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. This exam consists of three questions.

- You must answer question 1. It is worth 30% of the total exam score.
- You must answer question 2. It is worth 30% of the total exam score.
- You must answer question 3. It is worth 40% of the total exam score.

Watch the time carefully. The logic used to answer the question is important, so be sure to clearly specify your reasoning, with full sentences. Supporting your answer as rigorously as possible – usually by diagrams or equations – is also important. This is not the time to economize on paper. Make any graphs you draw large and easily read. Make sure your writing is legible; if we can’t read it, it will be assumed to be wrong.
QUESTION 1: Everyone must answer this question.
The U.S. Affordable Care Act known by everyone (including President Obama) as Obamacare is set to be fully implemented beginning in 2014. We will use basic microeconomic theory of consumer behavior to analyze some aspects of health care, health insurance, and Obamacare. In all cases we will be dealing with consumers who have “well behaved” preferences for health services (H) and a composite of all other goods (X). In other words, each consumer we consider has smooth, downward sloping indifference curves that are convex to the origin. We can think of health services as including check ups, preventive care, prescriptions, etc. Let $P_H$ be a composite price for health services and let the price of the composite good X be normalized to 1.0. There is, of course, a stochastic component to health and health care expenses, but we will not consider risk in this question.

a. A basic health plan under Obamacare is the “silver plan,” which pays on average 70% of a person’s healthcare costs. (Although in reality the 70% figure is based upon a variety of deductions and copayments in the plan, for our purposes we will consider that the plan pays $0.70 of each $1.00 in H purchased by the consumer.) Consider an individual with income (M) who can purchase the silver plan for cost (C) where C < M. Use a LARGE graph with indifference curves and budget constraints to analyze this purchase decision.

   i. Start with an equilibrium with no insurance and then depict how the purchase of insurance will impact this consumer’s behavior.

   ii. Does your consumer purchase the insurance if it is voluntary?

   iii. How can you tell from your diagram?

b. How does the purchase of insurance affect the consumption of the composite good X for a consumer? Explain using the concepts of income and substitution effects. A verbal answer will suffice, but you may also include graphs in your answer, but draw a new one; don’t use your graph from part (a).

c. Continue to assume that the insurance purchase is voluntary. Obamacare will operate with various levels of subsidy for the purchase of insurance plans based upon buyers’ incomes. Suppose a hypothetical consumer is eligible for a 50% subsidy on purchase of the silver plan, so that her costs are 0.5C. How will eligibility for the subsidy impact this consumer’s behavior? Show your answer graphically. (HINT: you must consider two cases: i) the consumer would purchase the insurance in the absence of the subsidy and ii) the consumer would not purchase the insurance in the absence of the subsidy.)

d. As most of you know in reality Obamacare entails universal coverage. In other words, everyone is required to have health insurance under Obamacare. Those who fail to show proof of having health insurance are charged a penalty or tax that is collected through income taxation. Also Obamacare requires insurers to cover patients with pre-existing conditions (illnesses, injuries, diseases). Why, as a matter of economics, is it important to the success of Obamacare to require universal coverage? Explain using the concept of adverse selection as part of your answer?
e. Using a large graph, begin by depicting a consumer who would NOT willingly purchase the silver plan. For simplicity we can assume this person is not eligible for any subsidy and would pay the full cost, $C$, of the plan. Show on your graph how large the penalty for not having insurance must be before this consumer will purchase the silver plan. (Hint: remember good X has a price of 1, so your "X" axis represents money units.)
QUESTION 2: Everyone must answer this question

Cardiovascular disease (CVD) is the leading cause of death in the United States, with enormous human as well as economic costs. A recent study by the American Heart Association (AHA) concluded that having a pet—a dog in particular—may lower the risk of heart disease:

* A study of 1179 subjects found that pet owners had lower systolic blood pressure (132.8 versus 139.5 mm Hg), pulse pressure (55.5 versus 63.9 mm Hg), and mean arterial pressure (105.0 versus 107.6 mm Hg) than nonowners and a lower incidence of hypertension (OR, 0.62; 95% CI, 0.49–0.80).

