Can radiation-contaminated food be marketed?

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Motivation

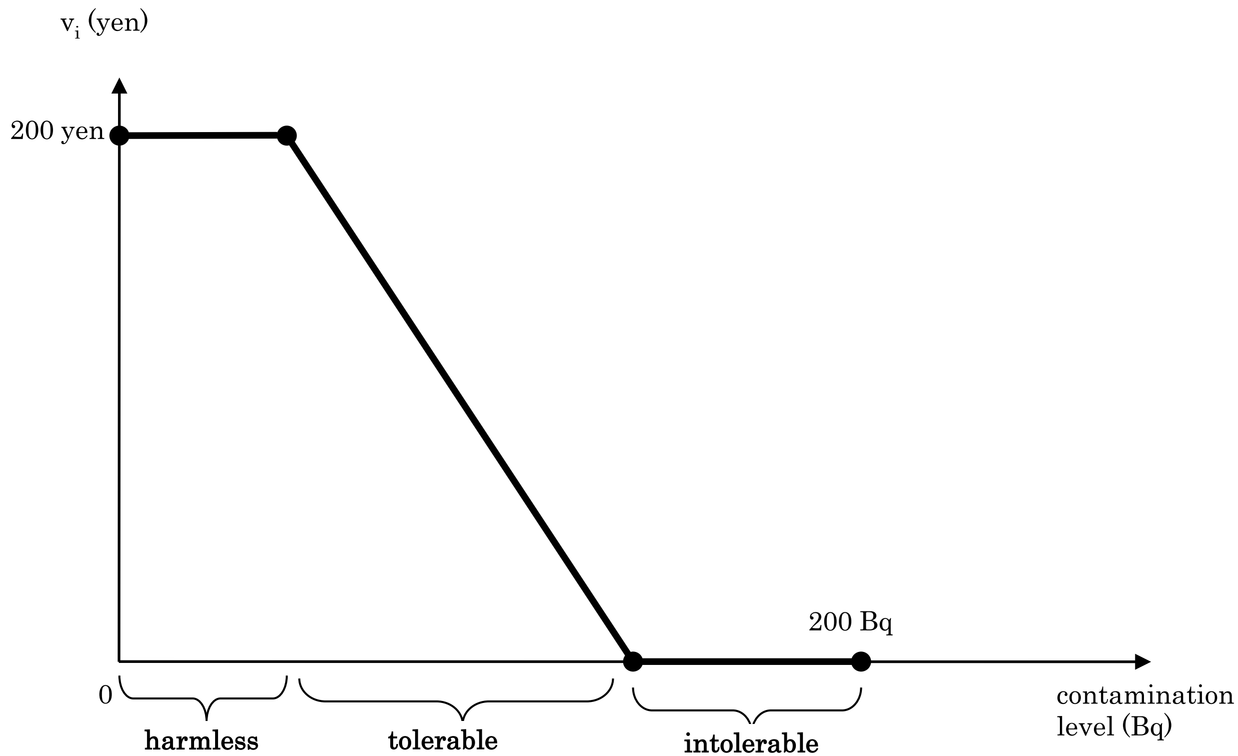
- Heterogeneity in attitude toward contamination risks
  - Some have strong preferences for zero risks, and refuse to purchase contaminated food.
  - Some reveal preferences for contaminated food as long as it is discounted for radiation risks.
- A relationship between risk perception and risk attitude
  - Individual attitude toward radiation risks may depend critically on own perception about cancer risks.
- Substitution and complementarity between primary markets and secondary (discount) markets
  - How are secondary markets substituted for primary markets in trading radiation-contaminated food?

