University of California, Davis

Department of Agricultural and Resource Economics

M.S. Comprehensive Exam, June 2016

You have four hours for this exam after a 20 minute reading period. 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. Financing a public good

The private financing of public goods is made difficult by the well-known free-rider problem. In this problem we will show that a way to improve the level of a public good financed by private contributions is to use a lottery (in the layman's sense of the word).

Suppose, for the sake of the argument, that an economy includes I identical agents, each endowed with the following *ex post* utility function:

$$u(x_i, y) = x_i + \alpha \ln(y) \tag{1}$$

where x_i is the consumption by agent i of an aggregate private good we will refer to as the numeraire, y is the level of public good, and $\alpha > 0$ is a positive parameter reflecting the intensity of agents' taste for the public good. Each agent enjoys the same level y of public good, and consumption of the public good by one agent does not diminish consumption by another (think of clean air or national security). We assume that the public good is financed through contributions of private good, one unit of private good giving one unit of public good (constant returns to scale). Each agent has $\omega > 0$ units of private good to start with and, when facing uncertain outcomes, satisfies the expected utility hypothesis.

The problem is structured as follows: first, we will derive the socially optimal level of public good for this economy. Second, we will show that if each agent is asked to contribute voluntarily to the financing of the public good, in equilibrium there will be too little public good compared to the social optimal. Finally, we will show that the situation can be improved through a lottery.

1. We define the socially optimal level of public good as the value y^* that solves the following constrained optimization problem, sometimes referred to as the social planner problem:

$$\max_{\substack{x_i \geq 0\ \forall i \\ y \geq 0}} \sum_{i=1}^{I} u(x_i, y) \quad \text{subject to} \quad y + \sum_{i=1}^{I} x_i \leq I\omega. \tag{2}$$

   (<u>Note</u>: the symbol $\forall$ means "for all.")

   (a) Do you recognize the type of preferences represented by the utility function in (1)?

   (b) Look at program (2) closely and interpret it in words.

   (c) Do the first-order conditions to program (2) fully characterize its solution? Briefly justify your answer.

   (d) Ignoring non-negativity constraints, solve program (2) and show that the socially optimal level of public good is $y^* = \alpha I$. What happens to y^* as I increases?

2. We now consider a mechanism by which each agent decides to contribute some of his endowment of private good ω towards the financing of the public good, <u>taking as given</u> the contributions of all the other agents. That is, we are considering a Nash equilibrium where the strategy of each agent is how much to contribute to the public good. We denote by z_i the contribution of agent i, and by Z_{-i} the sum of the contributions of all other agents. Agent i chooses z_i in order to solve the following optimization problem:

$$\max_{0 \leq z_i \leq \omega} u(\omega - z_i, z_i + Z_{-i}). \tag{3}$$

We are only interested in symmetric outcomes where all agents' contributions are the same.

(a) Look at program (3) closely and interpret it in words.

(b) Ignoring non-negativity constraints, solve program (3). That is, find the best response of agent i, denoted $\bar{z}_i(Z_{-i})$.

(c) Using symmetry and your answer to part (b), show that the level of public good that arises in equilibrium is $\bar{y} = \alpha$. Compare to 1(d) and discuss the difference.

3. Now suppose that the government decides to organize a lottery to help finance the public good. The government issues as many lottery tickets as agents demand, and the price of one ticket is one unit of numeraire. The government uses the receipts from the lottery to cover the cost of a prize equal to R units of numeraire, with $R < \alpha I$. The rest is used to finance the public good. (That is, if there are Z lottery tickets sold there will be $Z - R$ units of public good produced.) Finally, if one agent purchases z_i lottery tickets and other agents purchase Z_{-i} tickets in aggregate, the probability that agent i wins the prize is simply $\frac{z_i}{z_i + Z_{-i}}$. If he wins, agent i's consumption of numeraire is $\omega - z_i + R$. If he loses, agent i's consumption of numeraire is $\omega - z_i$.