The study concludes that “Pet ownership, particularly dog ownership, may have some causal role in reducing CVD risk.”

Consider a model of the following form:

\[ Y_i = \beta_0 + \beta_1 D_i + \varepsilon_i \]

where \( Y_i \) is any of the (bad) health outcomes above; \( D_i = 1 \) if person \( i \) has a dog and \( D_i = 0 \) otherwise; \( \beta_0, \beta_1 \) are parameters; and \( \varepsilon_i \) is a stochastic error. (You can think of this as a (bad) heart-health production function, with dog ownership as the input.) The AHA study found that the estimated \( \beta_1 \) was negative in all cases.

a. What is the ordinary least-squares (OLS) estimator for \( \beta_1 \) in this regression?

b. How would you test whether the estimate of \( \beta_1 \) is significant or not at the 95% significance level? Specifically, what would your test statistic look like, and what critical value would you use?

c. Obviously, other variables besides \( D_i \) influence heart-health outcomes. Does leaving these variables out of the above regression necessarily bias your estimate of \( \beta_1 \)? Why or why not?

d. Dr. Thomas Lee, a professor at Harvard Medical School, points out that: “It’s possible that healthier people—or those who are making the kinds of lifestyle changes that reduce heart risk—are more likely to have a dog than are people in frail health.” If Dr. Lee is correct, will an OLS estimate give a best linear unbiased estimate of the effect of \( D_i \) on \( Y_i \)? Why or why not?

---


e. In your determination to test whether a dog can be your heart’s best friend, you uncover a new variable, $Z_i$, that is significantly related to the demand for dogs but not directly to cardiovascular outcomes $Y_t$. An example might be the price of dog food, or a humane society project that randomly promotes the adoption of dogs in some cities but not in others. How could you use this new variable to address Dr. Lee’s concern in your econometric analysis?

f. The demand for dogs, like any good, ought to be a function of income as well as price. Would person $i$’s income be a good variable to help address Dr. Lee’s concern?

g. One possible reason for the AHA’s finding, widely cited in the press, is that some people walk their dogs, and exercise is good for hearts. (That’s also pointed out as a reason why cats don’t produce the same cardiovascular benefits.) Any dog owner knows that some breeds of dog require considerably more exercise than others. If you knew the breed of dog people own, how could this additional information be used to improve your model?
QUESTION 3: Everyone must answer this question.

Improved information often directly affects markets and the behavior of market participants. In a 2009 article, Muto and Yamano estimate the impact of the introduction of mobile phones on prices and market participation decisions among farmers in Uganda. In this setting, farmers typically sell their production at their ‘farm-gate’ to traders.

a. To frame their analysis, they propose the following conceptual framework where \( I_i \) is a measure of market information available to market participants (increased information increases this measure).

Suppose that the farm-gate price of farmer \( i \) at time \( t \) of commodity \( j \) is defined as \( p_{ijt} = p_j^M - \gamma_j(I_i) \tau_i \). \( p_j^M \) is the price of commodity \( j \) at the nearest market from the household \( i \) at time \( t \). \( \tau_i \) is the distance between the market and farmer \( i \).

i. Describe carefully the assumptions embedded in this simple model.

ii. If only traders had access to market information, would you expect this model to continue to hold? Explain why or why not.

iii. What would you expect the sign of \( \gamma_j \) to be? Explain briefly.

iv. Use first and second partial derivatives of this equation to show what it implies about the impact of information on farm-gate prices and how distance shapes this relationship. Explain.

v. The authors ultimately apply this conceptual model to data that includes both bananas and maize, i.e., \( j = \{ \text{banana, maize} \} \). Using the partial derivatives from part (iii), how would you expect these relationships to be different for these two crops? Be specific.

b. The authors use panel data collected in 2003 and 2005 from 856 Ugandan households to estimate the impact of mobile phones on markets and market participation. They distinguish between households that were covered by mobile phone networks in both years (Y/Y), only in 2005 (N/Y) and in neither year (N/N).