Main features in a theoretical model of valuation of radiation-contaminated food

- Preferences for radiation-contaminated food are heterogeneous
  - Among those with different observed characteristics
  - Among those with observationally identical characteristics

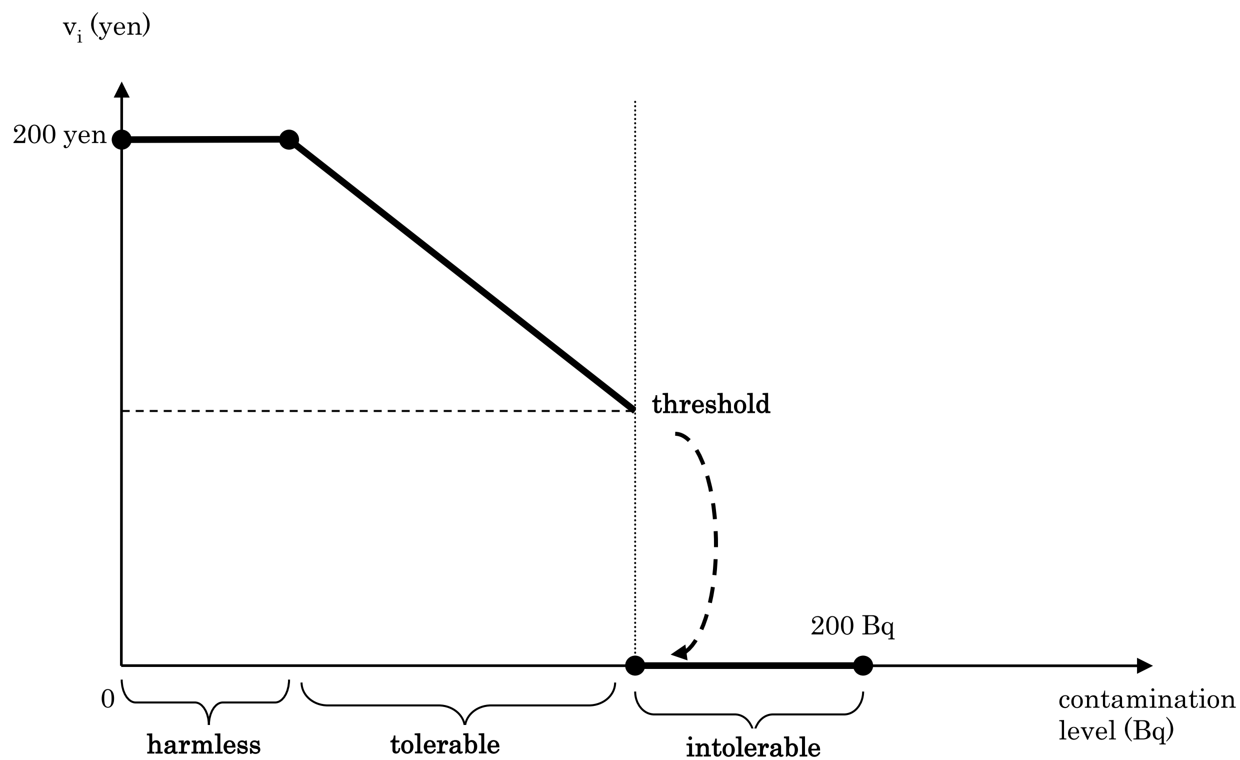
- A discrete/continuous choice model as a structural form
  - Harmless: traded at a normal price
  - Tolerable: traded at a discount price
  - Intolerable: no positive price at all

Figure 1-1: A case without any threshold



$\underline{v}_i$

Figure 1-2: A case with a threshold



A basic setup

- Valuation:

$$v_i = p_i d_i + 200(1 - p_i)$$

- Risk-adjusted weight:

$$\frac{\hat{p}_i}{\overline{p}_i} = \frac{200}{200 - \underline{v}_i}$$

- Idiosyncratic shocks:

$$x \sim U\left[\underline{D}_i, \overline{D}\right]$$

$$y\Big|_{x=X} \sim U\left[X, \overline{D}\right]$$

- A degree of zero risk preferences:

$$\kappa_i = \frac{-\underline{D}_i}{\overline{D} - \underline{D}_i}$$

Figure 2: A pattern in a consumer's valuation of radiation-contaminated milk

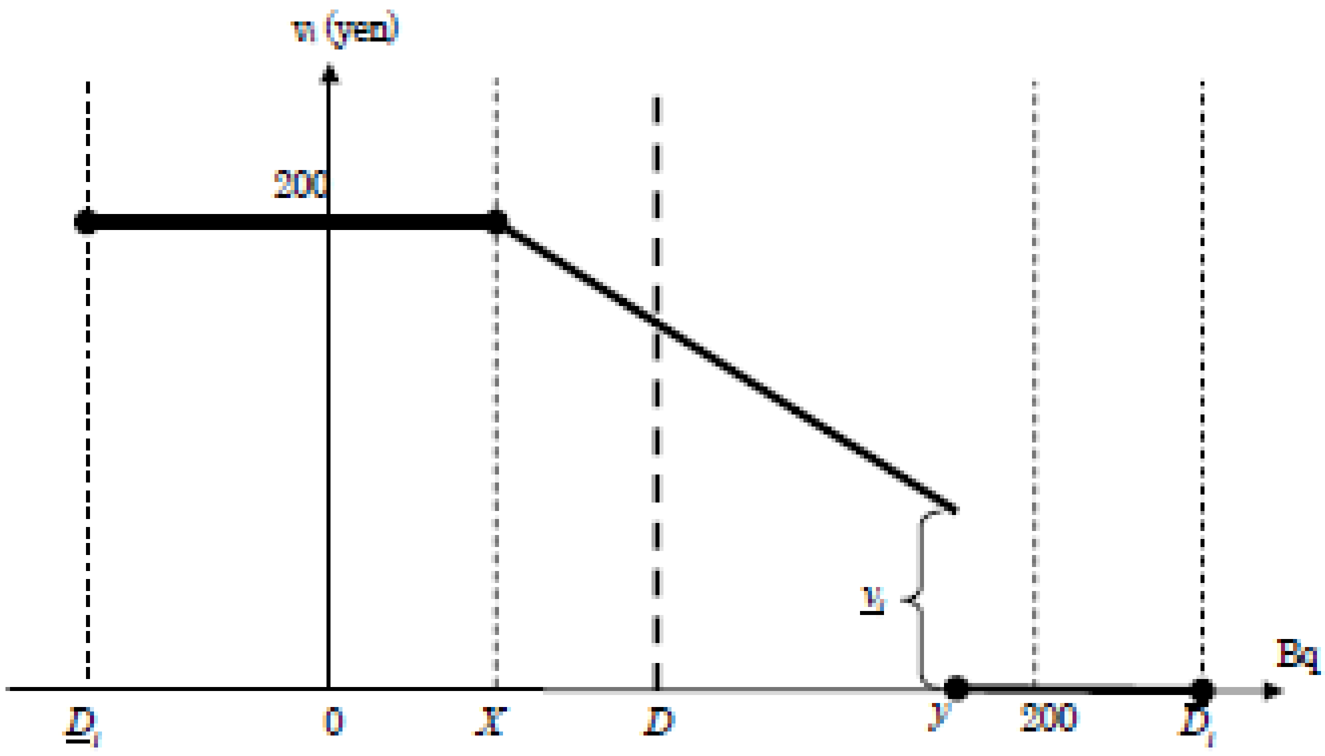


Figure 3-1: Case 1, $v_i = 200$

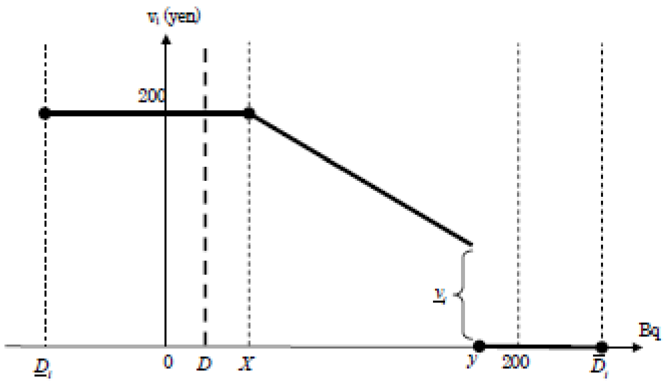


Figure 3-2: Case 2, $0 < v_i < 200$

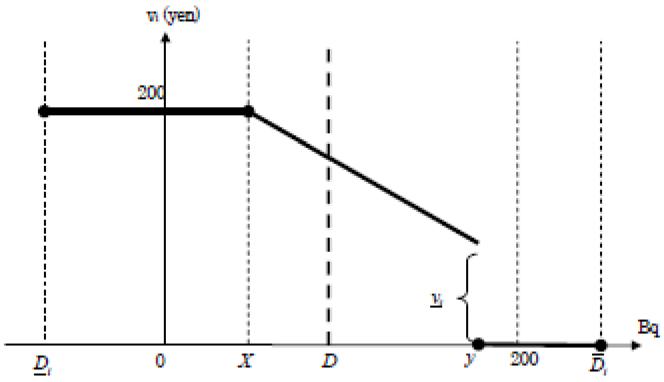
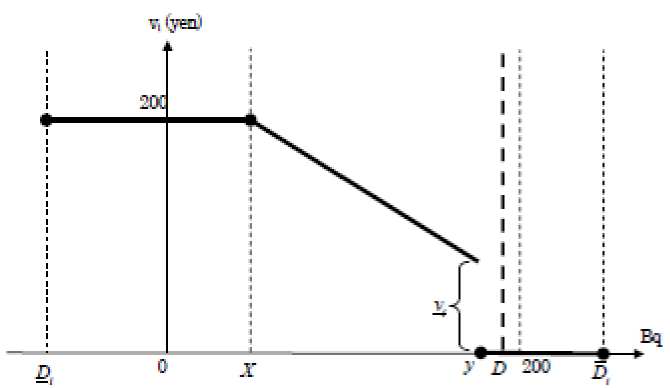


Figure 3-3: Case 3, $v_i = 0$



Distribution for Cases 1 through 3

$$
\begin{aligned}
\Pr\left(D \le x\right) &= \int_{D}^{\overline{D}} \frac{1}{\overline{D} - \underline{D}_t} dx \\
&= \frac{\overline{D} - D}{\overline{D} - \underline{D}_t}.
\end{aligned}
$$

$$
\begin{aligned}
\Pr\left(x < D < y\right) &= \int_{\underline{D}_t}^{D} \left(\frac{\overline{D} - D}{\overline{D} - x} \frac{1}{\overline{D} - \underline{D}_t} \right) dx \\
&= \frac{\overline{D} - D}{\overline{D} - \underline{D}_t} \left[\ln\left(\overline{D} - \underline{D}_t\right) - \ln\left(\overline{D} - D\right) \right]
\end{aligned}
$$

$$
\begin{aligned}
\Pr\left(y \le D\right) &= \int_{\underline{D}_t}^{D} \left(\frac{D - x}{\overline{D} - x} \frac{1}{\overline{D} - \underline{D}_t} \right) dx \\
