DIRECTIONS: This exam consists of six questions. Answer two of the first three, and two of the last three. You have three hours to complete the exam. Each question (but not parts within each question) counts equally, so don’t spend too much time on any one question. Be sure to write clearly and legibly. Answers that cannot be read will be assumed to be wrong.
Answer two of the following three questions. Do not answer all three!

1. The utility function $U(F,S)$ describes a farmer’s preferences over consumption of food, $F$, and hours of leisure, $S$. Our farmer lives in an isolated area with no markets for land, labor or food. In order to eat she must produce her own food according to: $F = G(L,T)$; where $G(.,.)$ is a production function, $L$ is hours of labor input, and $T$ is hectares of land. She has an endowment of $T$ hectares of land and $L$ hours of labor.

a. Write down (but don’t solve!) the farmer’s constrained optimization problem. Let her two choice variables be food consumption and hours worked.

b. Assume that the function $G(.,.)$ is homogeneous of degree one. Show that we can rewrite the production function as $F = T g(l)$; where $l = L/T$ is labor intensity (hours worked per-hectare) and $g(l) = G(l,1)$ is the per-hectare production function. (Note: If you cannot derive this result, simply assume that it holds in answering the rest of the question.)

c. Rewrite the farmer’s problem as an unconstrained optimization problem with $l$ as the single choice variable.

d. Derive and interpret the first order necessary condition for optimal labor intensity, $l^*$. (Discuss in terms of marginal cost and marginal benefit.)

e. If we increase the farmer’s land endowment by one hectare, would the optimal labor intensity increase, decrease or remain constant? For this part assume the following about the utility function: $U_F > 0; U_S >\theta; U_{FF} < 0; U_{SS} <\theta; U_{FS} > 0$. Give a formal answer if you can. Otherwise, provide an intuitive discussion.

f. You are an economist in a country with a highly unequal land distribution. You have been hired to design a land policy that will raise total food production in the country. Based on your answer to part (e), what type (or types) of policies would you recommend?
2. Many countries have so-called state trading enterprises (STEs), which act as single (monopoly) sellers of particular agricultural commodities produced by their farmers. In other words, producers must deliver their production to the STE, who is then in charge of marketing it. Many people believe that STEs are an impediment to international trade, and their existence is being challenged under negotiations for trade liberalization such as the GATT. The Canadian Wheat Board (CWB) is an example of an STE. All wheat produced by Canadian farmers must be sold through the CWB. The CWB sells wheat to various market outlets, collects revenues, deducts its costs, and then pays farmers a pool (average) price per unit of production. Importantly, the CWB is only a marketing entity; it does not attempt to regulate farmers’ production.

a. Let's consider first a very simple model of the CWB. Assume CWB sells a given, exogenous crop volume, \( \bar{Q} \), into two markets, domestic (\( Q_D \)) and export (\( Q_E \)), i.e., \( \bar{Q} \geq Q_D + Q_E \). Assume always that the CWB’s goal is to maximize farmer revenues, and assume initially that the CWB is a monopoly seller in both the domestic and export markets. For simplicity, you can also assume that CWB’s operating costs are all fixed costs. Characterize the CWB’s operation in terms of an optimization problem. Introduce your own notation, as necessary. What are the first-order conditions that characterize the solution to this problem?

b. Will the constraint in the optimization problem in part (a) always bind (i.e., \( \bar{Q} = Q_D + Q_E \) in equilibrium)? Explain why or why not? Assume that there is no storage.

c. Now suppose that CWB is not a monopoly seller in wheat export, but, rather, faces competition in exports from competitive U.S. traders (the U.S. does not have a STE for wheat). You can assume total U.S. production is exogenous, \( \bar{Q}^{US} \), and that Canadian law prohibits wheat imports into Canada. Generalize your model from part (a) to take account of this market environment.

d. Will Canada export more or less wheat under the market environment in part (a) or part (c), or is the answer ambiguous? Explain.

e. Here are three statements that represent various viewpoints that have been expressed concerning the CWB:

- **Canadian legislator representing a large city:** “The CWB should be abolished. It causes higher prices to Canadian consumers for breads and pastas.”
- **Colin Andre Carter, Canadian citizen and famous agricultural economist:** “The CWB should be abolished. It interferes with Canadian farmers’ opportunities to market their wheat and reduces their incomes.”
- **North Dakota (U.S.) wheat farmer:** “The CWB should be abolished. It distorts world grain trade and causes lower prices for U.S. farmers.”

Evaluate each of these statements in the context of the model, as it is expressed in part (c). Does the model support or not support the statement, or is the answer ambiguous? Explain.
3. As state governments around the U.S. confront budget deficits, many are turning to large increases in college tuition as a partial solution. Unlike UC where fees are assigned per quarter, many colleges assign fees per credit unit. Monique attends State U in the Midwest, and a 25% increase in tuition per credit unit is being contemplated. Monique’s only source of income is a grant from the state for $M_0$ dollars. Assume that Monique has well-behaved preferences for college credits (C) and all other goods (G). Let $P_C^0$ denote the initial tuition price and $P_G = 1$ denote the price for G.

a. Show graphically (Figure 1) the impacts of the tuition increase on Monique’s consumption behavior, assuming both goods are normal goods. Derive graphically the income and substitution effects from the price change.

b. On a second graph (Figure 2), positioned directly below your first graph, derive Monique’s Marshallian and Hicksian demand curves for C. Assume for convenience that these curves are linear.

c. Use Figure 2 to identify and define three alternative measures of the economic welfare effect to Monique from the increase in tuition.

d. Some members of the legislature in Monique’s state are arguing that state grants must be increased so that the students on financial aid are not harmed by the tuition increase. Which of the welfare measures from part (c) do you recommend that the legislature use to adjust the magnitude of the state grants? Why?

e. Now we have to move from theory to application. In reaching final decisions as to (i) tuition increases and (ii) adjustments in state grants, the legislature wants you to provide estimates of quantitative impacts. In particular, what will be the decrease in enrollment if the 25% tuition increase is enacted, either with compensation or without it, and, given your answer in part (d), what adjustment in the magnitude of the state grant is necessary to compensate grant recipients for the price increase? Discuss empirical work that you could do to generate these estimates. Be realistic in terms of data you can obtain and analyses you can conduct.
Answer two of the following three questions. Do not answer all three!

4. You live in a country with two very distinct regions called North and South. You are interested in empirically examining the relationship between farm size and yield, defined as value of output per hectare. Theory has suggested to you the following two hypotheses:

- Hypothesis 1: Regardless of region, yield is decreasing in farm size.
- Hypothesis 2: For all farm sizes, yield is greater in the North by a constant amount.

a. Draw a graph – label it Figure 1 – that depicts both hypotheses.

b. You have data on yield (y), and farm size, (T) for a cross section of households throughout the country. Specify an econometric model that would permit you to test these two hypotheses. Also state, in terms of the parameters of your model, the two null hypotheses.

c. A colleague disagrees and suggests instead that, while the relationship between farm size and yield is indeed negative in the North, that there is no correlation between farm size and yield in the South. Draw a graph – label it Figure 2 – that depicts your colleague’s hypothesis.

d. Modify your econometric model from part (b) in a way that would permit you to test your colleague’s hypothesis. State the hypothesis in terms of the parameters of the modified model.

e. A second colleague claims that you have a different problem. She says that you have not controlled for soil quality in your analysis. She argues that, historically, regions that have high quality soil attracted lots of farmers. Further, she argues that this has led to land fragmentation and a predominance of small farms precisely in those regions where soil quality is the highest. What econometric problem does this colleague’s concern raise? Specifically, discuss how this problem would affect your estimate on the parameter for farm size from part (d).
5. Consumers get utility from consuming widgets (W), at price \( p_W \), and food (F), at price \( p_F \). Their preferences are represented by a well-behaved utility function \( U=U(W,F;Z) \), i.e., assumed to be differentiable everywhere, strictly increasing in W and F, and quasi-concave. \( Z \) is a vector of consumer characteristics (gender, age, etc.) that affect the utility from W and F. Consumers spend all of their income (Y) on W and F.

a. Derive the first-order necessary conditions to this constrained optimization problem, and explain in economic terms the condition defining the consumer optimum.

b. The marginal propensity to consume a good, X, is given by \( \frac{\partial X}{\partial Y} \). Propose an econometric model to estimate the marginal propensity to consume widgets and food, using cross-section data from a survey of consumers.

c. How could you use your econometric model to:

   i. Obtain estimated own-price and cross-price elasticities of food and widget demand? (Please show exactly how you would obtain these elasticities from your regression results.)
   ii. Test whether food and widgets are normal or inferior goods?
   iii. Test the null hypothesis that the marginal propensities to consume widgets and food are, in fact, the same?

d. State two econometric problems that could arise when trying to estimate your model. For each of these problems, please:

   i. Define the problem.
   ii. Would the problem result in estimated marginal propensities to consume that are not BLUE? Explain your answer.
   iii. Propose a solution that would make your estimators have more desirable properties.
6. The department of agriculture hires you to do an econometric study of farmers’ adoption of a new corn variety. You have annual data for 15 years, starting with the year in which the new corn variety became available, on (a) total U.S. acreage cultivated in corn (C_t for t=1,...,15); (b) total acreage planted in the new corn variety (NC_t for t=1,...,15); and (c) average profit per acre each year from growing all corn varieties (\Pi_t), in thousands of dollars. You hypothesize that the share of corn acreage planted in the new variety (S_t=NC_t/C_t) is a function of profitability \Pi_t and also other factors that you hope to capture by including a time trend variable (t=1,...,15) in your regression equation. You use ordinary least squares (OLS) to estimate the following regression equation, with the results shown below (numbers in parentheses are standard errors):

\[ S_t = .01 + .05*\Pi_t + .10*t \]

\[ (.01) (.04) (.02) \]

\[ R^2 = .65 \quad \text{Durbin-Watson Statistic} = 0.15 \]

a. Interpret the estimated coefficients on \Pi_t and t—that is, explain their statistical significance and their economic meaning.

b. Find at least three things likely to be wrong with this OLS estimation, and for each thing wrong explain:

i. What happens to the properties of your OLS parameter estimates if you ignore the problem? (Are they still best linear unbiased estimators-BLUE? If not, why?)

ii. How might you re-estimate the model in a way that addresses the problem?
University of California, Davis
Department of Agricultural and Resource Economics

M.S. Comprehensive Exam
June 21, 2004

You have three hours for this exam. Choose four of the following six questions to answer. Watch the time carefully; each question (but not parts within the questions) count equally, so don’t get bogged down with any one. If you don’t get the whole answer within the designated time frame, just do what you can and move on. The logic used to answer the question is an important part of your grade, so be sure to clearly specify your reasoning, with full sentences. Also, make sure your writing is legible; answers that cannot be read will be assumed to be wrong.