i. Discuss what must be true about the expansion of mobile phone networks in order to produce reliable estimates of these effects. Include a discussion of what makes estimates “reliable.”

ii. To further illustrate your discussion in (i), provide a specific example of mobile phone network expansion that would make it difficult to produce reliable estimates and describe how it would affect these estimates.
c. Using this data, the authors estimate the following specification separately for bananas and maize:

\[
p_{05}^{BG}/p_{03}^{BG} = \beta_0 + \beta_1 LC1mob_j + \beta_2 LC1mob_j \times miles_j + \beta_3 miles_j + \epsilon_{it},
\]

where \(LC1mob\) is a dummy variable indicating whether village \(j\) (called a ‘Local Council 1’) received mobile coverage between the survey rounds (i.e., whether it is in group N/Y) and \(miles\) is the distance between village \(j\) and the district market.

i. The authors use the ratio of farm-gate prices between 2005 and 2003 instead of the difference between these prices because these prices are household-specific. Explain why this makes sense.

ii. Write these testable hypotheses implied by your work in parts a.(iv) and a.(v) above.

The results for the subset of households selling each commodity both years are shown in the following table (t-values in parentheses).

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Mobile coverage dummy</td>
<td>1.804* (2.42)</td>
<td>-0.231 (1.15)</td>
</tr>
<tr>
<td>Distance to district center (miles) (\times) mobile coverage</td>
<td>-0.822* (2.36)</td>
<td>0.009 (1.01)</td>
</tr>
<tr>
<td>Distance to district center (miles)</td>
<td>0.074* (2.53)</td>
<td>-0.008 (1.24)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.066 (0.12)</td>
<td>1.048** (8.18)</td>
</tr>
<tr>
<td># of observations</td>
<td>107</td>
<td>100</td>
</tr>
</tbody>
</table>

iii. In one paragraph, interpret these results by discussing your hypothesis tests as formulated above. Be sure to interpret both magnitude and statistical significance.

d. The authors also test the impact of mobile phones on farmers’ decision to sell their production to farmers.

i. Write out a specification to test how household mobile phone ownership affects this market participation decision. Define any new variables you introduce.

ii. What econometric issues arise with your specification?

iii. In order to use the expansion of mobile network coverage as an instrument for household mobile phone ownership, what must you assume?

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3 Note that the authors now use the subscript \(j\) to indicate village instead of commodity. This is sloppy; don’t do this when you write papers.
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. This exam consists of three questions.

- You must answer question 1. It is worth 30% of the total exam score.
- You must answer question 2. It is worth 45% of the total exam score.
- You must answer question 3. It is worth 25% of the total exam score.

Watch the time carefully. The logic used to answer each question is important, so be sure to clearly specify your reasoning, with full sentences. Supporting your answer as rigorously as possible – usually by diagrams or equations – is also important. This is not the time to economize on paper. Make any graphs you draw large and easily read. Make sure your writing is legible; if we can’t read it, it will be assumed wrong.
QUESTION 1: Everyone must answer this question.

You are at a party talking with two acquaintances. Talk turns to politics and health care. Donna Dem opines that government-run single payer health care is the optimal system. She goes on to explain that single payer refers to a system whereby everyone has health coverage (universal coverage) through the government, who is the sole payer (to doctors, hospitals, etc.) for healthcare costs. Ronald Rep scoffs at Donna’s view. He claims that the private market works fine for health care and the government should stay out of it. You believe your job in this conversation is to introduce some rational economic thought into it, regardless of your political views.

a. Consider a system where the market is completely free. It features health-care providers (e.g., doctors, clinics, hospitals) and private insurance companies who offer policies and coverage of their own choosing.
   (i) What factors might cause someone to purchase health insurance in this market?
   (ii) Is moral hazard a concern in this kind of a free-market healthcare system? Why or why not? Be specific in your answer in a way that demonstrates clearly that you understand moral hazard as the concept would apply to health care.
   (iii) Is adverse selection a concern in this free-market healthcare system? Why or why not? Be specific in your answer in a way that demonstrates clearly that you understand adverse selection as the concept would apply to health care.
   (iv) Does universal coverage help address the adverse selection problem in healthcare? Explain.

