomenon for which the framework initiated here might help analysts develop sound policy advice based on principles of benefit cost analysis, Pareto efficiency, and Pareto improvement.

3. Define the payoff function ω: $\{0,1\}^3 \times \{0,1\}^3 \rightarrow R \times R$ as $\omega(\sigma_A, \sigma_B)$ where σ_i denotes the strategy of player i with the following values:

$$\omega = \begin{bmatrix} (-1,0) & (4,-1) & (6,3) \\ (-2,4) & (2,0) & (-2,2) \\ (3,0) & (-2,1) & (4,-3) \end{bmatrix}$$

Does there exist a Nash equilibrium in which Player A plays a mixed strategy $\rho = (\rho_1, \rho_2, \rho_3)$ such that $\rho_1 = 0$; $\rho_2 \in (0,1)$; $\rho_3 \in (0,1)$? If yes, provide the Nash equilibrium strategies employed by both players in such an equilibrium.

4. A researcher wishes to recover the causal effect of maternal health on child health. In particular, she wishes to identify the effect of physical activity in teenage women on the health of their subsequent offspring. The researcher has access to a dataset that records the following information for households in the Unites States:

Maternal age
Number of children
Marital status
Household income
Maternal years of education
Child age
Child health status (Apgar score)
Weekly hours of maternal physical activity in high school
State of residence during high school

4.a. Explain why estimating the relationship between maternal physical activity in high school and child health status using OLS might yield inconsistent estimates of the causal effect of physical activity on child health.

The researcher proposes the following instrumental variable for maternal physical activity in high school: the implementation date of Title IX. Title IX is a federal law that prevents discrimination in educational opportunities, including sports, based on race and gender. Specifically, Title IX requires schools to provide equal opportunity to boys and girls to participate in school-sponsored athletics. The implementation year of Title IX varied by state.

4.b. List each of the assumptions necessary for the IV estimate to be interpreted as the LATE of maternal physical activity on child health when the implementation date of Title IX is used as an instrument. For each assumption, explain intuitively what is required for the proposed instrument to meet the stated requirement.

4.c. For each of the assumptions, provide an intuitive example of when the proposed instrument may fail that requirement.

5. a.

i. Provide an intuitive definition of a consistent estimator.

ii. Is it true that an unbiased estimator should always be preferred to a biased estimator?

b. A variable Y is determined by a variable X according to the following relationship:

$$Y = \beta_1 + \beta_2 X + u$$

where u is the disturbance term that satisfies the Gauss-Markov conditions. The values of X are drawn randomly from a population with variance σ_X^2. A researcher makes a mistake and regresses X on Y, fitting the equation:

$$\hat{X} = d_1 + d_2 Y$$

where $d_2 = \frac{Cov(X,Y)}{Var(Y)}$. When he realizes his mistake, he points out that the original relationship could be written

$$X = -\frac{\beta_1}{\beta_2} + \frac{1}{\beta_2} Y - \frac{1}{\beta_2} u$$

and hence d_2 will be an estimator of $\frac{1}{\beta_2}$. From this he could obtain an estimate of β_2.

i. Explain why it is not possible to derive a closed form expression for the expected value of d_2 for a finite sample.

ii. Demonstrate that d_2 is an inconsistent estimator of $\frac{1}{\beta_2}$ and determine the direction of the bias, if this is possible.

iii. Suppose there exists a third variable Z that is correlated with Y but independent of u. Demonstrate that if the researcher had regressed X on Y using Z as an instrument for Y, the slope coefficient d_2^{IV} would have been a consistent estimator of $\frac{1}{\beta_2}$.

iv. Explain with reference to the Gauss-Markov conditions, why d_2 yielded an inconsistent estimate of $\frac{1}{\beta_2}$ while d_2^{IV} yielded a consistent one.

v. At a seminar, someone suggests that X would be a valid instrument, and indeed the best possible instrument. Is this correct?