1. Consider a competitive industry producing fresh pears with equilibrium price \( P = 100 \) and equilibrium quantity \( Q = 100,000 \). Over the relevant range for this question the demand elasticity for fresh pears is \(-1.0\) and the industry supply elasticity is \(1.0\). There is no production variability and all participants know what how much will be produced and consumed at each price.

Now the 100 identical fresh pear growers set up a cooperative cartel under which the fresh pear price is raised to \( P_m = 120 \).

(a) Explain how to determine the new equilibrium quantity sold in the fresh pear market, and calculate this quantity.

(b) Explain and calculate the change in total expenditure for fresh pears.

(c) Explain and calculate the approximate change in the consumer surplus in the fresh pear market.

Now assume the pears not sold in the fresh pear market can only be sold in the juice market, and that the juice market is dominated by apple juice from China, which is a perfect substitute for pear juice and sells for a price of 90. Each firm is allocated a fixed amount – one percent of the total quantity – to sell in the fresh market, and sells any excess in the juice market.

(d) Explain and calculate the quantity of pears produced, the quantity sold in the juice market and the change in total revenue of producers.

(e) Explain and calculate the approximate change in the producer surplus compared to the competitive equilibrium.

(f) Explain and calculate the approximate welfare gain or loss to the economy from the cartelization of this market.
2. The emergence of large and diversified plants and firms in modern markets, such as Walmart rather than "mom & pop" drugstores, suggests that larger entities may be more efficient or profitable, and thus competitive. In reverse, the tendency of firms to downsize and specialize, such as toward boutiques rather than department stores, may imply that smaller operations are more competitive.

(a) What type of economic theory allows us to address these types of questions? (What types of diagrams and/or equations represent the economic theory underlying such issues?)

(b) What kinds of functions or equations might you specify and estimate to answer questions about whether firms' growth, or, alternatively, downsizing, might lead to enhanced efficiency?

(c) What kinds of regularity conditions would you need to take into account in your model and analysis? (such as monotonicity, curvature, homogeneity). In particular, what types of homogeneity (homotheticity) assumptions or restrictions might be relevant – or not?

(d) Consider the total cost function presented below. TC is the total cost, Y is the level of output and \( P_K, P_L, P_E, \) and \( P_M \) are the input prices for capital, labor, energy, and materials. Can you use this function to ask the types of questions you represented theoretically in (a). Why or why not? If so, discuss how you would estimate and evaluate measures addressing these questions. If not, discuss what you would have to do to adapt the model to consider these questions.

\[
\ln TC = \ln \alpha_0 + \ln Y + \alpha_K \ln P_K + \alpha_L \ln P_L + \alpha_E \ln P_E + \alpha_M \ln P_M + \frac{1}{2} \gamma_{KK} (\ln P_K)^2 \\
+ \gamma_{KL} \ln P_K \ln P_L + \gamma_{KE} \ln P_K \ln P_E + \gamma_{KM} \ln P_K \ln P_M + \frac{1}{2} \gamma_{LL} (\ln P_L)^2 + \gamma_{LE} \ln P_L \ln P_E \\
+ \gamma_{LM} \ln P_L \ln P_M + \frac{1}{2} \gamma_{EE} (\ln P_E)^2 + \gamma_{EM} \ln P_E \ln P_M + \frac{1}{2} \gamma_{MM} (\ln P_M)^2,
\]
3. Use the Gams printout reproduced below to answer the questions below that:

**Input Data**

<table>
<thead>
<tr>
<th>SETS</th>
<th>PRODUCTION PROCESSES</th>
<th>/COTTON, RICE, PASTURE, BEANS, TOMATOES/</th>
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<tbody>
<tr>
<td>J INPUTS</td>
<td></td>
<td>/LAND, WATER, LABOR/</td>
</tr>
<tr>
<td>JF(J)</td>
<td></td>
<td>/LAND, WATER/</td>
</tr>
</tbody>
</table>

**PARAMETER V(I) PRICE PER UNIT OUTPUT**

/COTTON 1300.0, RICE 251.0, PASTURE 170.0, BEANS 640.0, TOMATOES 51.5 /

**PARAMETER YB(I) SAMPLE AVERAGE YIELDS**

/COTTON 0.63, RICE 4.27, PASTURE 2.25, BEANS 2.96, TOMATOES 34.0 /

**PARAMETER XB(I) BASE OBSERVED ACRES**

/COTTON 108.0, RICE 10472, PASTURE 200, BEANS 88.0, TOMATOES 209 /

**PARAMETER CL(I) LINEAR AVERAGE COST**

/COTTON 479.0, RICE 606.0, PASTURE 361.0, BEANS 1136.0, TOMATOES 465.0 /

**TABLE RR(I,J) LEONTIEFF COEFFICIENTS**

<table>
<thead>
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<th>LAND</th>
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<td>TOMATOES</td>
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**Gams output**

**** MODEL STATUS 1 OPTIMAL

**** OBJECTIVE VALUE 5259092.5611

--- EQUI RESOURCE CONSTRAINED RESOURCES

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<td>4.7739E+5</td>
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--- EQUI CALIB CALIBRATION CONSTRAINTS

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--- VAR LX ACRES PLANTED

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<tbody>
<tr>
<td>COTTON</td>
<td>108.108</td>
<td>+INF</td>
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</tbody>
</table>
(a) If there were no calibration constraints on the calibrated LP above:

(i) How many activities would you expect to be in the optimal solution? Briefly explain using matrix algebra.
(ii) Which activities would NOT be in the optimal solution, and why?

(b) Use the Gams results to calculate, for the two most profitable crops:

(i) The intercept (\( \alpha \)) of the PMP cost function.
(ii) The slope of the PMP cost function (\( \gamma \)).

Show your calculations

(c) Use your results from part (d) above to show that a PMP model based on your (\( \alpha \)) and (\( \gamma \)) values will satisfy the necessary economic optimizing conditions for input allocation at the base acres

(d) Use the results from part (b) to calculate the elasticities of supply (actually acreage response) for the two most profitable crops implied by the PMP calibration methods. Remember, the PMP cost calibration is on a per acre basis.
4. A studious economics graduate student lives in a two-unit building next door to a group of loud economics undergraduates. The graduate student is preparing for a comprehensive exam and thus places a high value on peace and quiet at home. The undergraduates, in contrast, are about to graduate and thus like to have very loud parties every night.

Specifically, the undergraduates value their party each night as follows: \( V_u = 20 - 5h \), where \( V_u \) is the marginal benefit of the party per night to the undergrads and \( h \) is the number of hours of partying. For the graduate student, the marginal cost of noise is \( V_g = 5h \). All values are known to each party.

(a) How many hours will the party go on each night? Explain your answer. (For this part assume there are no rules against partying all night and that the graduate student and undergraduate student never interact with each other).

(b) Is the solution to part (a) efficient? Why or why not? (Be sure to define efficiency as an economist!).

(c) As a distinguished UC Davis – trained economist, you are hired to find the number of hours of partying that will maximize the combined welfare of both the undergraduates and the graduate student. What is the number of hours of partying that you recommend? Explain how you arrived at your recommendation.

(d) Can you devise a monetary transaction between the graduate student and the undergraduates that will lead to the socially optimal hours of partying? If not, explain why. If yes, clearly describe the transaction and explain how you came up with it.

(e) A non-UC Davis trained economist suggests that the optimal policy is to ban parties.

   (i) How much better off are the undergraduates under your transaction in part (d) than if the party was just banned? Explain.

   (ii) How much worse off is the graduate student under your transaction in part (d) than if the party was just banned? Explain.

(f) Explain the relevance of the Coase theorem to the above situation.
5. Microsoft has been accused in both federal and state courts of taking advantage of its market power in order to keep the prices of its products high, thus harming consumers of its software.

(a) One allegation is that the price Microsoft charges for its software is higher than it “should” be in a competitive market in terms of the markup of price over costs. Consider this allegation and how you might estimate measures to evaluate its legitimacy. In particular, what types of costs would you need to take into account? Would you be interested in average or marginal costs, and how might you distinguish them? How would you determine if the price was “too” high? (Use diagrams and/or equations to illustrate your points.)

(b) What kinds of data would you need and what estimation methods would you use to answer these questions (data analysis?, econometrics?)?

(c) Microsoft products are often sold as part of a computer system. For example, Dell may put a computer together, and purchase the software from Microsoft to load on the computer as part of the finished product. Therefore, the software “piece” of the final product may be considered an input into the final computer “output” for Dell. If this is the case, how might you measure how much of the monopolistic overcharge from Microsoft the final consumer (the purchaser of the computer) was paying? (Explain how evaluating the amount of this “tax” would require consideration of demand and supply curves, and what type of model you might construct to estimate these curves. Use diagrams and/or equations to illustrate your points.)

