AJAE appendix for "Voting for environmental policy under income and preference heterogeneity"

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Note: The material contained herein is supplementary to the article in the title and published in the American Journal of Agricultural Economics (*AJAE*).

Cobb-Douglas utility function

In the appendix, we analyze the policy preferences of the consumers assuming that their preferences are represented by a Cobb-Douglas utility function.

Let the utility function of consumer i be:

$$u_i = (1-\beta_i)\ln c_i + \beta_i \ln h_i + b\overline{h}.$$

where β_i is the weight of organic products in the utility function, c_i and h_i denote consumption of conventional and organic products for consumer i, and $\overline{h}$ denotes aggregate consumption of organic products. The budget constraint of the consumer i is given by

$$p_c c + p_h h = \widehat{w}_i + f$$

where f denotes non-taxable income and $\widehat{w}_i$ the disposable income of consumer type i.[1] The demands for conventional and organic products for consumer i are given by

$$c_i = \frac{(1-\beta_i)(\widehat{w}_i + f)}{p_c} \text{ and } h_i = \frac{\beta_i(\widehat{w}_i + f)}{p_h}.$$

Consider first the socially optimal demand for organic products. If the government is able to dictate consumption decisions, we have that the government chooses h_i so as to maximize

$$\begin{aligned} W = b\overline{h} &+ \lambda_{OP}\left[(1-\beta_{OP})\ln(w_P + f - ph_{OP}) + \beta_{OP}\ln h_{OP}\right] + \lambda_{NP}\ln(w_P + f - ph_{NP}) \\ &+\lambda_{OR}\left[(1-\beta_{OR})\ln(w_R + f - ph_{OR}) + \beta_{OR}\ln h_{OR}\right] + \lambda_{NR}\ln(w_R + f - ph_{NR}). \end{aligned}$$

This leads to

$$h_i^o = \frac{-(p-(w_i+f)b) \pm \sqrt{(p-(w_i+f)b)^2 + 4pb\beta_i(w_i+f)}}{2pb} \text{ for } i = OP, NP, OR, NR.$$

A comparison with $h_i^s(s) = \frac{\beta_i\left(\left(1-\frac{s\overline{h}^s(s)}{\overline{w}}\right)w_i + f\right)}{(p-s)}$ shows that in order to attain h_i^o for each consumer type, the government should use type-specific subsidies. Consequently, the first-best cannot be achieved using a single subsidy.

[1] We will discuss below what role f plays in the analysis.

Subsidy for organic products

Consider then a single subsidy for all consumer types. The aggregate demand for organic and conventional products under the subsidy scheme are

$$\overline{h}^{s}(s)=\frac{\left(K+\overline{\beta}f\right)\overline{w}}{(p-s)\overline{w}+Ks}\text{ and }\overline{c}^{s}(s)=\frac{(\overline{w}+f)\left[(p-s)\overline{w}+Ks\right]-p\overline{w}\left(K+\overline{\beta}f\right)}{(p-s)\overline{w}+Ks}$$

where $K=\lambda_{OP}\beta_{OP}w_P+\lambda_{OR}\beta_{OR}w_R$. Note that $\overline{w}>K$ because $\beta_i<1$ for all i. As should be expected, $\frac{\partial\overline{h}^{s}(s)}{\partial s}>0$. Consider then the policy preferences of the consumers. By inserting optimal demands into the utility function we obtain

$$v_i^s(s)=\ln(1-\beta)-\beta\ln(\frac{1-\beta}{\beta})+\ln\left[\left(1-\frac{s\overline{h}^{s}(s)}{\overline{w}}\right)w_i+f\right]-\beta_i\ln(p-s)+b\overline{h}^{s}(s)$$

The first condition for the most preferred subsidy for consumer i is then

$$\frac{\partial v_i^s(s)}{\partial s}=-\frac{\left(\frac{\overline{h}^{s}(s)}{\overline{w}}+\frac{s\frac{\partial\overline{h}^{s}(s)}{\partial s}}{\overline{w}}\right)w_i}{\left(1-\frac{s\overline{h}^{s}(s)}{\overline{w}}\right)w_i+f}+\frac{\beta_i}{p-s}+b\frac{\partial\overline{h}^{s}(s)}{\partial s}=0.$$

We can infer the following from this equation. First, we have

$$\frac{ds}{dw_i}=-\frac{\frac{\partial^2v_i^s(s)}{\partial s\partial w_i}}{\frac{\partial^2v_i^s(s)}{\partial s\partial s}}=\frac{\frac{\left(\frac{\overline{h}^{s}(s)}{\overline{w}}+\frac{s\frac{\partial\overline{h}^{s}(s)}{\partial s}}{\overline{w}}\right)f}{\left(\left(1-\frac{s\overline{h}^{s}(s)}{\overline{w}}\right)w_i+f\right)^2}}{\frac{\partial^2v_i^s(s)}{\partial s\partial s}}<0.$$

This is because the denominator of the right hand side is the second order condition for optimum which must be negative. Therefore, those with higher income prefer a lower subsidy if $f>0$. If $f=0$, income level does not affect the most preferred subsidy. In the same manner,

$$\frac{ds}{d\beta_i}=-\frac{\frac{\partial^2v_i^s(s)}{\partial s\partial\beta_i}}{\frac{\partial^2v_i^s(s)}{\partial s\partial s}}=-\frac{\frac{1}{p-s}}{\frac{\partial^2v_i^s(s)}{\partial s\partial s}}>0$$

that is, those with higher β_i prefer a bigger subsidy.

