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Evaluating Food Waste Reduction Policies: A Household Model with Heterogeneous Income Effects

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INTRODUCTION

One-third of global edible food is wasted annually (Gustavsson et al., 2011). In the United States, 133 billion pounds of the available retail and consumer food supply went uneaten with 90 billion pounds of purchased food lost at consumers level in 2010 (Buzby et al., 2014). Food waste is the largest source (35.2 mil tons) and among the most deleterious components (in terms of greenhouse gas emission) of U.S. municipal solid waste (EPA 2015).

Motivation:

It is widely accepted that food waste patterns differ between low-income and high-income countries.

Empirical estimates of the income effect at the consumer-level are divided.

- Lower income households may waste more since they cook and eat more at home (Kathirvale, Sopian & Samsuddin, 2003)
- Higher income households may waste more because their marginal benefit of food and wealth is lower (Parfitt et al., 2010; NSW EPA, 2012)
- No significant correlation is found between household income and the amount of food waste (Koivupuro et al., 2012; Neff et al., 2015)

Households' incentives for wasting and saving food

Incentives to waste food:

- Reduce time costs
- Reduce foodborne illness
- Enhance food quality

Incentives to reduce food waste:

- Marginal benefit from increased food intake
- Marginal benefit from lower food costs
- Reduce environmental impacts
- Reduce guilt about wasting food

Efficiency of consumer effort could influence both

- For example: large vs. small refrigerator

Theoretical Model

There is a representative consumer endowed with 24 hours per day. Time is divided between leisure $l \in [0,24]$, effort $e \in [0,24]$ reducing food waste (e.g., food shopping more frequently), or work with wage rate *w*. He could purchase *y* units of food at exogenous price *p*, or *x* units of a numeraire market good with normalized price 1.

$\alpha(w)$ is the efficiency of his effort. We assume high-wage households are better at time and waste management ($\alpha'(.) > 0$, $\alpha''(.) < 0$). As a result, $\exp(-\alpha(w)e)y$ units of food will be wasted and only $A = (1- \exp(-\alpha(w)e)y$ units of food will be eaten.

The consumer suffers disutility $\phi(.)$ from exerting food waste reduction effort. Two consumer characteristics share a common root, but affect disutility in different directions. First, disutility may change with sensitivity to foodborne illness risk ($H(.)$). The consumer who perceives high risks from suspicious food (e.g., food approaching label dates) experiences more disutility from eating it instead of wasting it. Second, disutility is negatively correlated with consumer concerns about the environmental impacts of food waste ($E(.)$). Both the health risk sensitivity and environmental concerns are increasing in exogenous wage rate, *w*, such that $E'(.) > 0$ and $H'(.) > 0$.

The consumer chooses food, numeraire, leisure and effort quantities to maximize utility *s.t.* budget and time constraints

$$\max_{(y,x,l,e)} u(A,l,x,\phi(w)e)$$

$$= \max_{(y,x,l,e)} u((1-\exp(-\alpha(w)e))y,l,x,\phi(w)e)$$

$$py + x \le w(24-l-e)$$

$$e \in [0,24], l \in [0,24], e+l \in [0,24]$$

Equilibrium

The optimal effort level and the comparative static w.r.t. the wage rate are:

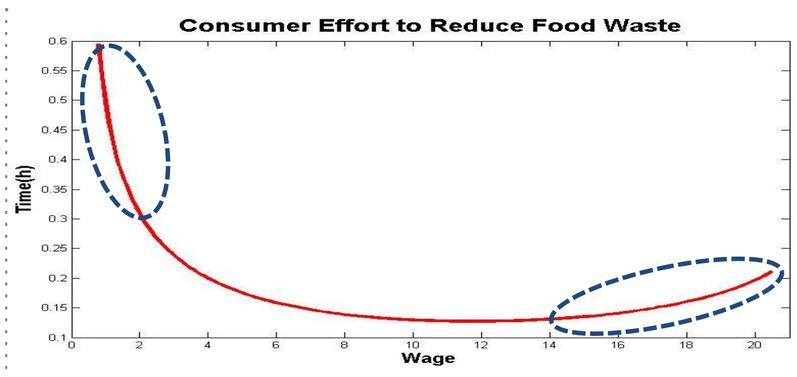
$$e^* = \frac{\ln(y)+\ln(u_1)+\ln(\alpha(w))-\ln(wu_3-\phi(w)u_4)}{\alpha(w)}$$

where $u_1 = \frac{\partial u}{\partial y} > 0, u_3 = \frac{\partial u}{\partial x} > 0$, $u_4 = \frac{\partial u}{\partial(\phi(w)e)} < 0$, $wu_3 - \phi(w)u_4 > 0$