&= \frac{D - \underline{D}_t}{\overline{D} - \underline{D}_t} - \frac{\overline{D} - D}{\overline{D} - \underline{D}_t} \left[\ln\left(\overline{D} - \underline{D}_t\right) - \ln\left(\overline{D} - D\right) \right]
\end{aligned}
$$

Conditional density for Case 2

$$
\begin{aligned}
\varphi\left(v_t(y) \middle| x < D < y\right) &= \int_{D_t(v)}^{D} \frac{\left(200-\underline{v}_t\right)\left(D-x\right)}{\left(\overline{D}-D\right)\left(200-v_t\right)^2}\left(\frac{1}{D-\underline{D}_t}\right)dx \\
&= \frac{\left(200-\underline{v}_t\right)}{2\left(\overline{D}-D\right)\left(D-\underline{D}_t\right)\left(200-v_t\right)^2}\left\{D-D_t\left(v\right)\right\}^2 \\
&= \begin{cases} \frac{(200-\underline{v}_t)(D-\underline{D}_t)}{2\left(\overline{D}-D\right)(200-v_t)^2}, & \underline{v}_t \leq v_t < \hat{v}_t \\ \frac{(200-\underline{v}_t)\left(\overline{D}-D\right)}{2(D-\underline{D}_t)(v_t-\underline{v}_t)^2}, & \hat{v}_t \leq v_t < 200, \end{cases}
\end{aligned}
$$

where:

$$
\hat{v}_t = \underline{v}_t + \left(200-\underline{v}_t\right)\frac{\overline{D}-D}{\overline{D}-\underline{D}_t}.
$$

