University of California, Davis

Department of Agricultural and Resource Economics

M.S. Comprehensive Exam, 22 June 2015

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 all three questions.

- Question I is worth 37.5% of the total exam score.
- Question II is worth 25% of the total exam score.
- Question III is worth 37.5% 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. Please support your answers as rigorously as possible – e.g., using diagrams or equations. If you use graphs, make sure they are clearly labeled and large enough to read easily. This is not the time to economize on paper, but keep your responses clear and concise. Make sure your writing is legible; if we can't read it, it will be assumed wrong.

I. Wine club memberships

California wineries typically offer different types of memberships to their customers. For instance, Saintsbury vineyards in Carneros, Napa County, offers its customers to become "three-bottle members," "six-bottle members," or "twelve-bottle members." All formulas involve a fixed upfront payment incurred once a year and a quarterly shipment of either three, six, or twelve bottles. Once the upfront payment is made, the customer does not pay for shipments. Formally, the winery offers a menu of contracts of the type (q, T), where $q \geq 0$ is the quantity of wine delivered in a year and $T \geq 0$ is the upfront fee.

In this problem, we seek to rationalize the use of such memberships by analyzing wineries' profit incentives. Suppose that customers differ in their taste for wine. Specifically, a customer of type θ is assumed to have the following quasi-linear utility function defined over the quantity q of wine from the winery and a composite good x that represents all other goods:

$$U_\theta(q, x) = \theta q - \frac{1}{2}q^2 + x.$$

The price of the composite good x is normalized to one. The cost of producing wine is zero.

First assume that the winery charges a price p per unit of wine (i.e., there are no membership contracts).

1. Solve the utility maximization problem of a consumer of type θ, denoting by w the consumer's income. You will assume that the solution is interior, that is, the consumer purchases a positive quantity of wine and a positive quantity of the composite good. Show that the demand for wine does not depend on the consumer's wealth w in this case.

2. In a fully labeled quantity-price diagram with the quantity of wine q on the horizontal axis, draw the demand curve of a consumer of type $\theta = 2$. Be sure to get the shape right.

3. If the winery sells wine by the unit, what is the price p_θ that would maximize the winery's profit from the sale to consumer θ? Compute the resulting profit of the winery. Show the location of the price p_θ on your previous diagram and show how you find it graphically.

Now suppose that instead of charging a per-unit price, the winery proposes a membership contract (q, T) to its customers. If the consumer accepts the contract, she receives q units of wine and has to give a transfer T to the winery, that is, her final wealth is $w - T$ and she uses it to purchase good x.

4. (a) What is the utility level of a consumer of type θ if she accepts the contract? if she does not accept the contract?

   (b) For a given quantity of wine q, what is the maximum transfer $T(q)$ that the winery can ask to a consumer of type θ so that the consumer still accepts the contract?

5. Given that the winery can charge $T(q)$ for a quantity q, what is the quantity q_θ that maximizes the winery's profit from sales to a consumer of type θ? Compute the resulting profit. We will call this contract $C_\theta = (q_\theta, T_\theta)$.

6. Argue that if the winery knows the consumer's type θ, it is better off proposing the contract C_θ than charging the price p_θ found in part 3. Explain why that is.

Now assume that there are two types of customers, those with $\theta = 1$ (in proportion λ of the total customer base) and those with $\theta = 2$ (in proportion $1 - \lambda$ of the total customer base). The winery knows the value of λ but it cannot recognize what type a particular customer is.

7. Make explicit the terms of the contracts C_1 and C_2 (that is, the contracts C_θ for $\theta = 1$ and $\theta = 2$).

8. (a) Suppose that the winery offers the same menu of contracts (C_1, C_2) to each customer. Show that both types of customers choose C_1 over C_2. Interpret the result. Compute the resulting expected winery profit per customer.

   (b) Suppose that the winery only offers C_2. Who purchases the membership in that case?

9. If the winery can only offer one type of contract, is it better off offering C_1 or C_2? Your answer should depend on λ.

Of course, the winery could also offer contracts different from C_1 or C_2 to every customer. We do not have time to formally derive the optimal menu of contracts here, but I will help you find it for the case where $\lambda \geq \frac{1}{2}$. In that case, the winery achieves the highest profit when it offers a menu $(\hat{C}_1, \hat{C}_2)$, where $\hat{q}_1 = \frac{2\lambda - 1}{\lambda}$ and $\hat{q}_2 = 2$, and the transfers $\hat{T}_1 \geq 0$ and $\hat{T}_2 \geq 0$ are such that type 1 customers purchase $\hat{C}_1$ and type 2 customers purchase $\hat{C}_2$.

10. (a) Find $\hat{T}_1$.