(a) Modify program (3) to reflect the new opportunities afforded by the lottery. (Hint: your program should now be an expected utility maximization program. Simplify the objective function as much as you can.)

(b) Assuming that $0 < z_i < \omega$, show, using the first-order conditions of the program identified in part (a), that the new best response $\tilde{z}_i$ satisfies the following equality:

$$-1 + \frac{RZ_{-i}}{(\tilde{z}_i + Z_{-i})^2} + \frac{\alpha}{\tilde{z}_i + Z_{-i} - R} = 0. \tag{4}$$

(c) Using equation (4) and symmetry, show that the equilibrium level of public good $\tilde{y}$ satisfies the following polynomial equation:

$$-(\tilde{y})^2 I + (\alpha I - R)\tilde{y} + \alpha I R = 0. \tag{5}$$

(d) Using equation (5), show that $\bar{y} < \tilde{y} < y^*$ and provide intuition for this result. (Hint: Try to plot the polynomial function in equation (5) on a graph with y on the horizontal axis.)

II. The Effect of Daylight Saving Time

Daylight saving time (DST), the practice of setting the clock one hour forward during spring and summer, is implemented in many countries around the world. The rationale behind DST is that having an additional hour of daylight will have several benefits: (1) households will use less electricity to light their homes leading to energy savings, (2) commuters will be driving during daylight leading to less traffic accidents. It is not clear whether these perceived benefits are actually true, and hence DST has spurred a lot of academic and policy debates.

In the following question, we will consider different empirical strategies to identify the causal effect of DST on fatal crashes.

1. Even though most of the United States follows the DST, several states and territories do not. Alaska, Arizona (with the exception of the Navajo Reservation), Puerto Rico, Hawaii and overseas territories do not follow the DST. Suppose you have data for all states as well as Puerto Rico and the overseas territories for the total number of fatal vehicle crashes (F) in 2015 and whether a state or a territory implements the DST or not (DST, a dummy variable for implementation of DST) as well as weather variables, such as rain fall (R) and visibility (V). Now you perform the following regression, where i indexes different states and territories,

$$F_i = \alpha + \beta DST_i + u_i.$$

   (a) How would you interpret β in this regression? Does it capture the causal effect of DST on fatal vehicle crashes? Explain your answer.

   (b) Now consider the weather variables you have, would either of them or both be suitable as instrumental variables for DST in the above regression? In your answer, specify the assumptions that an instrumental variable has to fulfill and explain which of these assumptions is fulfilled or violated by each of the weather variables, R and V.

2. Smith (2016, *AEJ: Applied*) studies this question by looking at weekly fatal crashes in the U.S. from 2002-2011. Below is one of the figures from the paper.

   (a) What is the estimation strategy that Smith (2016) is utilizing in this figure? Explain the key idea behind this strategy, its assumptions, and what type of causal effect it can identify.

   (b) What is the causal estimate according to the figure below? What is its interpretation?

(c) Now suppose you use a linear model to fit the observations in the figure below (instead of the given dashed lines), write down the regression model you would use. Specify any additional variables you need to introduce.

(d) Which standard errors would be suitable for the regression in (c)?

(e) Note that the above figure plots the average number of fatal crashes in the U.S. between 2001-2010. What are potential issues with this analysis in terms of accurately measuring the effect of DST on fatal crashes?

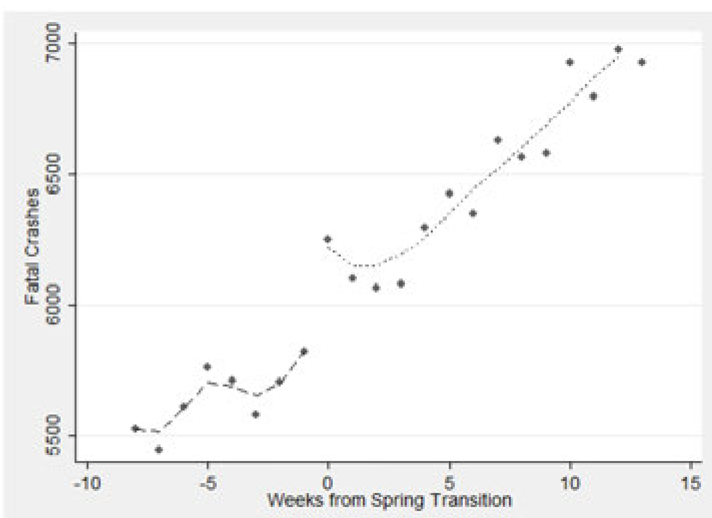
3. Now suppose that you have daily fatal crash data (2002-2011) and you would like to estimate the effect of DST on F. However, it is well established that accidents are more likely to happen on certain days of the week. Furthermore, overall weather conditions may be different from year-to-year causing traffic accidents to be more or less likely.