Substitution of secondary markets for primary markets

- A critical value for the degree of zero risk preferences

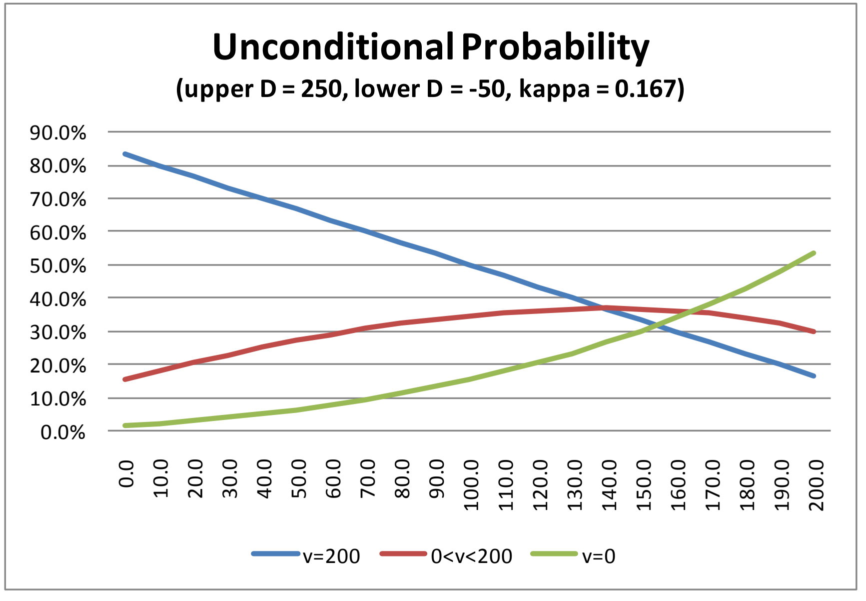
$$\kappa_i = \frac{-\underline{D}_i}{\overline{D} - \underline{D}_i} > 1 - \frac{1}{\exp(1)} \approx 0.632$$

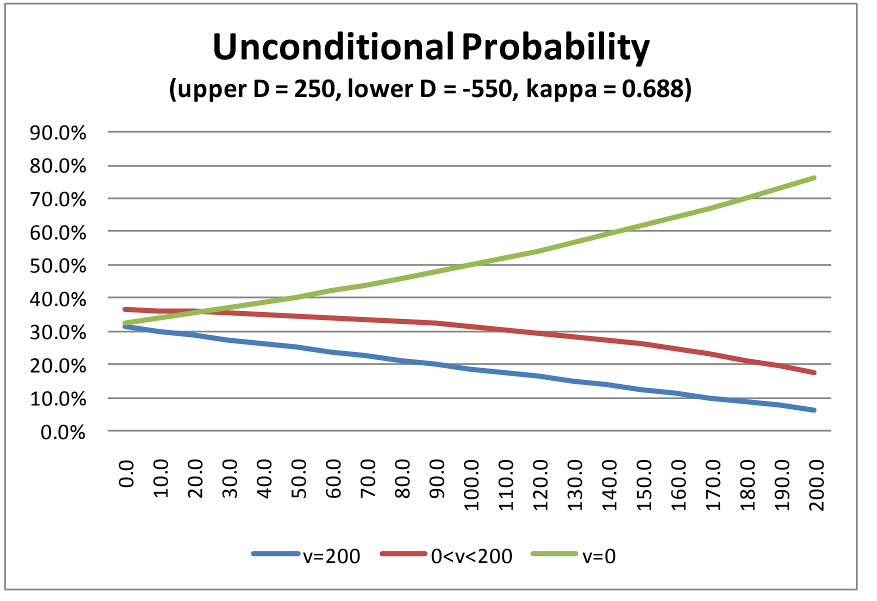
$$\frac{\partial \Pr(0 < v_i < 200)}{\partial D} = \frac{1}{\overline{D} - \underline{D}_i} \left(1 + \ln \frac{\overline{D} - D}{\overline{D} - \underline{D}_i} \right). \tag{19}$$