(d) Another concern raised has been whether this behavior by Microsoft limited innovation or technical change in the computer industry, and therefore hurt consumers also by reducing the quality or choice of software they might have. Discuss (in words – with support of graphs or equations if you can) how you as an economist would evaluate whether these concerns likely have merit.
6. Given the primal production problem:

\[ \text{Max } c'x \]
\[ x \]
\[ \text{subject } Ax \leq b, \quad x \geq 0 \]

where \( c \) is an \( n \) by \( l \) vector of net revenues per unit \( x \), \( A \) is an \( m \) by \( n \) matrix of linear input requirement coefficients, with \( n > m \) and rank \( A = m \), and defining the optimal basic solution as: \( x_B = B^{-1}b \):

(a) Write out the dual formulation of this problem, using the symbol \( \lambda \) for the vector of dual variables. Give a brief economic explanation of the dual constraints that you have defined.

(b) Show formally that optimality of the primal basic solution implies that the dual problem constraints are feasible.

(c) If a single element \( b_i \) of the right hand side vector in the problem in part (a) is parameterized over a range of values, show:

(i ) Why the resulting derived demand function is a step function.
(ii ) That the dual value on the primal constraint is equal to the marginal contribution of the resource to the objective function.

(d) Use micro theory and matrix algebra to show the relationship between the dual constraints and the dual complementary slackness principle.
INSTRUCTIONS:
Please answer TWO questions from Section One, ONE question from Section Two, and ONE question from Section Three. All four questions will be weighted equally when your exam is graded. Begin each question on a new sheet of paper.

You have 4 hours and 20 minutes to read and complete the exam. GOOD LUCK!

SECTION ONE. Answer TWO of the following four questions. Begin each question on a new sheet of paper.

1. The world price of crude oil has doubled in the last few years and is currently hovering above $50 per barrel. As in several other global markets, China plays an important role in crude oil. China's imports of crude oil rose 35% last year, making it the second largest importer in the world after the US.

Since the Asian financial crisis in 1997, China’s currency has been effectively pegged at 8.28 yuan to the US dollar. The US government claims that China’s fixed exchange rate keeps the price of exported goods from China artificially low. Some firms in the US claim the yuan is as much as 40 percent undervalued. Recently, the Bush administration has been increasing political pressure on China to revalue the yuan.

Assume you have just been hired as an economist by a large consulting firm. Your first task is to write a memo explaining what impact (if any) a significant revaluation of China's yuan would have on the price of oil in the world crude oil market. When writing your memo, be sure to state the explicit assumptions underlying your forecast of whether the world price of oil would rise or fall if the yuan appreciates.
2. 
A. Consider a Marshallian demand curve, \( P = c - dQ \). Algebraically show how the absolute value of the elasticity of demand varies with the price intercept, \( c \). Does the elasticity of demand vary inversely or directly with the price intercept? Please support your answer with a proof, using your expression for the elasticity of demand.

B. Consider the four linear demand curves (D1, D2, D3, and D4) in the figure below. The horizontal dashed line in the figure has been drawn at an arbitrary price. Please compare the elasticities on the different curves, at this common price, \( P \). Specifically,

i. Is the absolute value of the demand elasticity at point E less than, equal to, or greater than the elasticity at point F? Explain.

ii. Is the absolute value of the demand elasticity at point G less than, equal to, or greater than the elasticity at point E? Explain.

iii. Is the absolute value of the demand elasticity at point G less than, equal to, or greater than the elasticity at point H? Explain.
3. Suppose a monopolist can sell water in two markets that are effectively separated so he/she can price differently (price discriminate) in the two markets. The demand curves in these markets are given by:

\[ P_1 = 3 - \frac{1}{2} X_1 \quad \text{and} \quad P_2 = 2 - \frac{1}{2} X_2 \]

The variable costs of production are:

\[ C = 2 + (X_1 + X_2) \]

A. What are the profit maximizing prices in each market? What are the corresponding elasticities of demand in each market? What is the total profit?

B. What would happen to output if price discrimination was impossible because the water buyers (consumers) could resell water from one market to the other?

C. Is price discrimination between these two water markets desirable or undesirable for the monopolist? For the consumers?
4. Given the Cobb Douglas production function

\[ y = 2 \left( x_1^{\frac{1}{2}} x_2^{\frac{1}{2}} \right), \]

assume the price of output \( y \) is \( p \ (p = 0.5) \), the price of input \( x_1 \) is \( \omega_1 \ (\omega_1 = 4) \) the price of input \( x_2 \) is \( \omega_2 \ (\omega_2 = 4) \), and that the producer with this technology is a profit maximizer, and answer the following questions.

A. i. Derive the first order conditions for optimal input use.
   ii. Give an economic interpretation of these conditions.

B. i. Use the production function to define and briefly explain the concept of returns to scale.
   ii. Briefly explain the returns to scale that you would expect for the production function.

C. Use the results in Part A to:
   i. analytically derive the expansion path equation of the optimizing producer.
   ii. draw a diagram of the expansion path that you would expect.

D. i. Use your derivations to specify an input demand function for factor \( x_1 \).
   ii. Explain briefly how you would determine the elasticity of input demand.
SECTION TWO: Answer ONE of the following two questions.

5. Strawberry farmers must find an alternative to methyl bromide, which depletes the ozone layer and is scheduled to be banned. They want an alternative that is at least as profitable as methyl bromide. One chemical they are considering is chloropicrin. You are provided with the following data, and are asked to estimate the relationship between profits per acre and the pounds of chloropicrin applied per acre (application rate).

<table>
<thead>
<tr>
<th>Chloropicrin application rate (pounds/acre)</th>
<th>Profits (dollars/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4,500</td>
</tr>
<tr>
<td>100</td>
<td>7,800</td>
</tr>
<tr>
<td>200</td>
<td>9,400</td>
</tr>
<tr>
<td>300</td>
<td>9,500</td>
</tr>
</tbody>
</table>

A. Assume a linear relationship between profits and the chloropicrin application rate.
   i. Write down the econometric model, and identify its systematic and random components.
   ii. Given the data above, calculate the least squares estimates of the intercept and slope. Provide an economic interpretation of these estimates.
   iii. Calculate the value of the residuals for an application rate of 200 lbs/acre. Provide an economic interpretation of the residual.
   iv. If the application rate increases by 10%, how much will profits increase?
   v. Profits when using methyl bromide are $5,500/acre. How many pounds of chloropicrin must be applied for farmers to obtain the same profits?
   vi. Graph the relationship between the chloropicrin application rate use and profits per acre. Does this model make economic sense? Why or why not? HINT: In this problem, strawberries are produced using pesticides and land, which is measured in acres.

B. Assume that the relationship between profits per acre and the chloropicrin application rate is quadratic, and you have estimated the following relationship:

   \[ \text{Profits} = 4,354 + 35 \times \text{Rate} - 0.064 \times \text{Rate}^2 \]

   i. What is the profit-maximizing application rate for chloropicrin?
   ii. Graph the relationship between the application rate and profits per acre.
   iii. Does this model make economic sense? Why or why not?
   iv. Would it make economic sense if the estimated relationship was instead:

   \[ \text{Profits} = 4,608 + 18 \times \text{Rate} + 0.023 \times \text{Rate}^2 \]
6. Consider the following specifications of the demand for chicken.

\[
\begin{align*}
(1) \quad \ln Y_t &= \alpha_1 + \alpha_2 \ln X_2 + \alpha_3 \ln X_3 + u_t \\
(2) \quad \ln Y_t &= \gamma_1 + \gamma_2 \ln X_2 + \gamma_3 \ln X_3 + \gamma_4 \ln X + u_t \\
(3) \quad \ln Y_t &= \theta_1 + \theta_2 \ln X_2 + \theta_3 \ln X_3 + \theta_4 \ln X_4 + \theta_5 \ln X_5 + u_t \\
(4) \quad \ln Y_t &= \beta_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + u_t \\
(5) \quad \ln Y_t &= \sigma_1 + \sigma_2 \ln X_2 + \sigma_3 \ln X_3 + \sigma_4 \ln X_4 + \sigma_5 \ln X_5 + \sigma_6 \ln X_6 + u_t \\
\end{align*}
\]

\( Y = \) per capita consumption of chicken in pounds  
\( X_2 = \) real disposable income per capita in dollars  
\( X_3 = \) real retail price of chicken per pound in cents  
\( X_4 = \) real retail price of pork per pound in cents  
\( X_5 = \) real retail price of beef per pound in cents  
\( X_6 = \) average real price of pork and beef weighted by pounds consumed

A. Which of these demand functions would you choose to estimate, and why?

B. How would you interpret the coefficients of \( \ln X_2 \) and \( \ln X_3 \) in each of these models?

C. What is the difference between specifications (4) and (5)? Which do you prefer, and why?

D. Regardless of whether or not it is the correct model, consider the following estimate of specification (4):

\[
\hat{\ln Y_t} = 2.19 + 0.34 \ln X_2 - 0.50 \ln X_3 + 0.15 \ln X_4 + 0.09 \ln X_5 + u_t
\]

i. What is the income elasticity of the demand for chicken?
ii. What is the cross-price elasticity of the price of pork on the demand for chicken?
iii. Are all of the signs of the estimated coefficients consistent with the predictions of economic theory? Why or why not?

E. Many researchers hypothesize that peoples’ consumption decisions are influenced by their consumption decisions in previous periods.

i. If this hypothesis is correct, what assumption of the classical linear regression model is violated?
ii. What test would you use to determine whether or not this is a problem for your data?
iii. If necessary, how would you revise your estimation procedure to account for this problem?
SECTION THREE: Answer ONE of the following two questions.