b. Using economic concepts, compare and contrast free-market and single-payer health-care systems in terms of their ability to control health-care costs. Even if you are not very familiar with the economics of health care, you should be able to formulate a passing answer based upon the brief description of each system provided at the beginning of the question and your knowledge of microeconomics.

c. Use indifference curves and budget constraints to analyze a simple market for health insurance. Suppose that Felipe has normal preferences for health care (H) measured in dollars and all other goods (Z) measured in dollars. He has M dollars to spend per period. Depict Felipe’s equilibrium consumption of H and Z under the following scenarios on a single large graph:
   (i) Health care is available at price \( P_H \), and the price of Z is normalized to 1.0. The market is free, and Felipe has no insurance. Label this solution \((H_1, Z_1)\).
   (ii) Felipe buys a health-care policy that pays 50% of all of his medical costs. The policy costs \( C < M \) dollars per period. Label this solution \((H_2, Z_2)\).
   (iii) For the same cost \( C \), Felipe buys an insurance policy with a deductible of \( T < M \) dollars, but this policy pays 75% of all of his medical costs. Label this solution \((H_3, Z_3)\) (A deductible is the amount the insured must pay before the insurer pays anything. For example, most car insurance plans have a deductible of, say, $500, which the insured must pay before any car insurance kicks in.)
QUESTION 2: Everyone must answer this question

Some of the most influential applied economists have spent their careers estimating production functions and refining these empirical methods in order to characterize production relationships more accurately.

a. Briefly describe the policy relevance of characterizing production functions. In your description, use a specific example to demonstrate the practical merits of applied production analysis. In your example, discuss two specific policies that might be improved by a careful econometric characterization of production relationships.

b. While agricultural production is inherently shaped by geography, the relationship between agricultural productivity and isolation tends to be stronger in poor countries than in rich countries. That is, in poor countries the more isolated a farmer is the less productive he is likely to be.

(i) Use your understanding of production economics and your economic intuition to describe three specific factors (labeled #1, #2, #3) that might explain how isolation affects agricultural productivity in developing countries. Carefully discuss each factor and how it may relate to productivity.

(ii) When framing a research question, it is often insightful to represent the relationships of interest in a theoretical model. Without formally writing out such a model, address the following questions:

• What kind of theoretical model could encompass the factors you identified in part (i)?
• What would be the key elements of the objective function and constraints in the model you have in mind?
• What specific assumptions do you think you have to make for the model to be tractable?
• How would the kind of model you have described above allow you to explore how each of your factors potentially links isolation and agricultural productivity (refer explicitly to #1, #2, #3)? Be specific.

c. Consider how you might empirically test the relationship between isolation and productivity.

(i) Devise an econometric specification that would allow you to test whether/how isolation affects agricultural productivity. Define the variables in your specification and discuss the hypotheses of interest.

(ii) What kind of data would you need to estimate this econometric model?
A recent analysis in Madagascar used rice yield (kg/acre) at the plot-level as the dependent variable to estimate the following reduced-form determinates of yield:

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std.Dev.</th>
<th>Coef.</th>
<th>Std.Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of transporting 50kg of rice to nearest urban market (log)</td>
<td>8.78</td>
<td>1.25</td>
<td>-0.17</td>
<td>0.017</td>
</tr>
<tr>
<td>Distance from plot to passable route (minutes walking)</td>
<td>20.1</td>
<td>22.65</td>
<td>-0.005</td>
<td>0.00075</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
<td>4.39</td>
<td>0.15</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td></td>
<td></td>
<td>0.08</td>
<td></td>
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<tr>
<td>N=</td>
<td></td>
<td></td>
<td>1,939</td>
<td></td>
</tr>
</tbody>
</table>

(i) If these results were part of a paper you were writing, how would you interpret and discuss these results? Write a single paragraph that discusses these results, including their economic/statistical significance and potential limitations.