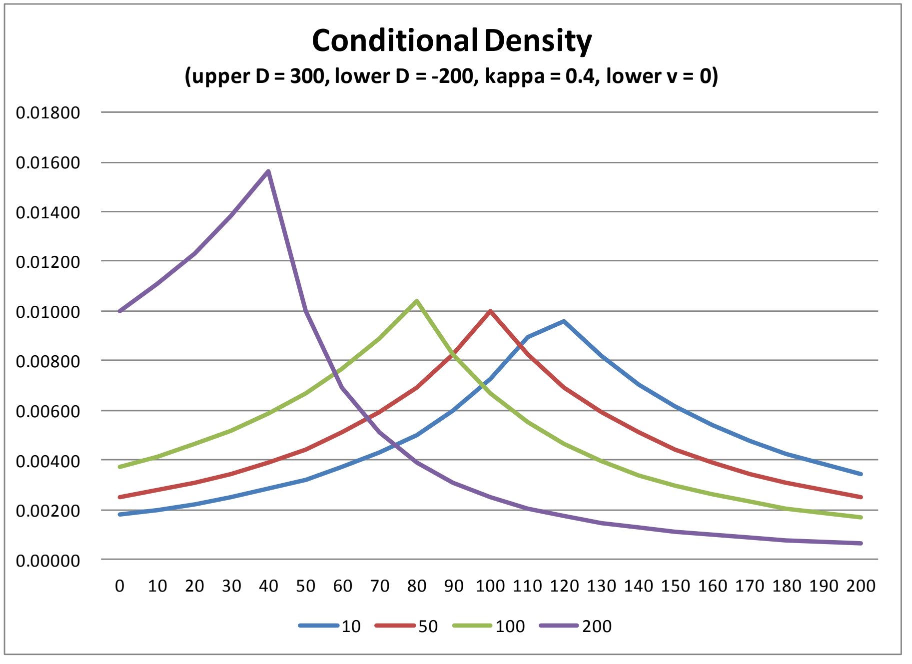
From equation (19), if $D \leq \underline{D}_i + (\overline{D} - \underline{D}_i)\left(1 - \frac{1}{\exp(1)}\right)$, then $\frac{\partial \Pr(0<v<200)}{\partial D} \geq 0$. Hence, if $\frac{-\underline{D}_i}{\overline{D} - \underline{D}_i} \leq 1 - \frac{1}{\exp(1)} \approx 0.632$, $\frac{\partial \Pr(0<v<200)}{\partial D}$ can be positive when D is positive.[1] In this case, a secondary market substitutes to some extent for a primary market, before both markets shrink.

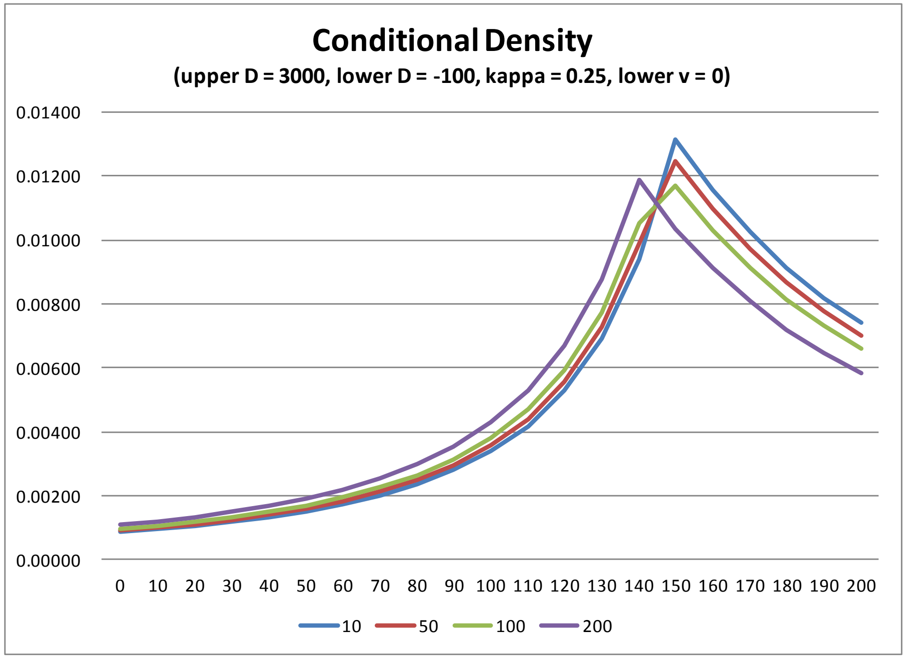
On the other hand, if $\frac{-\underline{D}_i}{\overline{D} - \underline{D}_i} > 1 - \frac{1}{\exp(1)} \approx 0.632$, then $\frac{\partial \Pr(0<v<200)}{\partial D}$ is always negative. In this case, an increase in contamination levels necessarily dampens demand in a secondary market where radiation-contaminated milk is discounted continuously according to the contamination level.