7. Use the Gams printout below to answer the questions about the results of the cost "minimizing problem facing the Yolo Gravel Co that has to supply:
Six (6) Construction sites S1..S6 from three (3) Gravel Quarries Q1..Q3."
The costs of transporting the gravel from Quarry to Site are in the table below:

<table>
<thead>
<tr>
<th></th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>6</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>S2</td>
<td>7</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>S3</td>
<td>7</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>S4</td>
<td>8</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>S5</td>
<td>3</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>S6</td>
<td>11</td>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

EXIT -- OPTIMAL SOLUTION FOUND

---- EQU QUARRY QUANTITY OUT OF QUARRY

<table>
<thead>
<tr>
<th></th>
<th>LOWER</th>
<th>LEVEL</th>
<th>UPPER</th>
<th>MARGINAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>-INF</td>
<td>550.000</td>
<td>550.000</td>
<td>-3.000</td>
</tr>
<tr>
<td>Q2</td>
<td>-INF</td>
<td>400.000</td>
<td>400.000</td>
<td>-1.000</td>
</tr>
<tr>
<td>Q3</td>
<td>-INF</td>
<td>725.000</td>
<td>800.000</td>
<td>.</td>
</tr>
</tbody>
</table>

---- EQU DEMAND QUANTITY LOWER BOUND

<table>
<thead>
<tr>
<th></th>
<th>LOWER</th>
<th>LEVEL</th>
<th>UPPER</th>
<th>MARGINAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>305.000</td>
<td>305.000</td>
<td>+INF</td>
<td>5.000</td>
</tr>
<tr>
<td>S2</td>
<td>260.000</td>
<td>260.000</td>
<td>+INF</td>
<td>10.000</td>
</tr>
<tr>
<td>S3</td>
<td>180.000</td>
<td>180.000</td>
<td>+INF</td>
<td>4.000</td>
</tr>
<tr>
<td>S4</td>
<td>200.000</td>
<td>200.000</td>
<td>+INF</td>
<td>7.000</td>
</tr>
<tr>
<td>S5</td>
<td>410.000</td>
<td>410.000</td>
<td>+INF</td>
<td>6.000</td>
</tr>
<tr>
<td>S6</td>
<td>320.000</td>
<td>320.000</td>
<td>+INF</td>
<td>5.000</td>
</tr>
</tbody>
</table>

---- VAR X QUANTITIES QUARRY TO SITE

<table>
<thead>
<tr>
<th></th>
<th>LOWER</th>
<th>LEVEL</th>
<th>UPPER</th>
<th>MARGINAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1.S1</td>
<td>.</td>
<td>.</td>
<td>+INF</td>
<td>4.000</td>
</tr>
<tr>
<td>Q1.S2</td>
<td>.</td>
<td>140.000</td>
<td>+INF</td>
<td>.</td>
</tr>
<tr>
<td>Q1.S3</td>
<td>.</td>
<td>.</td>
<td>+INF</td>
<td>6.000</td>
</tr>
<tr>
<td>Q1.S4</td>
<td>.</td>
<td>.</td>
<td>+INF</td>
<td>4.000</td>
</tr>
<tr>
<td>Q1.S5</td>
<td>.</td>
<td>410.000</td>
<td>+INF</td>
<td>.</td>
</tr>
<tr>
<td>Q1.S6</td>
<td>.</td>
<td>.</td>
<td>+INF</td>
<td>9.000</td>
</tr>
<tr>
<td>Q2.S1</td>
<td>.</td>
<td>.</td>
<td>+INF</td>
<td>5.000</td>
</tr>
<tr>
<td>Q2.S2</td>
<td>.</td>
<td>80.000</td>
<td>+INF</td>
<td>.</td>
</tr>
<tr>
<td>Q2.S3</td>
<td>.</td>
<td>.</td>
<td>+INF</td>
<td>5.000</td>
</tr>
<tr>
<td>Q2.S4</td>
<td>.</td>
<td>.</td>
<td>+INF</td>
<td>2.000</td>
</tr>
<tr>
<td>Q2.S5</td>
<td>.</td>
<td>.</td>
<td>+INF</td>
<td>5.000</td>
</tr>
<tr>
<td>Q2.S6</td>
<td>.</td>
<td>320.000</td>
<td>+INF</td>
<td>.</td>
</tr>
<tr>
<td>Q3.S1</td>
<td>.</td>
<td>305.000</td>
<td>+INF</td>
<td>.</td>
</tr>
<tr>
<td>Q3.S2</td>
<td>.</td>
<td>40.000</td>
<td>+INF</td>
<td>.</td>
</tr>
<tr>
<td>Q3.S3</td>
<td>.</td>
<td>180.000</td>
<td>+INF</td>
<td>.</td>
</tr>
<tr>
<td>Q3.S4</td>
<td>.</td>
<td>200.000</td>
<td>+INF</td>
<td>.</td>
</tr>
<tr>
<td>Q3.S5</td>
<td>.</td>
<td>.</td>
<td>+INF</td>
<td>2.000</td>
</tr>
<tr>
<td>Q3.S6</td>
<td>.</td>
<td>.</td>
<td>+INF</td>
<td>5.000</td>
</tr>
</tbody>
</table>
A. If you were forced to deliver ALL the contracted gravel for Site # 4 from Quarry # 1, how much extra would it cost the company?

B. If Yolo county let you expand the capacity of one of the quarries
   i. Which quarry would you expand, and why ?
   ii. How much could you profitably spend per ton capacity on expansion?

C. If the trucking costs from quarry # 1 to sites #3 and #4 decreased by $4/ ton, how many of the optimal activities would change and why ?

D. Use the optimal trucking from Quarry #1 to sites S1, S2 and S3 to show that the Dual complementary slackness conditions hold.

E. Formally show how the Dual complementary slackness conditions are linked to the Simplex optimality conditions for this problem.
8. Given a standard PMP calibration problem with one binding resource constraint and observed levels of crop production $\bar{x}$, The LP model with calibration constraints added is defined as:

$$\begin{align*}
\text{Max} & \quad c'x \\
\text{Subject to} & \quad Ax \leq b \\
& \quad Ix \leq \bar{x} + \varepsilon = \\
& \quad x \geq 0
\end{align*}$$

Where $v$ is a $n \times 1$ vector of gross revenues, $c$ is a $n \times 1$ vector of average costs, $x$ is a $n \times 1$ vector of activity levels, $A$ is an $m \times n$ matrix of Leontief production coefficients, $b$ is a $m \times 1$ vector of input resources available, $\bar{x}$ is a $n \times 1$ vector of observed activity levels, and $\varepsilon$ is a corresponding vector of small perturbation variables.

A. Analytically explain whether a PMP calibrated model solution will optimize at the observed cropping levels without using additional information on the marginal activity.

B. "If you knew the elasticity of supply of the marginal crop, show how you could use this information in the calibration of the model.

C. "Compare and explain the properties of the two models calibrated by the two methods in Part A and Part B. Will the dual values for the binding constraint be the same for the models in Part A and Part B? Explain analytically.

D. If the PMP models in parts A, B, are used to generate points on a derived demand function for the constraining input by reducing the right hand side constraint value, and a supply function by changing the price of the marginal crop, describe analytically:

i. The difference in the resulting derived demand function between a LP model and the Part A PMP model.

ii. The difference in the supply function for the marginal crop, between the Part A PMP model and the Part B PMP model.
You have three hours for this exam. Choose four of the following questions to answer, including at least one from each section. Watch the time carefully; each question (but not parts of each question) count equally, so don’t get bogged down with any one. If you don’t get the whole answer within the designated time frame, do what you can and move on. The logic used to answer the question is important, so be sure to clearly specify your reasoning, with full sentences. Supporting your answer, usually using diagrams or equations, is also important. Make sure your writing is legible; if we can’t read it, it will be assumed wrong.

Section I

I.1.

Consider a case where a phone company (say, AT&T) has a very large share of the market, and therefore is considered an oligopolist (or even a monopolist if they control virtually all of the market).

a. Describe why this market situation might be considered by an economist to reduce welfare compared to a competitive market, using graphs and/or equations to support your argument.

b. If you were an economic consultant asked to evaluate the extent of economic loss from market power in this industry, discuss what kind of measure you would construct, and how you would measure and interpret your estimate of market power.

Now say that the regulatory agency is convinced by your (or others’) arguments that this company is too large and diversified, and the regulator decides it must be broken into pieces so there is more competition. Competition between these new companies takes place for a while but eventually mergers begin to take place (say, between Cingular and AT&T), and company diversification to increase (say, by AT&T trying to bundle cable TV with telephone services).

c. Discuss what kinds of economies might be present in this market that would motivate such behavior (the mergers and diversification). How might these economies be represented by graphs and/or equations, and how might they be measured?

d. Assuming the mergers and diversification were for economic reasons, does it appear that the initial partitioning of the company into smaller pieces was welfare-enhancing? Support your argument(s) with graphs and/or equations.
I.2.

Choose a (1) general function from consumer or producer theory (for example, a utility, indirect utility, expenditure, production, cost, or profit function).

a. Identify (mathematically and/or graphically) the properties (regularity conditions) that the function must satisfy to be consistent with economic theory.

b. Explain the intuition behind these conditions and why they must be satisfied for the theory to “make sense.”

c. Discuss whether these conditions imply anything about properties for, or shapes of, other related economic functions (say, demand or supply functions).

d. Explain how these conditions would inform you about empirical analysis. That is, what types of economic questions might you address using such a function, how would you construct an estimating equation(s) to answer the question, and how would the properties provide guidance regarding the empirical results you would expect (e.g., signs of parameters).
Section II.