(ii) Both measures of isolation in the model above depend on the placement of roads, which emerge from decades of decisions about where to put roads. What econometric problems might arise from how these decisions were made? Be as specific as possible.

(iii) What could you do to remedy this econometric problem(s)? Again, be specific.

d. The reduced-form model above takes a primal production approach.

(i) What about the model makes it a primal approach?

(ii) What are the main limitations with a primal approach?

(iii) Suppose you wanted to take a dual approach to this same research question. Write out an econometric specification that would allow you to test the relationship between isolation and agricultural productivity using a dual approach. Define variables as needed and discuss the key hypothesis tests.
QUESTION 3: Everyone must answer this question.

The California Department of Food and Agriculture (CDFA) wants you to do an econometric study of changing crop patterns across the state. It gives you annual data for 15 years on: (a) California’s statewide acreage planted in crop i in year t (C_it for crops i=1,...,I and years t=1,...,15); (b) the total state acreage cultivated in all crops at time t (TC_t); and (c) the average profit per acre for each crop over the 15-year period (Π_i), in thousands of dollars. You hypothesize that the share of each crop’s acreage (S_it=C_it/TC_t) is a function of profitability Π_i and other factors that you hope to capture by including a time trend variable (t=1,...,15) in your regression equation. A Berkeley grad on the CDFA staff suggests you use his ordinary least squares (OLS) estimate of the following regression equation, with the results shown below (numbers in parentheses below each coefficient are standard errors):

\[ S_{it} = 0.02 + 0.04\Pi_i + 0.001t \]

\( \begin{align*} 
  & (.01) \quad (.03) \quad (.008) \\
  R^2 = .65 & \quad \text{Durbin-Watson Statistic} = 0.12 
\end{align*} \)

a. Interpret the estimated coefficients on Π_i 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?
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. This exam consists of 3 questions. They will have equal weight. The subsections within each question will have equal weight within the question.

*Watch the time* carefully. The logic used to answer the question is important, so be sure to clearly specify your reasoning with full sentences. Supporting your answer as rigorously as possible – usually by diagrams or equations – is also important. This is not the time to economize on paper. Make any graphs you draw large and easily read. Make sure your writing is legible; if we can't read it, it will be assumed wrong.
I. Lettuce Market Question

1) Suppose the normal annual supply and demand for California iceberg lettuce are characterized by

\[ Q_D = 10 - 0.1 \cdot P \quad \quad \text{Supply}: \quad Q_S = -2 + 0.2 \cdot P \]

Quantities are in billions of heads of lettuce per year, and prices are in cents per head. For the competitive equilibrium, label the following elements clearly on a supply and demand diagram, and calculate each element (pay attention to units for prices, quantities, and values). Include your answers in the appropriate place on the attached table:

- Quantity of iceberg lettuce sold
- Price paid by consumers
- Price received by producers
- Total producer revenue
- Consumer surplus
- Producer surplus
- Total economic surplus
- Elasticity of demand
- Elasticity of supply

2) We wish to analyze the economic effects of two changes in the market relative to the equilibrium represented in question 1. Analyze each change separately:

   a. An exotic pest destroys a large portion of the romaine lettuce crop (a substitute for iceberg), raising its price.
   b. An excellent season results in a slightly larger crop of iceberg lettuce.

Draw a supply and demand model for each of these two changes, and illustrate the nature of the adjustment to the market equilibrium (make sure you label the axes and curves carefully and clearly to distinguish the “before” and “after” positions of the curves and the equilibrium prices and quantities).