6. Consider a market where each firm simultaneously and independently selects a quantity q_i. The inverse demand function for this market is given by $P(Q) = 50 - Q$, where $Q = \sum_{i=1}^{n} q_i$.

a) Suppose the market is monopolized by a single firm with constant marginal cost of production equal to c_1. Find the profit-maximizing output, price, and profit for the firm.

b) Compare the outcomes in (a) to that which would arise in a perfectly competitive market where all firms have $MC = c_2$, where $c_2 < c_1$.

c) Suppose that the above market is served by two identical firms with constant $MC = c_2$. Derive the Cournot equilibrium price and the quantity produced by each firm. Compare the aggregate quantity and price to the results in (a) and (b).

d) Finally, compare the results from (a), (b) and (c) to the outcomes of a Bertrand model for the same market.

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1. Answer the following questions about consumer demand:

A. Suppose that a consumer can purchase 3 goods $\{x_1, x_2, x_3\}$ with $x_i \in R_+ \ \forall\, i$. Let ω_i denote the budget share of good *i*; ε_i denote the expenditure elasticity of good *i*; and η_{ij} denote the Marshallian price elasticity of good *i* with respect to the price of good *j*. Prove that if the following are true, then consumer preferences do not satisfy a locally non-satiated rational preference ordering:

$$
\begin{aligned}
\omega_1 &= \ \ 0.4 \\
\varepsilon_1 &= \ \ 0.8 \\
\varepsilon_3 &= \ \ 1.5 \\
\eta_{11} &= -1.0 \\
\eta_{13} &= -0.76 \\
\eta_{31} &= -1.2
\end{aligned}
$$

B. A researcher estimates the following regression equation with one thousand observations (the data have been demeaned to remove the constant), where q_i denotes quantity demanded of good *i*, p_i denotes the price of good *i* and *m* denotes total expenditure:

$$\log q_1 = \alpha \log m + \beta \log p_1 + \gamma \log p_2 + \varepsilon_i$$

They report the following coefficient estimates and covariance matrix.

$$
\begin{aligned}
\alpha &= \ \ 0.59 \\
\beta &= -0.92 \\
\gamma &= \ \ 0.70
\end{aligned}
$$

$$\Omega = \begin{bmatrix} .0009 & .0015 & .0002 \\ & .0036 & -.0050 \\ & & .0100 \end{bmatrix}$$

Can we reject the null hypothesis that demand for good 1 satisfies homogeneity at the five percent significance level?

2. Agent 1 has the following utility function $U: R^3_+ \to R$:

$$U(x) = x_1^{1/2} x_2^{1/4} x_3^{1/4}$$

with initial endowment vector $\omega^1 = [4, 4, \omega_3^1]$.

Agent 2 has the following utility function $V: R^3_+ \to R$:

$$V(y) = \frac{y_1}{2} + \frac{y_2}{4} + \frac{y_3}{2}$$

with initial endowment vector $\omega^2 = [3, 5, 2]$.

Agent 1 and Agent 2 are allowed to trade. Define an equilibrium in this economy.

Suppose that in equilibrium, Agent 1 consumes six units of good 1. What was ω_3^1?

3. Define the payoff function $\omega: \{0,1\}^3 \times \{0,1\}^3 \to R \times R$ as $\omega(\sigma_A, \sigma_B)$ where σ_i denotes the strategy of player *i* with the following values:

$$\omega = \begin{bmatrix} (2,4) & (-2,-2) & (-1,0) \\ (1,0) & (0,1) & (2,2) \\ (-1,2) & (1,-1) & (3,-2) \end{bmatrix}$$

Does there exist a Nash equilibrium in which Player A plays a mixed strategy $\rho = (\rho_1, \rho_2, \rho_3)$ such that $\rho_1 \in (0,1)$; $\rho_2 \in (0,1)$; $\rho_3 = 0$? If yes, provide the Nash equilibrium strategies employed by both players in such an equilibrium.

4. A researcher wishes to recover the causal effect of child mortality on subsequent fertility. The researcher has access to a dataset that records the following information for households in a large tropical nation:

Maternal age
Number of children
Household income
Maternal years of education
Township of residence
Month and year of interview
Indicator for death of a child in the past year
Indicator for birth of a child in the past year
Indicator for current pregnancy status

4.a. Explain why estimating the relationship between current pregnancy status and death of a child in the past year using OLS (a linear probability model) might yield inconsistent estimates of the causal effect of mental health on employment.

The researcher proposes the following instrumental variable for the death of a child in the past year: an index of malaria transmission danger. This index is constructed based on ecological and climatic factors using a method validated in the epidemiological literature.