II.1. The Cobb-Douglas production function relates output (Q) to capital (K) and labor (L) inputs and a random error u by the relation

\[ Q_t = \beta_1 K_t^{\beta_2} L_t^{\beta_3} e^{u_t}, \quad u_t \sim iid N(0, \sigma^2) \]

which is linear in the logarithms and produces the regression equation

\[ \log Q_t = \log \beta_1 + \beta_2 \log K_t + \beta_3 \log L_t + u_t \]

rewritten

\[ Y_t = \beta_1^* + \beta_2 X_{i2} + \beta_3 X_{i3} + u_t \]

where \( \beta_1^* \equiv \log \beta_1, \quad Y_t \equiv \log Q_t, \quad X_{i2} \equiv \log K_t, \quad \) and \( X_{i3} \equiv \log L_t. \)

a. Some economists are certain that there are constant returns to scale, i.e., that \( \beta_2 + \beta_3 = 1 \) and want to force this to be true when obtaining their regression estimates. How would you set up the regression to do this? Briefly, why would you impose this restriction if you believed it to be true?

b. Other economists are less sure about constant returns to scale, and would test it rather than impose it. How would you use an indirect t test to answer this question? Be explicit about what the variables are in the regression you propose to run. (If you cannot use the indirect t test, use any alternative test for partial credit.)

c. It has been argued that it is not just capital that determines output, but instead it is capital that is actually in production (since during slumps there may be excess capacity). For a given industry, the government reports a series on capacity utilization (C), the proportion of productive capacity that is actually in use. Then the capital input should be \( K \times C \) rather than just K so that now

\[ Q_t = \beta_1 (K_t C_t)^{\beta_2} L_t^{\beta_3} e^{u_t} \]

which becomes

\[ \log Q_t = \log \beta_1 + \beta_2 \log K_t + \beta_3 \log C_t + \beta_3 \log L_t + u_t \]

after taking logarithms. Renaming the variables, we get

\[ Y_t = \beta_1^* + \beta_2 X_{i2} + \beta_2 X_{i4} + \beta_3 X_{i3} + u_t \]

with \( X_{i4} \equiv \log C_t \) and the remaining variables as defined above.

c1. If this new model is in fact correct and capacity utilization is an important part of the model specification, what implications would this have for the parameter estimates and hypothesis tests in parts a and b above?

c2. How would you estimate the new model incorporating the capacity utilization effect? Be sure to explicitly develop the variables used in the regression. (Notice that since utilized capital is \( K_t C_t \) both \( \log K_t \) and \( \log C_t \) have the same coefficient \( \beta_2 \).)
II.2.
Cross-section data on aggregate personal income, expenditures on domestic travel, and population for the 50 states and D.C. in 1993 were reported in the 1995 Statistical Abstract of the United States. The data are ordered from smallest to largest population. The variable definitions are:

- `exptrav` = Travel expenditures in billions of dollars, (Range 0.708 - 42.48);
- `income` = Personal Income in billions of dollars, Table 712, (Range 9.3 - 683.5);
- `pop` = Population is in millions, Table 27, Page 28 (Range 0.47 - 31.217).

An ordinary least squares (OLS) regression was run relating the logarithm of expenditures on travel to a constant and the logarithm of income (the population data were not used) with the following results:

Model 1: OLS estimates using the 51 observations 1-51
Dependent variable: ln `exptrav`

| PARAMETER | VARIABLE | COEFFICIENT | STDERR | T STAT | 2Prob(t > |T|) |
|-----------|----------|-------------|--------|--------|-----------|
| $\beta_1$ | const    | -2.000      | 0.236  | -8.461 | < 0.00001 *** |
| $\beta_2$ | ln `income` | 0.821      | 0.0569 | 14.742 | < 0.00001 *** |

Mean of dependent variable = 1.377
Standard deviation of dep. var. = 0.965
Sum of squared residuals = 8.573
Standard error of residuals = 0.418
Unadjusted R-squared = 0.816
Adjusted R-squared = 0.812

a. Assuming the model is correctly specified, formally test the hypothesis that the expenditure – income elasticity is equal to one at the 5% significance level. (Note that the elasticity is the coefficient in this double logarithm model.) State the null and alternate hypotheses and give the test statistic and its distribution, and a plain language conclusion.

b. It is suspected that the error terms are heteroskedastic, with the variances changing with population. How would you use the Goldfeld-Quandt (GQ) test to confirm or refute this suspicion? Describe any regressions you would run to compute the test. State the null and alternate hypotheses, and the test statistic and its distribution. Would you reject the null hypothesis for large values of the test statistic, or small? How would you tell whether the variances increase or decrease with population? (Answer all parts)
c. Suppose the GQ test confirms significant heteroskedasticity, with the variances increasing with the square of population. What implications would this have for the OLS estimates and hypothesis test in part a. above?

d. Specify a model to account for the heteroskedasticity based on your finding in part c. above. How would you estimate the parameters of new model? Be explicit regarding any transformed variables you would construct, and the regression you would run. Show how the transformation eliminates heteroskedasticity.

e. Verbally, what properties could you claim for the estimates in part d. above? Assume that all the classical assumptions hold except for the heteroskedastic error.
Section III.

III.1.

In a linear statistical model, the least-squares (LS) methodology can be specified as follows:

PRIMAL:

\[
\min_{\beta, u} SSR \quad u'u/2
\]  

subject to

\[
y = X\beta + u
\]  

where SSR is the sum of squared residuals, \(y\) is a \((T \times 1)\) vector of dependent variables, \(X\) is a \((T \times K)\) matrix of explanatory variables, \(\beta\) is a \((K \times 1)\) vector of unknown parameters and \(u\) is a \((T \times 1)\) vector of unknown residuals.

Given the above specification,

a) Derive the dual specification corresponding to the above PRIMAL problem.

b) Give a meaningful interpretation of the objective functions of the primal and dual problems. Interpret (explain) the dual constraints.

c) What are the Lagrange multipliers of the dual constraints?
III.2.

Given a vector of inverse demand functions for final commodities in number greater than two, \( p \ c - D x \), where \( p \) is the vector of prices, \( x \) is the vector of quantities, \( D \) is an ASYMMETRIC positive semidefinite matrix, and given a linear technology defined as \( Ax \leq b \), where \( A \) is the matrix of technical coefficients and \( b \) is the vector of limiting inputs,

a) State (specify) the relevant analytical problem of a perfectly discriminating monopolist who owns all the inverse demand functions. Clearly explain the economic context and the analytical setup BEFORE writing down any algebraic formulation of the problem.

b) Re-state the above problem in terms of the Linear Complementarity Problem and explain each step.
You have four hours for this exam after a 20 minute reading period (8:30-12:50). You do not need to use the whole time period; each of the three questions should take about one hour, so you have one hour extra if you need it.

Choose one question from each of the three following sections to answer. Watch the time carefully; each question (but not parts of each question) counts equally, so don’t get bogged down with any one. The logic used to answer the question is important, so be sure to clearly specify your reasoning, with full sentences. Supporting your answer, usually by diagrams or equations, is also important. Make sure your writing is legible; if we can’t read it, it will be assumed wrong.
Section I.

I.1. Suppose that a researcher wants to estimate a demand function for oranges. She wants to estimate the effect of changes in the own price of oranges on the quantity demanded of oranges. Only retail scanner data, however, are available. She does not have consumers’ per capita income that theory dictates should be included in the demand equation. She estimates the following function:

\[ Y_i = \beta_1 + \beta_2 X_i + u_i \]

where \( Y_i \) represents per capita quantity demanded of oranges in pounds, \( X_i \) denotes price of oranges in dollars per pound, and \( u_i \) represents all omitted factors.

a. Derive the least squares estimator of \( \beta_2 \) in the above model

b. Does the ordinary least squares estimated coefficient of \( \beta_2 \) represent the impact of price of oranges on the quantity demanded of oranges? Explain verbally. Be specific.

c. Assume that the true demand function includes own price and per capita income (also continue to assume a linear model, as above). Is the least squares estimator in part (a) biased? Justify your answer and explain whether it is unbiased, biased upward, or biased downward.

d. Given that the variance of the least squares estimator of \( \beta_2 \) in part (a) is smaller than the variance of the estimator of \( \beta_2 \) obtained when both price and income are included as regressors, would you recommend omitting relevant variables in a demand function? Explain.

e. Suppose we include all the explanatory variables in the data set in the demand function of oranges (assume \( K < n \), i.e., the number of explanatory variables is less than the sample size). Discuss what affect this would have on the properties of the estimated coefficients.
I.2.

Given the following regressions of average hourly earnings on gender and education binary variables and other characteristics, please answer the questions below.

<table>
<thead>
<tr>
<th>Dependent Variable: Average hourly earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regressor</strong></td>
</tr>
<tr>
<td>College</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Northeast</td>
</tr>
<tr>
<td>Midwest</td>
</tr>
<tr>
<td>South</td>
</tr>
<tr>
<td>Intercept</td>
</tr>
<tr>
<td>SER(standard error of regr.)</td>
</tr>
<tr>
<td>$R^2$</td>
</tr>
<tr>
<td>n</td>
</tr>
</tbody>
</table>

where,

Dep. Var. = average hourly earnings in 1998 dollars
College = binary variable (1 if college, 0 if high school)
Female = binary variable (1 if female, 0 if male)
Age = age (in years)
Northeast = binary variable (1 if region = Northeast, 0 otherwise)
Midwest = binary variable (1 if region = Midwest, 0 otherwise)
South = binary variable (1 if region = South, 0 otherwise)
West = binary variable (1 if region = West, 0 otherwise)
a. Formally, explain whether there appear to be important regional differences. As always, state the null and alternate hypotheses, the test statistic and its distribution, and draw a precise conclusion in plain language.

b. Suppose that all or most of the individual coefficients are not significantly different from zero at any reasonable level of significance. Is it possible to obtain a significant result for the whole regression (or goodness of fit)? Explain.

c. Suppose the researcher includes all four regional dummy variables in the above model. What are the econometric consequences of this approach?

d. Juanita is a 28-year-old female college graduate from the South. Jennifer is a 28-year-old female college graduate from the Midwest. Calculate the expected difference in earnings between Juanita and Jennifer.

e. Explain how a researcher can always obtain a high $R^2$. What may be the costs associated with only concentrating on obtaining a high $R^2$. 