In the attached table indicate (with “+” for increase, “-” for decrease, and “?” for uncertain the direction of change in each of the following variables (as measured in question 1) in the model of the iceberg lettuce market (do not calculate any numbers for this part):

- Quantity of iceberg lettuce sold
- Price paid by consumers
- Price received by producers
- Total consumer spending on iceberg lettuce
- Total producer (after tax) revenue from sales of iceberg lettuce
3) Return to the base case in question 1, and consider the effects of a tax of 2 cents per head of iceberg lettuce, collected from producers when they sell lettuce. Draw a new supply and demand diagram to illustrate the effects of the tax, and recalculate each of the variables listed in question 2. In addition, calculate the tax revenue raised. Report your results in the table. Describe the effects on welfare of consumers and producers from introducing this tax.

4) Suppose, as an alternative to the tax collected from producers, a tax of 2 cents per head of lettuce is collected from buyers. Report the effects in the table. Compare the producer, consumer, taxpayer, and total welfare effects of the two taxes—i.e., collected from producers as in this question or from buyers as in question 3—in the market for iceberg lettuce. If it helps, draw a supply and demand diagram to illustrate your answer. Discuss the implications for whether producers would prefer a tax collected from consumers or from producers.
<table>
<thead>
<tr>
<th>Question/Scenario</th>
<th>( Q )</th>
<th>Consumer\ Price ( (P_c) )</th>
<th>Prod.\ Price ( (P_p) )</th>
<th>Consumer\ Spending</th>
<th>Producer\ Revenue</th>
<th>Consumer\ Surplus ( (CS) )</th>
<th>Producer\ Surplus ( (PS) )</th>
<th>Tax\ Revenue ( (TS) )</th>
<th>Total\ Surplus ( (NS) )</th>
<th>Demand\ Elasticity ( (\eta) )</th>
<th>Supply\ Elasticity ( (\varepsilon) )</th>
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<tbody>
<tr>
<td>1) Competitive\ Equilibrium</td>
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<td>2a) Pest Outbreak in Romaine Lettuce (Effects in iceberg lettuce market only – see above)</td>
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<td>2b) Bumper Iceberg Lettuce Crop</td>
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<td>3) Tax Collected from Producers</td>
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<tr>
<td>4) Tax Collected from Buyers</td>
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II. Water Demand Question

The City of Davis wants to know if they should increase residential water prices in order to pay for improvements to their water system. To answer this question, you have been given access to the City’s billing records for the years 2004–2013. The billing data provide each household’s monthly water consumption $\text{Quantity}_{i,t}$ (measured in gallons), where $i$ is an index for each household and $t$ is an index for each of the 120 months over the 10 year sample.

In addition, the data include the price (in 2013 dollars) that each household paid for each gallon of water ($\text{Price}_{i,t}$). Changes in the cost of service caused the prices to vary from year to year. In addition, the prices varied across households because of differences in the home sizes, the number of family members, and the locations.

1) The City asks you to estimate the model below using OLS:

$$\ln(\text{Quantity}_{i,t}) = \gamma + \theta \cdot \ln(\text{Price}_{i,t}) + \epsilon_{i,t}$$

What assumption must be true for the OLS estimator $\hat{\theta}$ to produce an unbiased estimate of the true value of residential price elasticity of demand, $\theta$?

2) You tell the City that the error term in the model above may contain a household-specific component that does not vary over time ($\epsilon_{i,t} = \alpha_i + \mu_{i,t}$). Therefore, you advocate estimating a Random Effects (RE) or Fixed Effects (FE) model. Explain how you would test if you should be estimating either a RE model or a FE model. Specifically:

a) What is your test statistic and how do you construct it?
b) What is your null hypothesis?
c) What will be your criteria for rejecting the null hypothesis?