   (a) Propose an estimation strategy that controls for day-of-the-week and year-specific unobservable factors. Write down the regression equation and define any additional variables you need to introduce.

   (b) What is the key assumption that ensures that the method you propose in (a) identifies the effect of DST on F? Explain what this assumption rules out.

   (c) Suppose you have annual weather variables for the U.S., would you include them in the regression in (a)? Explain your answer.

Figure 2: Fatal Crashes Around the Spring Transition



Notes: Each point represents the total number of fatal crashes occurring during that week from 2002-2011. Smoothed lines are results of locally weighted regression.

Question 3

Differentiation among food and beverage products has exploded in recent decades. These products come packaged with a bewildering array of information. Much of this information is conveyed by certifications.

1. Two common certifications for food products are Organic and Fair Trade (FT), which assures consumers that a certified product provides greater-than-normal benefits to disadvantaged producers.
    a. Using economic concepts, describe briefly the justification for organic certification and the impact organic certification has on food markets.
    b. Using economic concepts, describe briefly the justification for FT certification.
    c. Compare and contrast these two common forms of certification. How are their economic implications different? Be specific.

2. Coffee is perhaps the most familiar certified FT product. FT certification provides two main benefits to producers: (i) a price floor, p_f, that is paid to growers whenever the prevailing market price $p < p_f$ and (ii) a social premium, ρ, that is intended to directly benefit producers. All prices and the premium are per pound. For now, assume that coffee is of uniform quality.
    a. Assume that s is the share of a grower's total coffee production that is sold as FT and c is the cost of certification per pound of coffee produced, which is paid to a third-party certification organization. Use this notation to define the per pound net benefit of certification, B^{FT}.
    b. Assume that any producer who pays c can sell his coffee as FT and that p is stochastic. What must be true about $E[B^{FT}]$ in equilibrium?
    c. Describe what happens as ρ increases. Write an equation to justify your answer.

3. Coffee is one product that has experienced dramatic differentiation. In addition to FT certification, there are several other certifications that differentiate coffee. There are big differences in quality and in roasting methods.
    a. Suppose you wanted to understand how much consumers valued different aspects and attributes of coffee. Write down a hedonic regression specification that you could estimate. Be as specific and complete as possible.
    b. Describe carefully what kind of data you would need to estimate your specification.
    c. Discuss how you would decide whether or not to pool coffee from different regions of the world.

4. de Janvry et al. (2015) empirically estimate the FT premium paid to coffee growers in a Central American country. Individual coffee producers in this setting pool their total production in cooperatives. Cooperatives then sell this output to a large coffee association. Each sale is split into several different marketing channels depending on prevailing market conditions. That is, at each sale, the association purchases a portion (on average 20%) of a given cooperative's "delivery" as FT coffee and purchases the rest at different non-FT market prices depending on the marketing channel. To qualify to sell any share of its production as FT, the cooperative must pay the annual cost of FT certification.
    a. They explain that "incentives for high-quality producers to sell through FT should increase with the FT premium." This raises a "causal inference problem" for estimating the overall FT premium, accounting for both p_f and ρ. Explain.