4.b. List each of the assumptions necessary for the IV estimate to be interpreted as the LATE of child mortality on subsequent fertility when malaria transmission risk is used as an instrument. For each assumption, explain intuitively what is required for the proposed instrument to meet the stated requirement.

4.c. For each of the assumptions, provide an intuitive example of when the proposed instrument may fail that requirement.

5. For a sample of 1755 white males in the United States in the year 2000, a researcher has the following data:

years of schooling, ***S***,
weekly earnings in dollars, ***W***,
hours worked per week, ***H***, and
hourly earnings, ***E*** (computed as *W/H*)

She calculates *LW*, *LE*, and *LH* as the natural logarithms of *W*, *E*, and *H*, respectively, and reports the following results:

Table 2: OLS Regressions Results

	(1)	(2)	(3)	(4)	(5)
Respondents	All	All	All	Full-time	Part-time
Dependent Variable	LE	LW	LE	LW	LW
S	0.099 (0.006)	0.098 (0.006)	0.098 (0.006)	0.101 (0.006)	0.030 (0.049)
LH	-	1.190 (0.065)	1.190 (0.065)	0.980 (0.088)	0.885 (0.325)
Constant	6.111 (0.082)	5.403 (0.254)	5.403 (0.254)	6.177 (0.345)	7.002 (1.093)
RSS	741.5	737.9	737.9	626.1	100.1
Observations	1755	1755	1755	1669	86

Notes: Standard errors in parentheses; RSS = residual sum of squares. Full-time employment defined as working at least 35 hours per week. The correlation between ***S*** and ***LH*** is 0.06.

(a) Explain why specification (1) is a restricted version of specification (2), stating and interpreting the restriction.

(b) Supposing the restriction to be valid, explain whether you expect the coefficient of *S* and its standard error to differ, or be similar, in specifications (1) and (2).

(c) Supposing the restriction to be invalid, how would you expect the coefficient of *S* and its standard error to differ, or be similar, in specifications (1) and (2)?

(d) Perform an *F* test of the restriction.

(e) Perform a *t* test of the restriction.

(f) Explain whether the *F* test and the *t* test could lead to different conclusions.

(g) Interpret the results reported in columns 2 and 3. Why are some estimates the same and others different?

(h) At a seminar, a commentator says that part-time workers tend to be paid worse than full-time workers and that their earnings functions are different. Based on the results reported above, test whether the commentator's assertion is correct. (Hint: For a reference, the critical value of $F(3,1000)$ at the 0.1% level is 5.46.)

(i) What are the implications of the commentator's assertion for the test of the restriction?

6. An **incumbent** (denoted I) and a **possible entrant** (denoted E) play the following game:

First, the incumbent decides whether to be **passive** or **active**. Being active costs **C** and it is a sunk cost.

Then, Nature selects the opportunity cost of entry $k \in K$ (that is, the profit that the entrant could make in the best alternative investment) according to the cumulative distribution function F [thus, for every number x, $F(x)$ is the probability that the opportunity cost of entry k is less than or equal to x]. The value of k is revealed to both incumbent and possible entrant (and becomes common knowledge between them).

Then, the possible entrant decides whether or not to enter and if she enters then there is a simultaneous duopoly game (which we do not specify: it could be a Cournot game).

Let D_I and D_E be the incumbent's and entrant's profits, respectively, at the Nash equilibrium of the duopoly game following entry with a passive incumbent, and G_I and G_E be their respective profits at the Nash equilibrium of the duopoly game following entry with an active incumbent (G_I includes the cost C). Assume that if she is indifferent between entering and not entering, the entrant will choose to enter.

If the possible entrant stays out, her payoff is k (drawn from $F(x)$), whereas the incumbent's payoff is M if passive and $(M - C)$ if active.

Assume that $M > C > 0$. Production costs are zero for both firms.

(a) Draw the extensive form of this game for the case where $K = \{k_1, k_2\}$ (replace each duopoly game with the corresponding equilibrium payoffs; write all the payoffs).
(b) Provide a formal definition of a subgame-perfect equilibrium for the extensive form game.
(c) Assume instead that K = [A, B] (the closed interval between A and B, $0 < A < B$) and $A < G_E < D_E < B$. Under what conditions are the subgame-perfect equilibria characterized.