Section II.

II.1. Say that you took a job for the California Department of Social Services and were asked to do an analysis of food insecurity in California. In particular, you are asked to address concerns about how low income households allocate their incomes to different types of foods, with a focus on dairy products.

Your boss suggests that you use some household survey data on prices and quantities of food demand by individuals of different income levels to estimate a log-log equation for dairy product demand of the form:

$$\ln D_i = \alpha \ln p_{Di} + \beta \ln p_{Fi} + \gamma \ln p_{Mi} + \delta \ln I_i,$$

where $i$ denotes individual, $D_i$ is the quantity of dairy products purchased by individual $i$, $p_m$ the price of food product $m$ paid by individual $i$, (where the $m$ are $D$=dairy products, $F$=fruit, $M$=meat), $I_i$ the income of individual $i$, and $\alpha$, $\beta$, $\gamma$ and $\delta$ the parameters to be estimated. Your boss says that from estimates of this equation you should be able to analyze your questions of interest.

You first want to theoretically evaluate this model and think about its application. Discuss briefly, with diagrams or equations as support of your answer if relevant:

a) What theoretical optimization model does such an equation come from (write out or diagram), and what assumptions are implied by the theory? Might the assumptions limit your analysis? If no, why not. If yes, how?

b) What are the required properties of such a function (such as monotonicity, homogeneity), and do any of the properties provide information about what sign or size the estimated coefficients of the model should be?

c) If you wished to evaluate the (own and cross) price and income demand responsiveness of individuals in this sample, what estimates would you compute?

d) If you are interested in the differential demand behavior of higher and lower income individuals, or when prices of other products are relatively high or low, can you address such questions with this equation? If yes, how? If no, what might you do to adapt the model to do so?

e) If you think peoples’ behavior has differed over time, can you address this with the model? If no, what adaptions would allow you to do so?

f) Does a single equation like this represent the behavior implied by the underlying theoretical model? Might this be important to consider?

g) Are there other models that you might alternatively use to address your questions? For example, AIDS or latent variable models? Briefly outline how the theoretical foundations of such models differ, and what different kinds of information you might obtain from using such models.

h) What are you going to suggest to your boss?
II.2.

Say that you are interested in analyzing production relationships for California fruit and vegetable producers. In particular, you are interested in what types of production structure and behavior affect the well-being of farmers. You initially decide to carry out your analysis based on estimation of the general production function:

\[ q = f(K, L, A, S, T, t), \]

where \( q \) is output (an aggregate of fruit and vegetable production), \( K \) is capital (such as tractors), \( L \) is labor, \( A \) is land (acreage), \( S \) is seeds, \( T \) is trees (stock of fruit trees), and \( t \) is time.

Before assuming a particular functional form for estimation, you want to think conceptually about how you would use this function to evaluate the production relationships you are interested in, and whether another type of model (such as one based on cost or profit functions, or directly on demand or supply equations) might be preferable to answer the questions you are interested in.

Discuss, using diagrams or math to support your statements, whether and how you could use such a function to evaluate:

a) **substitution among inputs** For example, can you use such a function to create measures that show how farmers respond to increasing land prices? If not, what kind of theoretical function might be a better basis to evaluate such questions?

b) **scale economies** For example, can you use such a function to determine whether farmers with bigger farms produce more “efficiently”? If not, what kind of model, or adaptation of this model, would you need to do so?

c) **scope economies** For example, might farmers that produce both fruit and vegetables produce more (or less) efficiently than those who produce only one? If not, suggest alternative models that might allow consideration of this possibility.

d) **output choice and substitution** For example, can you consider whether and why farmers might decide to produce alfalfa instead of tomatoes? If not, what kind of model would you need to do so?

e) **technical change** How would you represent this? Or how would you adapt the model to allow you to do so?

f) **Short- versus long-run behavior** What would the distinction between short and long run behavior depend on, and what kind of model might you need to consider such differences?
Section III.

III.1.

This question deals with risky output prices within the context of a single “price-taking” firm.

The firm uses a non-stochastic linear technology represented by the matrix $A$ of technical coefficients. It possesses a vector, $b$, of non-stochastic quantities of limiting resources. However, it faces a vector of stochastic output prices, denoted by a “tilde,” $\tilde{p}$.

a) Discuss the optimization goal of this firm using the expected utility framework. That is, the firm wishes to maximize its expected utility of money subject to the available technology.

To achieve this goal, assume that the entrepreneur in question possesses the following utility function for money, $r : u(r) = 1 - e^{-\phi r}$ where $\phi$ is a constant risk aversion coefficient. Assume also that prices are distributed normally as $\tilde{p} \sim N[E(\tilde{p}), \Sigma_p]$.

b) Set up and discuss in detail the primal and dual quadratic programming specifications that represent this problem. That is,

(i) Explain all the components of the problem and give a complete interpretation of all the primal and dual constraints.

(ii) Explain how you derive, and then derive, the dual specification.

(iii) Explain what is a risk aversion coefficient and what is a risk premium.
III.2. This question is about market equilibrium with many price-taking producers. It has two parts.

**Part One: symmetry of the matrices \( D \) and \( E \).**

To begin with, assume consumers are represented by an aggregate system of (inverse) demand functions \( p \cdot c - Dx \), where \( p \) is a vector of final commodity prices faced by consumers, \( x \) is a vector of final commodity quantities purchased by consumers, \( c \) is a vector of intercepts of the demand functions and \( D \) is a symmetric, positive semidefinite matrix of price/quantity slopes. There is a large number, \( N \), of commodities.

On the producers’ side, assume the total supply of resources in the economy is \( s = b + Ey \), where \( s \) is a vector of total quantities of resources, \( y \) is a vector of implicit prices of resources, \( b \) is vector of intercepts and \( E \) is a symmetric positive semidefinite matrix. There is a large number, \( M \), of resources, and a large number of competitive firms, \( K \), each of which operates using a specific linear technology, \( A_k \), to produce a specific vector of outputs, \( x_k \), using a specific vector of resources, \( s_k \). Hence, the given information is represented by the symbols \( c, D, b, E, A_k \). The unknowns \( p, x, x_k, s, s_k, y \) and all the other dual variables associated with the primal constraints are regarded as the solution of this problem.

Set up a symmetric quadratic programming framework that will represent a general market equilibrium. You must derive the dual specification. In doing so, give a complete technical and economic explanation of the various components of the problem with special attention to the meaning of the dual constraints. In other words, you must discuss the general economic framework for this scenario and state the corresponding analytical relations (and what they mean) that correspond to a system of equations capable of producing a meaningful solution.

**Part Two: asymmetry of the matrices \( D \) and \( E \).**

It is unlikely that the price/quantity matrices \( D \) and \( E \) of systems of demand and supply functions, which have been estimated by econometric methods, will turn out to be symmetric. In this case, these systems are not integrable.

Discuss and set up the appropriate programming framework corresponding to this modification of the general market equilibrium problem using the specification of the various components given in Part I (except for the symmetry of the \( D \) and \( E \) matrices).
University of California, Davis  
*Department of Agricultural and Resource Economics*

M.S. Comprehensive Exam  
August 20, 2007

You have four hours for this exam after a 20 minute reading period (8:30-12:50). You do not need to use the whole time period; each of the three questions should take about one hour, so you have one hour extra if you need it.

**Choose one** question from **each** of the **three** following **sections** to answer.  
**Watch the time** carefully; each question (but *not* parts of each question) counts equally, so don’t get bogged down with any one. The logic used to answer the question is important, so be sure to clearly specify your reasoning, with full sentences. Supporting your answer, usually by diagrams or equations, is also important. Make sure your writing is legible; if we can’t read it, it will be assumed wrong.
Section I.

I.1. Consider the estimated model of the value of houses in a particular area.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>28.41</td>
<td>5.37</td>
</tr>
<tr>
<td>CRIME</td>
<td>-0.18</td>
<td>0.04</td>
</tr>
<tr>
<td>NITOX</td>
<td>-22.81</td>
<td>4.16</td>
</tr>
<tr>
<td>ROOMS</td>
<td>6.37</td>
<td>0.39</td>
</tr>
<tr>
<td>AGE</td>
<td>-0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>DIST</td>
<td>-1.33</td>
<td>0.20</td>
</tr>
<tr>
<td>ACCESS</td>
<td>0.27</td>
<td>0.07</td>
</tr>
<tr>
<td>TAX</td>
<td>-0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>PTRATIO</td>
<td>-1.18</td>
<td>0.14</td>
</tr>
</tbody>
</table>

where

VALUE = median value of owner-occupied homes in $1000’s and is the dependent variable,
CRIME = per capita crime rate,
NITOX = nitric oxides concentration (parts per million).
ROOMS = average number of rooms per dwelling,
AGE = proportion of owner-occupied units built prior to 1940,
DIST = weighted distances to the nearest five employment centers,
ACCESS = index of accessibility to radial highways,
TAX = full-value property-tax rate per $10,000, and
PTRATIO = pupil-teacher ratio by town.

a. Find a 95% confidence interval for the coefficient of CRIME. (Note: You may use the asymptotic critical t value.)

b. Test the hypothesis that increasing the number of rooms by one increases the value of a house by $7,000.

c. Suppose that you believe heteroskedasticity might be present. How would you test for it? If it were present, how would you estimate the model?

d. What impact would multicollinearity have on the estimated coefficients? Be specific.

e. How would you arrive at the “best” functional form for the value of homes?
I.2.