b. They have data on all sales from almost 300 cooperatives to the association from 1997 to 2009. In all, they observe 11,602 such deliveries of coffee from coops to the association. With each sale, they observe the sales price for FT and non-FT coffee, the date of the transaction, and 13 quality labels to distinguish different quality grades. What kind of data is this? Describe briefly the advantages of this kind of data by discussing the econometric approaches it enables. Be specific.
c. The authors' preferred specification for estimating the overall FT premium is to use "delivery-level fixed effects". That is, they include a fixed effect for each delivery from a cooperative to the association. Explain how this addresses the causal inference problem raised in 4(a) above.
d. Their results are shown in Table 1 below. Referring to these results, respond to the following questions:
    i. What variables are used to estimate the coefficients representing the year-specific FT premia?
    ii. Provide a brief interpretation of these estimated year-specific premia from model (1) in the context of this research question.
    iii. Why do the authors not control for quality categories when using delivery fixed effects?
    iv. In model (2), the authors use cooperative fixed effects instead of delivery fixed effects. Describe how this changes the interpretation of the estimated premia?
    v. Why do you think the authors report "robust standard errors"?
e. The estimated FT premia in Table 1 are nominal in the sense that they represent how much higher the final FT price is than the non-FT price. The authors argue that what matters to the cooperatives and small scale producers is the *effective* (expected) FT premium. What adjustment to the nominal FT premium must be made to compute the effective (expected) FT premium? (HINT: Look back to 2(b) and 2(c) above.)

5. Summarize the key considerations raised by this problem in two or three sentences. (Think about what you would say at the coffee shop if someone asked what you thought of FT coffee!)

TABLE 1—ESTABLISHING THE QUALITY-ADJUSTED ANNUAL FT NOMINAL PREMIUM

	Contract price (U.S. cents per pound)			
	(1)	(2)	(3)	(4)
Fair trade premium				
1997	4.73**	0.83	6.35	11.25*
	[1.03]	[1.69]	[5.21]	[5.17]
1998	22.50**	14.06**	13.34**	9.33**
	[1.19]	[0.94]	[2.68]	[3.07]
1999	10.95**	9.95**	12.58**	10.79**
	[0.70]	[0.98]	[1.51]	[1.70]
2000	20.35**	20.52**	24.07**	25.14**
	[0.83]	[1.29]	[2.80]	[2.94]
2001	61.11**	64.33**	64.47**	64.57**
	[0.65]	[0.64]	[1.08]	[1.09]
2002	52.80**	60.64**	61.96**	61.85**
	[3.21]	[0.83]	[1.26]	[1.24]
2003	53.83**	61.77**	60.43**	59.23**
	[1.44]	[0.34]	[0.67]	[0.77]
2004	45.22**	42.78**	44.16**	42.40**
	[1.73]	[0.91]	[1.38]	[1.43]
2005	2.63	4.10**	6.05**	4.89**
	[2.62]	[0.88]	[1.05]	[1.14]
2006	6.76**	9.21**	7.70**	6.89**
	[1.23]	[0.52]	[0.61]	[0.70]
2007	9.14**	6.50**	7.23**	6.71**
	[1.16]	[0.69]	[0.86]	[0.97]
2008	3.34*	2.02**	4.93**	4.73**
	[1.32]	[0.67]	[1.18]	[1.24]
2009	2.83	12.94**	13.60**	12.07**
	[3.44]	[1.22]	[1.38]	[1.46]
Controls				
Quality categories	-	Yes	Yes	No
Shipment month FE	-	Yes	Yes	Yes
Cooperative FE	-	Yes	-	-
Delivery FE	Yes	No	-	-
Observations	4,403	18,234	3,764	3,764
Number of deliveries/ cooperatives FE	1,451	296		
R^2	0.68	0.92	0.90	0.86

Robust standard errors in brackets. Significant at *5%; **1%. Quality categories are Prime-Washed, Extra Prime Washed, HB, SHB, Fancy SHB, SHB-HH, SHB-EPW, GAP, and Small Beans. All regressions also control for UTZ certification for sustainable farming. Column headings 1: deliveries sold partly as FT and partly as non-FT with same shipment month; 2: all deliveries; 3 and 4: all sales.