3) Assume that you determine that it is appropriate to estimate a Fixed Effects model. To do so, you create a set of dummy variables $\{D_i\}$ for each of the $N$ households, where $D_i = 1$ for household $i$ and 0 otherwise. Using OLS, you estimate the following model:

$$\ln(\text{Quantity}_{i,t}) = \sum_{i=1}^{N} (\alpha_i \cdot D_i) + \beta \cdot \ln(\text{Price}_{i,t}) + \mu_{i,t}$$

Assume there are 1,200,000 total observations (10,000 households in the sample and 120 monthly observations from each household). You find a point estimate of $\hat{\beta} = -0.9$ with a standard error of 0.02. Explain how you would construct a 95% confidence interval around the point estimate. Explain how you would use the confidence interval to test whether demand for water is inelastic.
4) Finally, you point out that demand for water is likely very different among households that live in single-family housing units versus households that live in apartments. To model this heterogeneity, you create a dummy variable $H_i$ which equals 1 if household $i$ lives in a single-family residence and 0 otherwise. Using this new dummy variable, you estimate the following model:

$$
\ln(\text{Quantity}_{i,t}) = \sum_{i=1}^{N} \left( \alpha_i \cdot D_i \right) + \beta_1 \cdot \ln(\text{Price}_{i,t}) + \beta_2 \cdot H_i \cdot \ln(\text{Price}_{i,t}) + \mu_{i,t}
$$

You find the following point estimates and standard errors for $\beta_1$ and $\beta_2$, as well as two different linear combinations of the estimators:

<table>
<thead>
<tr>
<th>Estimator</th>
<th>Point Estimate</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{\beta}_1$</td>
<td>-1.10</td>
<td>0.03</td>
</tr>
<tr>
<td>$\hat{\beta}_2$</td>
<td>0.30</td>
<td>0.05</td>
</tr>
<tr>
<td>$\hat{\beta}_1 - \hat{\beta}_2$</td>
<td>-1.40</td>
<td>0.08</td>
</tr>
<tr>
<td>$\hat{\beta}_1 + \hat{\beta}_2$</td>
<td>-0.80</td>
<td>0.08</td>
</tr>
</tbody>
</table>

To increase their revenue from water sales, the City is considering increasing the rates for only the households living in single-family residences (with $H_i = 1$). From the results presented above, explain how you could test whether the proposed rate increase would increase the City’s revenue (relative to not changing any rates). Specifically:

a) What is your test statistic and how do you construct it?
b) What is your null hypothesis?
c) Do you reject the null hypothesis at the 95% confidence level?
III. Marketing Orders and Price Discrimination

Recent evidence on the demands for fresh lemons and processed lemons suggest that they are segmented markets – that is, the price of processed lemons does not influence the quantity demanded of fresh lemons, and vice versa. The demand at the farm for fresh lemons has been estimated to be:

\[ p^F = 20 - 2 \cdot Q^F, \]

Where \( Q^F \) is the quantity of fresh lemons in millions of cases, and \( p^F \) is the price paid to farmers for fresh lemons (in dollars per case). The comparable demand relationship for lemons for processing is:

\[ p^P = 10 - \frac{1}{2} \cdot Q^P. \]

The total quantity of lemons available, whether they are sold fresh or for processing, is 20 million cases.

1) In a competitive market, what would be the equilibrium value for \( p^F \) and \( p^P \) and the corresponding \( Q^F \) and \( Q^P \)? What is the industry’s total revenue?

2) If a marketing board had to market all of the lemons but could allocate lemons to one market or the other, what would be the values of \( p^F \) and \( p^P \) and the corresponding \( Q^F \) and \( Q^P \)? What is the industry’s total revenue?

3) If the marketing board was allowed to discard a portion of the lemons, as opposed to selling all 20 million cases, what would be the values of \( p^F \) and \( p^P \) and the corresponding \( Q^F \) and \( Q^P \)? What is the industry’s total revenue?

For Part (4), return to the assumption that the marking board cannot discard any lemons -- that is, they must sell all 20 million cases as you solved for in Part (2). Assume that 2 million cases worth of lemons have blemishes on their skins. The skin blemishes matter to fresh consumers, but do not matter for processing, and regulation prohibit the sale of blemished lemons for fresh consumption.

4) Suppose not all farmers produce unblemished lemons in the same proportion as the industry does. What is the maximum proportion of blemished lemons a farmer could have and still prefer the pricing strategy of the marketing board (as opposed to the competitive outcome)?