(Note: each of these questions is separate. You can tie your responses in b-e to the model in (a) but it is not necessary.)

a. A standard “money demand” function used by macroeconomists has the form:

\[ \ln(m) = \beta_0 + \beta_1 \ln(GDP) + \beta_2 R \]

where \( m \) is the quantity of (real) money, \( GDP \) is the value of (real) gross domestic product, and \( R \) is the value of the nominal interest rate measured in percent per year. Suppose that \( \beta_1 = 1.0 \) and \( \beta_2 = -0.02 \).

(i) What will happen to the value of “\( m \)” if GDP increases by 2%?

(ii) What will happen to “\( m \)” if the interest rate increases from 4% to 5%?

b. Verbally, in 25 words or less, explain the meaning of consistency. Provide an example of a consistent estimator.

c. Give an example of perfect or exact multicollinearity.

d. Say that the true model is

\[ y_i = \beta_1 + \beta_2 x_{i2} + \beta_3 x_{i3} + u_i \]

but you estimate the model

\[ y_i = \beta_1 + \beta_2 x_{i2} + v_i \]

show that the least squares estimator of \( \beta_2 \) is biased.

e. If a Durbin-Watson statistic indicates significant first-order autocorrelation, what are the properties of your least-squares estimators? What estimation procedure would you recommend? Be specific.
Section II.

II.1.

Say that you are interested in estimating a model of hospitals’ costs and its determinants, such as equipment prices, nurses’ wages, and scale economies. You decide to estimate a cost function of the form:

\[ \ln TC = \alpha_0 + \alpha_Y Y + \alpha_K P_K + \alpha_L P_L + \alpha_M P_M, \]

where TC is total cost, Y is output, P_K is the price of capital equipment, P_L is the price of labor (nurses, doctors), and P_M is the price of materials (medications, food...),

and that you obtained the estimates (with the standard errors in parentheses)

\[
\begin{align*}
\alpha_0 & \quad 0.5 \ (0.03) \\
\alpha_Y & \quad 1.2 \ (0.9) \\
\alpha_K & \quad -0.4 \ (0.02) \\
\alpha_L & \quad 2.3 \ (0.3) \\
\alpha_M & \quad 4.2 \ (1.5)
\end{align*}
\]

a. Can you identify any problems with the specification of the equation that might not be consistent with production theory?
b. Can you identify any issues about the parameter estimates that might lead you to question your specification and/or data?
c. What kinds of measures would you want to compute to evaluate the questions you might be interested in answering? Can you answer them with these estimates?

Say that you decide to try another specification, the log-log form:

\[ \ln TC = \ln \alpha_0 + \alpha_Y \ln Y + \alpha_K \ln P_K + \alpha_L \ln P_L + \alpha_M \ln P_M. \]

resulting in the following parameters

\[
\begin{align*}
\alpha_0 & \quad 5.2 \ (1.7) \\
\alpha_Y & \quad 0.8 \ (0.07) \\
\alpha_K & \quad 0.2 \ (0.02) \\
\alpha_L & \quad 0.3 \ (0.1) \\
\alpha_M & \quad 0.7 \ (0.5)
\end{align*}
\]

d. What advantages might this have over the previous specification, based on your answers to a-d above?
e. What are the interpretations of these parameter estimates?
f. Does this seem like a better or worse specification than above? Why?

Then you decide to instead estimate a 2nd order log-log function (a translog), of the form:

\[
\begin{align*}
\ln TC &= \ln \alpha_0 + \ln Y + \alpha_K \ln P_K + \alpha_L \ln P_L + \alpha_M \ln P_M + \frac{1}{2} \gamma_{KK} (\ln P_K)^2 + \gamma_{KL} \ln P_K \ln P_L \\
&\quad + \gamma_{KM} \ln P_K \ln P_M + \frac{1}{2} \gamma_{LL} (\ln P_L)^2 + \gamma_{LM} \ln P_L \ln P_M + \frac{1}{2} \gamma_{MM} (\ln P_M)^2,
\end{align*}
\]

g. What advantages and disadvantages might this function have over the previous ones?
h. Is this function set up to appropriately ask the questions you’re interested in?
II.2.

The retail market for compact disks (CDs) consists of many stores, from grocery and warehouse stores to Virgin Records. Assume that the primary producer of CDs (Sony for the purpose of this example) decides that due to competition from Internet download sites they will drop the price of their CDs to purchasers of the CDs (wholesalers and retail stores) from $8 to $7. Further, assume that the standard retail price of a CD is $12.99.

a. Assume that all retail stores that sell CDs purchase their CDs directly from Sony, and that the retail market is perfectly competitive. How would Sony’s decision to lower their price affect the retail price of a CD? Why? (draw diagrams and/or use equations to support your discussion)

b. Would there be a difference between what would happen in the short run and long run? Why? Trace any adjustment you would expect to take place, and corresponding price changes (qualitatively, not numerically).

c. Now assume that companies in the retail market are not perfectly competitive, but are differentiated. For example, both customers and competitive conditions for Virgin Records are likely very different than Costco. Would you expect pricing responses to be different in the two outlets? How would you represent that kind of situation (graphically or by equations) and what kind of final CD price would you expect in that market (qualitatively, not numerically)? Would prices vary across retailers?

d. If there were an additional layer of distribution so that instead of purchasing directly from Sony retailers purchased CD’s from wholesalers, would that make a difference for your analysis?
Section III.

III. 1.

This question deals with the behavior of a perfectly discriminating monopolist.

A given entrepreneur “owns” a system of demand functions for final commodities represented by \( p^c - Dx \), where \( p \) is a vector of final commodity prices faced by consumers, \( x \) is a vector of final commodity quantities purchased by consumers, \( c \) is a vector of intercepts of the demand functions and \( D \) is an asymmetric, positive semidefinite matrix of price/quantity slopes. There are more than two final commodities.

The available technology is represented by a matrix \( A \) of fixed coefficients. The vector of the available limiting resource is represented by \( b \).

a. Before writing any mathematical symbols, discuss in English the economic framework for this perfectly discriminating monopolist that will lead to an equilibrium solution.

b. Set up the analytical framework representing this behavior. Explain each component of the primal problem.

c. Draw and explain a careful diagram representing the equilibrium scenario of this entrepreneur (in this case, assume only one final commodity).

d. Derive the dual problem and explain each component of it.
III.2.

This question is about market equilibrium with many price-taking producers.

To begin with, consumers are represented by an aggregate system of (inverse) demand functions \( p\ -c - D x \), where \( p \) is a vector of final commodity prices faced by consumers, \( x \) is a vector of final commodity quantities purchased by consumers, \( c \) is a vector of intercepts of the demand functions and \( D \) is an asymmetric, positive semidefinite matrix of price/quantity slopes. There is a large number, \( N \), of commodities.

On the producers' side, the relevant information is as follows: The total supply of resources in the economy is \( s\ - b + E y \), where \( s \) is a vector of total quantities of resources, \( y \) is a vector of implicit prices of resources, \( b \) is vector of intercepts and \( E \) is an asymmetric positive semidefinite matrix. There is a large number, \( M \), of resources. There exists also a large number of competitive firms, \( K \), each of which operates using a specific linear technology, \( A_k, k = 1,\ldots,K \), for producing a specific vector of outputs, \( x_k \) using a specific vector of resources, \( s_k \).

Hence, the given information is represented by the following symbols: \( c, D, b, E, A_k \). The unknowns \( p, x, x_k, s, s_k, y \) and all the other dual variables associated with the primal constraints are regarded as the solution of this problem.

You are asked to set up a symmetric quadratic programming framework that will represent a general market equilibrium for this scenario. You must derive the dual specification. In doing so, you must give a complete technical and economic explanation of the various components of the problem with special attention to the meaning of the dual constraints. In other words, you must discuss the general economic framework for this scenario and state the corresponding analytical relations (and what they mean) that will correspond to a system of equations capable of producing a meaningful solution.
You have four hours to write this exam plus a 20 minute reading period (8:30 – 12:50). You do not need to use the whole time period. This exam consists of six questions and is divided into three parts. Read the following directions carefully and follow them exactly.

Part 1 consists of Question 1. You MUST answer question 1. It represents 30% of your grade.

Part 2 consists of Questions 2, 3, and 4. You MUST answer two of these three questions, but do not answer all three. Each question here is worth 20% of your score, so Part 2 is worth 40% in total.

Part 3 consists of Questions 5 and 6. You MUST answer one of these two questions, but do not answer both. Each question here is worth 30% of your score, so Part 3 is worth 30% in total.

Be sure to allocate your time wisely given this information.

The logic used to answer each question is important, so be sure to clearly specify your reasoning, using full sentences. Supporting your answers with diagrams and/or equations is also important. Make sure your writing is legible. Unreadable answers are assumed to be wrong.
1. Most goods (e.g., wine, cars, etc.) have multiple attributes (e.g., sugar content, engine size, etc.) – each of which may be valued differently by consumers. Applied economists often use hedonic price regressions to estimate the value consumers attach to these various attributes of a good. A hedonic price regression includes the price of the good as the dependent variable and attributes of the good as independent variables.