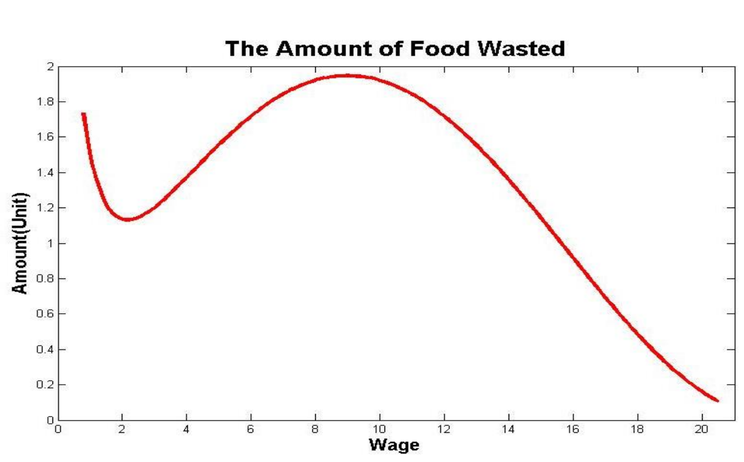
LEMMA 1: *Consumer effort increases with the amount of food purchased and the marginal utility of food, while effort decreases with the marginal utility from market goods (which is equal to the marginal utility from disposable income) and the disutility of effort.*

$$\frac{de^*}{dw} = \frac{1}{\alpha}\left(\frac{1}{y}\frac{dy}{dw}+\frac{1}{u_1}\frac{du_1}{dw}\right)+\frac{1}{\alpha}\left(\frac{1}{\alpha}-e\right)\frac{d\alpha}{dw}$$
$$+\frac{1}{\alpha}\left(\frac{\phi' u_4}{wu_3-\phi u_4}+\frac{\phi}{wu_3-\phi u_4}\frac{du_4}{dw}\right)$$
$$+\frac{1}{\alpha}\left(\frac{-u_3}{wu_3-\phi u_4}-\frac{w}{wu_3-\phi u_4}\frac{du_3}{dw}\right)$$

PROPOSITION 1: *When the wage rate is low, the change of the consumer effort is mainly determined by the utility change from food and the tradeoff between effort level and its efficiency. As the wage rate increases, low income households decrease effort due to significant improvements in effort efficiency and great decreases in the marginal utility from food.*



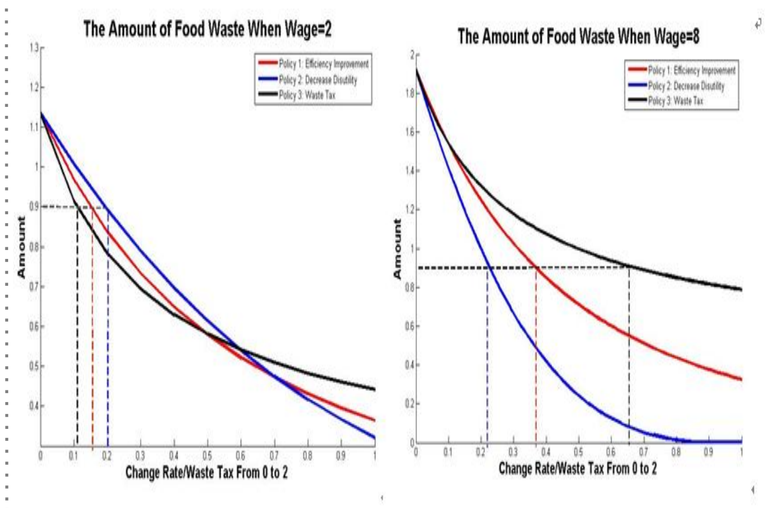
PROPOSITION 2: *When the wage rate is high and increasing, the change in marginal utility from food and the efficiency improvement will be limited. Disutility and the opportunity cost of the effort will be more important for higher-income households when they determine how much food to waste. The households with intermediate incomes waste much food due to health concerns and preferences for market goods and leisure, while the richest households make more effort to save food due to environmental concerns.*

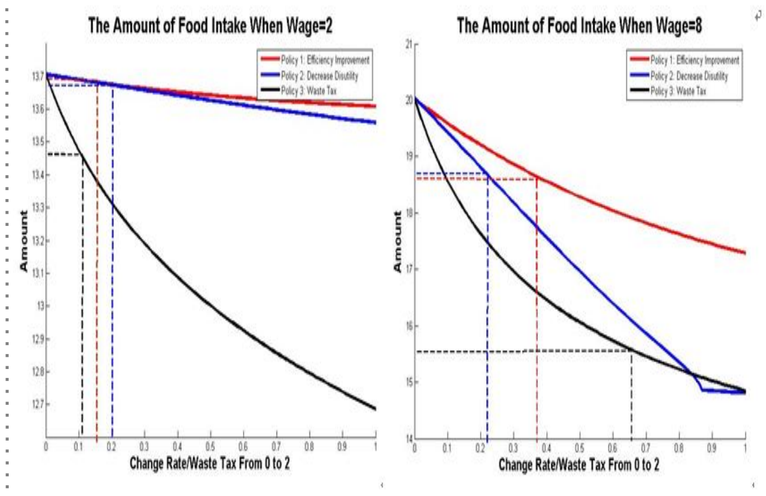


Policy Implication:

Types of policy:

- Inexpensive food/waste: The Korean government charges residents and businesses for food waste based on weight (Mazzoni, 2013)
- Package/portion size: An experiment in U.S. hotel restaurants reduced food waste ~20% simply by reducing plate size (Kallbekken & Sælen, 2013).
- Health Concerns: The United Kingdom removed 'sell-by' date on food packages.
- Environment Concerns: Programs like *Love Food Hate Waste* are initiated to improve efficiency.





Program Targeting Insights

- Information programs that decrease consumer disutility of effort are best for the high-income households.
- Waste taxes could reduce food waste from low-income households but at a great cost of food intake/security.

Conclusions

- Households food waste behavior varies with income levels nonlinearly.
- Policies lacking customization to income may be inefficient.
- Waste tax or waste fee is less effective for high-income households. Although it may help low income household reduce more food waste, the reduction is at great cost of food intake/security.

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