    (b) Find $\hat{T}_2$. Explain why type 2 customers enjoy an information rent.

II Econometrics Question

1. Impressed by your answers to Part (1) a local winery has offered you a position as Marketing Director. Your first task is to review a consulting report paid for by your predecessor. The consulting firm, **Shaydee LLC**, surveyed 2000 residents of California and asked them how many bottles of kinds of different wines they would purchase at different price levels. As best you can tell from the report, the consultants ran a regression of the form:

$$\ln\left(\text{Quantity}_{i,j}\right) = \beta_0 + \beta_1 \ln\left(\text{Price}_{i,j}\right) + u_{i,j},$$

where i indexes households and j indexes wines.

   (a) What assumptions must be true for the OLS estimator b_1 to produce an unbiased estimator of the true value of the elasticity of wine demand β_1.

   (b) You are somewhat suspicious of the consultants' report. In particular, you know that when purchasing wine consumers often use price as a signal of the quality of the wine they are buying.

   (c) How does this affect your interpretation of the results above? Do you think the consultants are likely to have over or under estimated the own price elasticity? Clearly state any assumptions you need to make to sign any potential bias.

   (d) In discussing your concerns with your boss, they suggest using an *Instrumental Variables* approach. Specifically, they suggest using the ratings – these are scores provided by expert judges after tasting a wine – published by Wine Spectator magazine as an Instrument.

      1. In your opinion, do the Wine Spectator ratings meet the criteria of a valid instrument?
      2. How do you feel about using instrumental variables under these circumstances? Is there an alternative approach you would suggest?

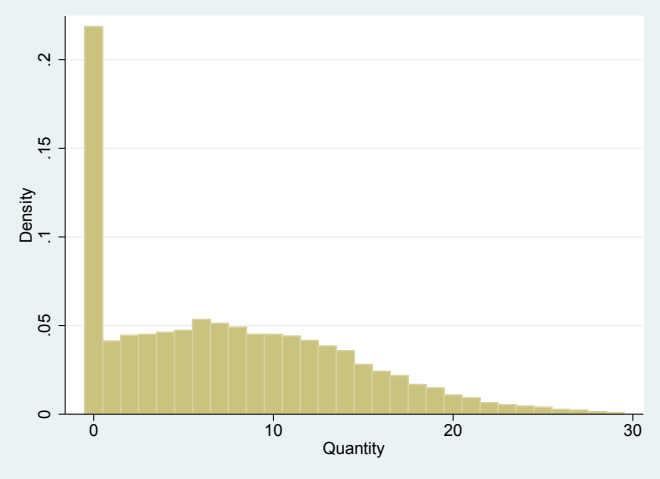
2. You become even more suspicious when looking at the regression results and notice that the number of observations reported by the consultants is lower than the number of households surveyed. You obtain the raw survey responses and plot a histogram of the outcome variable **Quantity**.

   (a) Can you explain why the number of observations in the regression and the number of households in the survey differ?

   (b) Thinking only about the issues raised by Figure 1, do you think the elasticity provided by the consultants is an over estimate or an under estimate of the true elasticity of demand?

   (c) What might be an appropriate strategy to analyze data of this form? Describe the method and the any assumptions or additional data you would require to implement it.

Figure 1: Distribution of Quantity



III. Production functions and fertilizer in Africa

Agricultural productivity in Sub-Saharan Africa (SSA) lags behind all other regions of the world. Low fertilizer application rates are one factor that contributes to this low productivity. For example, farmers in SSA apply on average 8kg/ha of fertilizer each year compared to 200kg/ha on average in East Asia. The World Bank calls this "an escalating soil fertility crisis" in Africa.

In this problem, you will explore possible explanations for low fertilizer usage and evaluate different empirical approaches to test these explanations.

1. Suppose that farmers are risk-neutral and maximize profits. To simplify the problem initially, suppose that they each have the same fixed amount of land and face a one input production function $y=f(N)$ where $N\geq 0$ indicates the amount of fertilizer (nitrogen) they apply and $f'>0$ and $f''<0$.

    (a) Write out a farmer's maximization problem. Introduce and define any additional notation you need. Use the first order condition to characterize the solution to this simple model.

    (b) Use your simple model to discuss **two** ways that the degree of spatial market integration may explain low fertilizer application rates. Be specific.

    (c) Explain carefully why it may be problematic to assume that farmers in SSA are profit-maximizers. With this distinction in mind, provide and discuss **one** additional explanation for low fertilizer usage in SSA.