Below are hedonic price regression results from a sample of 782 different types of olive oil available in European markets. The dependent variable is price in Euros per 0.5 liter. Note that Europe uses International Olive Council standards for determining whether a particular olive oil qualifies as “extra virgin”: the oil must be processed in a certain way and must have no taste defects.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Degree of Acidity (mean=0.58)</td>
<td>-1.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Extra virgin dummy (1 if certified as extra virgin, 0 otherwise)</td>
<td>1.7</td>
<td>0.4</td>
</tr>
<tr>
<td>Italian origin dummy</td>
<td>0.7</td>
<td>0.1</td>
</tr>
<tr>
<td>Greek origin dummy</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Spanish origin dummy</td>
<td>0.3</td>
<td>0.05</td>
</tr>
<tr>
<td>Glass bottle dummy (1 if sold in glass bottle, 0 otherwise)</td>
<td>1.2</td>
<td>1.4</td>
</tr>
</tbody>
</table>

N=782  
R²=0.67

a. Interpret these econometric results in words. As you discuss these results, carefully assess the statistical and economic significance of these estimates.

b. Formulate null and alternative hypotheses to test whether consumers value extra virgin certification. Derive a test statistic from these results to test this hypothesis and interpret the result of this test.

c. Formulate null and alternative hypotheses to test whether consumers distinguish and discriminate between olive oil from different origins. Discuss carefully how you would test this null hypothesis, including the test statistic you would use.

d. Suppose Greek olives tend to have relatively high acidity, while Spanish and Italian olives tend to have lower acidity. Describe why this matters for the validity and interpretation of this hedonic price regression.

e. The U.S. does not currently regulate or certify what qualifies as extra virgin olive oil. As a result, there is substantial consumer confusion about what the term extra virgin means on an olive oil label. You have been given access to
the data used in the regression above and have collected data from an additional 700 types of olive oil in the U.S. market. Specify a single regression model you could estimate from the pooled European and U.S. data to test whether Americans and Europeans are different in their hedonic valuation of olive oil.

f. The California legislature is currently debating a bill that would impose International Olive Council standards for any extra virgin olive oil sold in California. Suppose the bill passes and these standards are effective January 1, 2009. Suppose further that you could track the prices of 300 types of olive oil sold in California each year from 2008 to 2013. Specify and discuss a model you could estimate in 2014 to determine how California’s adoption of extra virgin standards has changed consumer valuation of extra virgin olive oil over the period 2008 to 2013.

g. In general, what market assumptions must hold in order for hedonic price regressions to offer meaningful insights into consumers’ marginal valuation of attributes?
PART 2: YOU MUST ANSWER TWO OF THE FOLLOWING THREE QUESTIONS (QUESTION 2, 3, AND 4). DO NOT ANSWER ALL THREE.

2. Suppose a farm labor union is investigating a sector of California agriculture that produces an edible widget, using labor as a major input. The labor union has asked for your economics advice on whether it should try to organize workers in this sector and attempt to raise their wages, as the workers are complaining about low wages. You determine that you must first study the characteristics of the demand for labor in this sector before providing advice to the union.

Assume that labor costs are a large share of production costs in this sector, and the other major input is energy. Further, assume that the price elasticity of demand for the final product (edible widgets) is relatively high, as there are a number of substitutes available to final consumers.

a. For this sector, explain how you would derive a rough estimate of the own wage elasticity of demand for labor, defined as the percentage change in its employment given a 1% increase in the wage rate. Explain theoretically what functional relationships you would need to represent and estimate in order to compute such an elasticity, and whether your theory and intuition provide insights about the size of such an elasticity. If you need to make additional assumptions to answer this question, please state them clearly.

b. Draw the supply and demand curves for labor in this sector. Indicate clearly how your estimate of the elasticity of demand for labor corresponds to what you show in the diagram. Then using this diagram, indicate the economic effects on wages and employment of any attempt by the union to try and raise wages. Clearly state your final recommendation to the union’s leadership.
3. In 2008 we are experiencing a significant commodity price boom. Grains and oilseeds have doubled or tripled in price in the past 18 months and livestock prices are now starting to increase, up about 25% in the past 6 months.

Argentina is an important exporter of beef, soybeans, wheat and other agricultural products. In response to the recent increase in global agricultural commodity prices, Argentina has imposed high export taxes on agricultural products. The export tax on many agricultural products now exceeds 40% in Argentina.

a. Why do you suppose that Argentina’s government would decide to tax agricultural exports? Please explain in detail who in Argentina would gain and who would lose from such a tax, in terms of economic welfare. What about the net economic effects on the country as a whole? Feel free to use graphs and/or algebra as part of your answer. If you make certain assumptions in arriving at your answer, please state them clearly.

b. If the government of Argentina implemented the export tax to try and correct what they perceive as a “problem” in the domestic market, do you think that use of a “domestic” policy instrument rather than a “trade” policy instrument (i.e., the export tax) would have been a better or worse choice from an economics perspective? Please answer which is better—a domestic or a trade policy instrument—and explain your answer, including the criterion used for ranking the two policy options.

c. Finally, what impact do you suppose the export tax might have on world markets for the commodities in question? Please use clear economic logic in answering this question and give precise reasoning.
4. Both federal and state laws in the U.S. allow agricultural industries to undertake joint action, if they choose, through what are known as marketing orders. This question will examine one of the functions that can be performed under the authority of marketing orders, generic advertising.

a. Generic advertising works by collecting a tax per-unit-of-production from farmers (i.e., an excise tax) and using the funds collected to promote the product. Use a simple graphical model of a competitive market to illustrate how a generic advertising program will affect the market. Consider effects on both demand and supply. Explain your graphical analysis in words.

b. A key question for producers is whether generic advertising programs are “effective.” Suppose you were the owner of a large agricultural firm and had concerns whether the funds you were contributing to the generic advertising program represented a wise investment. Use your graphical model to develop a conceptual basis to evaluate a program’s success. Depict graphically a program that is (i) successful and (ii) unsuccessful, based upon your framework.

c. Ultimately the impact on demand of any generic advertising program is an empirical question. Sketch an econometric approach to estimating a program’s effectiveness. As part of your answer, (i) set forth equation(s) you would estimate, (ii) indicate data you would need to conduct your estimation, and (iii) discuss any econometric issues/problems you believe you would encounter. Make sure your answer in (iii) is tailored to this problem and does not represent a mere recounting of problems you know exist in econometrics.
PART 3: ANSWER EITHER QUESTION 5 OR QUESTION 6. DO NOT ANSWER BOTH.

5. High gas prices have directed attention to consumers’ vehicle purchases in terms of fuel economy. Of course, we all prefer vehicles that get better gas mileage, ceteris paribus, but poor gas mileage generally means more of other things, such as safety, space, engine size, that many consumers value. Thus, we can say that automobiles are a horizontally differentiated product as it pertains to gas mileage per gallon, when we recognize that mileage serves as a proxy for other vehicle attributes.

We will consider a model with the following assumptions:

(i) Consumers are distributed uniformly with respect to their preference for automobile gas mileage along the interval \([a, b]\), where \(a < b\).

(ii) Three types of cars exist: Type A is low mileage (e.g., Hummer), Type C is medium mileage (e.g., Camry), and Type B is high mileage (e.g., Prius). Types of cars are located along the interval \([a, b]\) based upon their mileages as follows: \(A = a\), \(B = b\), and \(C = c\), where \(a < c < b\).

(iii) Auto makers compete in prices and there are \(N \geq 2\) brands at each location.

(iv) Manufacturers’ cost per vehicle is constant per unit and is the same for all manufacturers of a given vehicle type. The ranking of costs by vehicle type is as follows: \(0 < C_C < C_B < C_A\).

(v) Consumers’ purchase either one car or none. Utility is \(U = \bar{U} - tx\), and net surplus from purchasing an automobile is \(U - \Pi\), \(i = A, B, C\). Consumer surplus if no automobile is purchased is \(U = 0\), where \(x\) is the distance in the miles-per-gallon space of the car, relative to the consumer’s preferred type, and \(t > 0\) is the utility cost per unit of mileage distance.

a. Draw a diagram of this market, assuming Bertrand-Nash competition among auto manufacturers and noting particularly assumption (iii). Structure your diagram so that each consumer purchases a vehicle in equilibrium, i.e., the market is covered. Your diagram should include (i) the locations of each vehicle type, (ii) the price of each vehicle type, and (iii) the market area (demand) for each vehicle type. (HINT: Using a Hotelling model is a very good idea.)

b. On the same diagram as you drew for part (a), depict the equilibrium with \(t' > t\) such that the market is not covered.

c. A more realistic description of the car market would incorporate that consumers’ costs include both the purchase price of an automobile and the costs of operating it. With this thought in mind, and maintaining other assumptions, discuss how higher gas prices will affect this auto market. A diagram may be helpful, but is not absolutely necessary.
d. Carbon emissions from an automobile are inversely related to the car’s gas mileage. Assume carbon emissions are bad for society, and discuss in words the societal problem created by these emissions. Then consider the following two possible policy responses to this societal problem:

- Miles-per-gallon standard: All vehicles must meet a mileage standard \( s > a \).
- Vehicle subsidy: Anyone who purchases a vehicle that gets at least \( \tau \) miles per gallon, where \( c < \tau < b \) receives a subsidy of \( \kappa > 0 \).

Indicate how each of these policies addresses the societal problem and affects the car market. Try to make specific predictions of impact for the endogenous variables in your graphical model. Again, drawing graphs is probably helpful but not absolutely necessary.
6. Demand estimation.

a. Define and discuss the following restrictions as implied by demand functions from either consumer theory (final goods) or producer theory (inputs). For each of the four categories below, define the restriction and identify a theoretical assumption from which the restriction follows.
   i) Adding up
   ii) Homogeneity
   iii) Symmetry
   iv) Negativity

b. Using either consumer or producer theory, discuss how each of these restrictions relate to both the demand functions and the optimization process that generates these functions.
   (For example, for the producer, what is the optimization model that results in the input demand equations and how do the restrictions in (a) relate to both the optimization model and the demand equations?)

c. If you assumed a particular functional form for the function you were optimizing over in (b), how would you construct an equation (or equations) to represent the demand functions? (For example, how might you specify input demands from a cost function for producer theory or commodity demand from an AIDS model for consumer theory?)

d. How would you estimate such a model? In particular, what parameter restrictions might be implied by the adding-up and symmetry restrictions, and would this affect how you would estimate the demand model?

e. Describe how theory can be used to formulate empirical tests of at least two of the restrictions listed in (a).