I. Financing a public good

The private financing of public goods is made difficult by the well-known free-rider problem. In this question, we will show that the public financing of a public good might be a good response to this problem.

We consider an economy with I agents. Agent i is endowed with the following utility function:

$$u_i(x_i, y) = x_i + \alpha_i \ln(y) \tag{1}$$

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 $\alpha_i > 0$ is an agent-specific (strictly) positive parameter reflecting the intensity of the agent's taste for the public good. We rank agents so that $\alpha_1 > \alpha_2 > \ldots > \alpha_I$, i.e., agent 1 has a stronger preference for the public good than agent 2 and so on. We assume that the public good is produced under constant returns to scale, one unit of private good giving one unit of public good. Each agent has the same endowment $\omega > 0$ of private good to start with.

The question 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, only one agent contributes and the total amount of public good is lower than the socially optimal level. Finally, we will show that if agents are asked to vote on a tax to finance the public good, the level of public good may be improved.

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:

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

(Note: the symbol $\forall$ means "for all.")

[0.3] (a) Look at program (2) closely and interpret it in words.

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

[0.6] (c) Ignoring non-negativity constraints, solve program (2) for the socially optimal level of public good y^*. Comment on your finding.

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, taking as given 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:

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

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

[0.8] (b) Solve program (3), explicitly considering the non-negativity constraint $z_i \geq 0$. That is, find the best response of agent i, denoted $\bar{z}_i(Z_{-i})$. (Hint: Because you need to consider the non-negativity constraint, your best response should have two parts to it.) Represent the best-response function on a graph with Z_{-i} on the horizontal axis and z_i on the vertical axis and check that your function is continuous.

[0.6] (c) Show that in equilibrium, only agent 1 contributes to the public good while the other agents free ride. (Hint: First show, using your answer to part (b), that it is not possible that more than one agent contributes to the public good.)

[0.4] (d) What is the level of public good in equilibrium? Compare it to the socially optimal level.

3. Now suppose that the government decides to implement a tax on agents' endowments to finance the public good, while letting agents vote on the tax rate to be implemented. If a tax τ is implemented, then each agent has to give $\tau\omega$ in taxes to the government, who then uses the tax proceeds $I\tau\omega$ to produce the public good. Before the vote is announced, each agent i determines their preferred tax rate $\hat{\tau}_i$ by solving the following maximization program:

$$\max_{0\leq\hat{\tau}_i\leq 1} u_i(\omega(1-\hat{\tau}_i), I\hat{\tau}_i\omega).$$

[0.6] (a) Ignoring the inequality constraints on $\hat{\tau}_i$, derive the preferred tax rate of agent i.

We now add the assumption that there is an odd number of agents in the economy. The government decides to proceed as follows: prior to the vote, each agent was asked to send through the mail their preferred tax rate $\hat{\tau}_i$. The government then conducts a series of pairwise votes between tax rates $(\hat{\tau}_i, \hat{\tau}_j)$ that were sent to him by the agents. That is, all preferred tax rates are compared to all others in pairwise votes. After all the pairwise votes have been conducted, the government selects a tax rate $\hat{\tau}_i$ if it beats all others by a simple majority, that is, if in all pairwise comparisons involving $\hat{\tau}_i$, more than half of the agents chose $\hat{\tau}_i$.

[0.6] (b) Argue that a tax rate does get selected by this (complex) procedure, and write down which one it is. (Hint: Use your intuition.)

[0.4] (c) What is the level of public good financed through this procedure? Is it always higher than that obtained under the voluntary contribution equilibrium?

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) Under what circumstances would β have the causal interpretation of DST's effect on fatal vehicle crashes? Explain your answer.

   (b) You are concerned that omitted variables may bias your answers. Under what circumstances would either of or both weather variables be suitable as proxy variables in the above regression? In your answer, specify the assumptions that a proxy variable has to fulfill.

2. One way to answer this question would be by looking at weekly data on fatal crashes in Indiana - which has the peculiarity that some counties adopt DST while others do not. Another approach might be to use the fact that in 2007 DST was extended another four to five weeks - it started three weeks earlier and ended two weeks later.

   (a) Write down a model of traffic fatalities that leverages *both* of these insights? Be sure to define any additional variables you introduce.

   (b) Explain the set of assumptions under which you can recover a causal estimate of the effect of DST on traffic fatalities? Can you propose a graphical analysis that would make your findings more convincing?

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

3. Now suppose that you have *daily* fatal crash data (2002-2011) for every state and you would like to estimate the effect of DST on F. However, traffic laws vary considerably by state – for example Montana allows a maximum speed limit of 80 mph whereas Hawaii has a maximum speed limit of 60 mph, and New York does not allow drivers to make a right at a read light whereas most states do, etc ... Furthermore, traffic fatalities are highly seasonal and vary considerably month-to-month with the weather.

   (a) Propose an estimation strategy that controls for state 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) What is the difference between the causal estimate you would obtain from 3(a) and the one you obtain from 2(a)?

   (d) Suppose you have maximum speed limits for each state, would you include them in the regression in (a)? Explain your answer.

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. Claim: "Organic certification addresses a market failure." Clearly state your agreement and disagreement with this claim and provide support for your position. If you agree, identify and discuss the market failure.
    b. Claim: "FT certification addresses a market failure." Clearly state your agreement and disagreement with this claim and provide support for your position. If you agree, identify and discuss the market failure.

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. Write an expression for the total earnings for a grower who sells X pounds as FT coffee.
    b. 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}.
    c. Assume that any producer who pays c is qualified to sell his coffee as FT, although the market dictates the share s. What must be true about B^{FT} in equilibrium?
    d. 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. Suppose you wanted to pool data for coffee from different regions of the world together, but still want to allow for Arabica and Robusta varieties of coffee to be valued differently depending on where it was grown. Write down a specification that accomplishes this.
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.
    i. Give one example of a "causal inference problem" in general.
    ii. Explain this specific "causal inference problem" in as much detail as possible.
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. A portion of each delivery is potentially purchased as FT coffee; the rest is purchased as non-FT coffee. 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? (HINT: How would you construct the variables in Stata?)
    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: Remember that the share of coffee sold as FT coffee can vary from delivery to delivery.)

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.