2. Von Liebig, a 19th Century German chemist, discovered what is known as the "law of the minimum." Applied to crop production, this law states that there is some threshold level of soil fertility above which N limits output and below which it is other inputs that limit output. To be more precise, denote soil fertility as soil organic matter (SOM) and the threshold level of SOM as SOM^*. Then, the law of the minimum states that

$$\frac{\partial y}{\partial N}\begin{cases} > 0 \ if \ \ SOM \geq SOM^* \\ \approx 0 \ if \ \ SOM < SOM^* \end{cases}$$

    (a) Suppose that you and the farmer can both observe SOM and know SOM^*. Start with a Translog production function and modify it to create an econometric specification that would allow you to test whether SOM^* really is a von Liebig minimum. Be sure to define any additional notation you introduce. Discuss the interpretation of the coefficients in your specification and statistical tests you would use for the von Liebig minimum.

(b) Now, suppose that while you can observe *SOM,* you do not know the threshold *SOM** (you do, however, know that one exists). Formulate and describe an econometric approach you could use locate the threshold. Be sure to state explicitly the tests you would use.

3. Primal production functions suffer from some specific limitations, which is why economists often estimate dual functions instead.

   (a) Describe carefully **one** econometric limitation of your proposed specification in 2(a) and discuss as precisely as possible the nature of this limitation in the context of this problem.

   (b) Would a dual representation of this problem be better than your primal specification given the research question in 2(a)? Explain why or why not.

4. So far we have assumed that both you and the farmer can observe *SOM*. Let's consider alternate 'observability' assumptions. If you have to make additional assumptions to fully discuss these alternatives, state these additional assumptions clearly.

   (a) Suppose that neither you nor the farmer can observe *SOM,* but the von Liebig minimum still exists. Rewrite your specification in 2(a) to reflect this new assumption. Compare and contrast the econometrics of this modified specification with the original.

   (b) Now consider an asymmetric information case, which happens to be the most likely case of all: The farmer knows both *SOM* and the von Liebig minimum, but you can observe neither. Discuss carefully the econometric challenges introduced by this asymmetry.

5. This problem is based on a 2009 AJAE paper by Marenya and Barrett. In that paper, they estimate the marginal value product of *N* and non-parametrically regress this on a measure of *SOM*. This regression (shown below) clearly shows the presence of a von Liebig minimum.

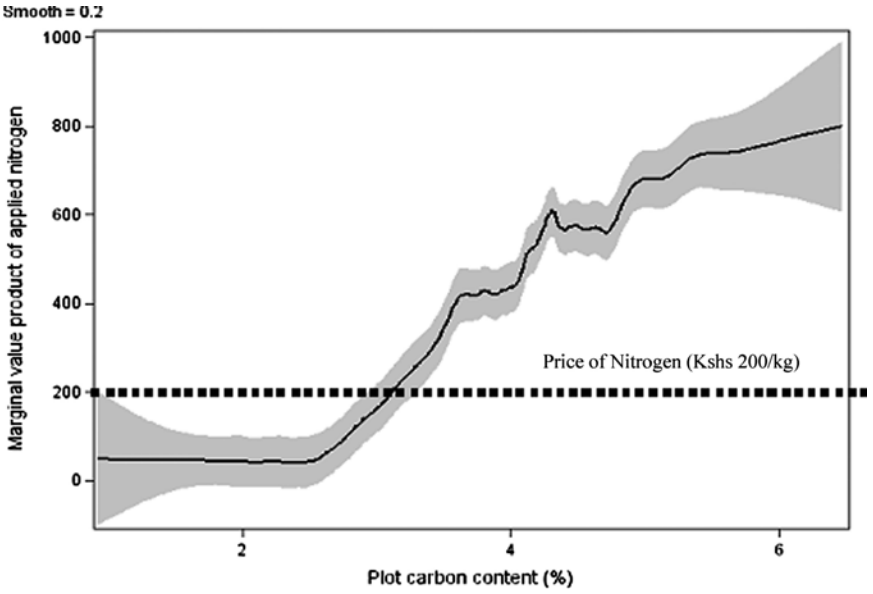


Figure 3 Estimated marginal value product of nitrogen fertilizer (Kshs/kg N) conditional on plot soil carbon content (SOM) with 95% confidence bands in gray

(a) Discuss the policy implications of this figure. As part of your discussion, revisit the reasons you provided in 1(b) and 1(c) above, update your discussion of these reasons for low fertilizer rates, and describe any additional policy-relevant insights provided by this figure.

(b) The "escalating soil fertility crisis" in Africa is partly due to the fact that farmers have been extracting soil fertility without replenishing it with organic or chemical fertilizers. Using what you have learned in this problem, describe briefly the dynamic interactions between agricultural productivity, soil fertility and poverty in SSA. What might these dynamics mean for farmers, for policy makers and for economic development more broadly?