Second, for some consumers, the most preferred subsidy will be zero. In order to analyze this case, let us evaluate $\frac{\partial v_i^s(s)}{\partial s}$ at $s=0$. Consider those for whom $\beta_i = 0$. In that case

$$\begin{aligned}\frac{\partial v_i^s(s)}{\partial s} &= -\frac{\frac{\overline{h}^s(s)}{\overline{w}} w_i}{w_i+f} + b\frac{\partial \overline{h}^s(s)}{\partial s} \\ &= -\frac{\frac{\left(K+\overline{\beta}f\right)}{p}\frac{w_i}{\overline{w}}}{w_i+f} + b\frac{\left(K+\overline{\beta}f\right)\left(\overline{w}-K\right)}{p^2\overline{w}}\end{aligned}$$

Corner solution will be optimal for a consumer with $\beta_i = 0$ if

$$\frac{\partial v_i^s(s)}{\partial s} < 0 \Leftrightarrow w_i > \frac{b}{p}\left(\overline{w}-K\right)\left(w_i+f\right)$$

This inequality is satisfied if w_i is large and $\frac{b}{p}$ is small. That is , the rich who do not consume organic products are most likely to prefer no intervention especially when the social benefits of organic farming are small.

Tax on conventional products

Under the tax scheme, the aggregate demands are

$$\overline{c}^t(t) = \frac{\overline{w}-K+f\left(1-\overline{\beta}\right)}{1+t\overline{\beta}} \text{ and } \overline{h}^t(t) = \frac{K+t\overline{\beta}\overline{w}+f\overline{\beta}(1+t)}{p\left(1+t\overline{\beta}\right)}.$$

Again, $\frac{\partial \overline{c}^t(t)}{\partial t} < 0$ and $\frac{\partial \overline{h}^t(t)}{\partial t} > 0$. As above, we can write the indirect utility function of the cosnumers as

$$v_i^t(t) = (1-\beta)\ln(1-\beta) + \beta\ln\frac{\beta}{p} + \ln\left[w_i + t\overline{c}^t(t) + f\right] - (1-\beta_i)\ln(1+t) + b\overline{h}^t(t).$$

The first order condition for most preferred tax rate is given by

$$\frac{\partial v_i^t(t)}{\partial t} = \frac{\overline{c}^t(t) + t\frac{\partial \overline{c}^t(t)}{\partial t}}{w_i + t\overline{c}^t(t) + f} - \frac{1-\beta_i}{1+t} + b\frac{\partial \overline{h}^t(t)}{\partial t} = 0.$$

First, we have

$$\frac{dt}{dw_i} = -\frac{\frac{\partial^2 v_i^t(t)}{\partial t \partial w_i}}{\frac{\partial^2 v_i^t(t)}{\partial t \partial t}} = \frac{\frac{\overline{c}^t(t)+t\frac{\partial \overline{c}^t(t)}{\partial t}}{\left(w_i+t\overline{c}^t(t)+f\right)^2}}{\frac{\partial^2 v_i^t(t)}{\partial t \partial t}} < 0$$

Again assuming that $\frac{\partial^2 v_i^t(t)}{\partial t \partial t} < 0$. In addition, since $\frac{\partial^2 v_i^t(t)}{\partial t \partial \beta_i} = \frac{1}{1+t}$, we have that $\frac{dt}{d\beta_i} > 0$. The rich prefer a lower tax rate than the poor and those with higher β prefer a higher tax rate.

Second, consider the policy preferences of those who do not consume organic products. Then, again evaluated at $t = 0$ we have

$$\frac{\partial v_i^t(t)}{\partial t} = \frac{\overline{w} - K + f\left(1 - \overline{\beta}\right)}{w_i + f} - 1 + b\frac{\partial \overline{h}^t(t)}{\partial t}$$

and it follows that

$$\frac{\partial v_i^t(t)}{\partial t} < 0 \Leftrightarrow \frac{\overline{w} - K + f\left(1 - \overline{\beta}\right)}{w_i + f} + b\frac{\partial \overline{h}^t(t)}{\partial t} < 1$$

Again, those who do not consume organic products prefer no intervention if their income is high and the social benefits of organic farming are small.