Figures 4-2 to 4-3: Numerical examples






Conditional Density
(upper D = 300, lower D = -200, kappa = 0.4, lower v = 0)
0.01800
0.01600
0.01400
0.01200
0.01000
0.00800
0.00600
0.00400
0.00200
0.00000
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
10
50
100
200


Conditional Density
(upper D = 3000, lower D = -100, kappa = 0.25, lower v = 0)
0.01400
0.01200
0.01000
0.00800
0.00600
0.00400
0.00200
0.00000
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
10
50
100
200

Statistical model

We thus assume the following linear specification for these systemic parts:

$$\underline{D}_i = \mathbf{z}_i\beta + const_{\underline{D}}, \tag{20}$$

$$\underline{v}_i = \mathbf{z}_i\gamma + const_{\underline{v}}, \tag{21}$$

where $\mathbf{z}_i$ is a $1 \times K$ vector which represents individual characteristics, and β and γ are respectively $K \times 1$ coefficient vectors.

It is in principle possible to formulate $\overline{D}_i = \mathbf{z}_i\alpha + const_{\overline{D}}$ as well. But, we treat $\overline{D}$ as a constant parameter to avoid potential identification problems in estimating $\overline{D}_i$ together with $\underline{D}_i$ and $\underline{v}_i$.

Logarithmic likelihood: A single point observation

$$
\ln L\left(v \middle| \Theta, D\right) = \begin{cases}
\ln\left[\frac{D-\underline{D}_i}{\overline{D}-\underline{D}_i} - \frac{\overline{D}-D}{\overline{D}-\underline{D}_i}\left\{\ln\left(\overline{D}-\underline{D}_i\right) - \ln\left(\overline{D}-D\right)\right\}\right], & v_i = 0 \\
\ln\left[\frac{(200-\underline{v}_i)(D-\underline{D}_i)}{2\left(\overline{D}-\underline{D}_i\right)(200-v_i)^2}\left\{\ln\left(\overline{D}-\underline{D}_i\right) - \ln\left(\overline{D}-D\right)\right\}\right], & \underline{v}_i \leq v_i < \hat{v} \\
\ln\left[\frac{(200-\underline{v}_i)\left(\overline{D}-D\right)^2}{2\left(\overline{D}-\underline{D}_i\right)(D-\underline{D}_i)(v_i-\underline{v}_i)^2}\left\{\ln\left(\overline{D}-\underline{D}_i\right) - \ln\left(\overline{D}-D\right)\right\}\right], & \hat{v} \leq v_i < 200 \\
\ln\left[\frac{\overline{D}-D}{\overline{D}-\underline{D}_i}\right], & v_i = 200.
\end{cases}
$$

Logarithmic likelihood: Multiple point observations (1)

$$
\begin{aligned}
&\Pr(\text{case}) \\
&= \begin{cases}
\Pr\left(D^4 \le x\right) = \frac{\overline{D}_i - D^4}{\overline{D}_i - \underline{D}_i}, & \text{Case} = (1,1,1,1) \\
\Pr\left(D^3 \le x < D^4 < y\right) = \frac{\overline{D}_i - D^4}{\overline{D}_i - \underline{D}_i} \ln\left(\frac{\overline{D}_i - D^3}{\overline{D}_i - D^4}\right), & \text{Case} = (1,1,1,2) \\
\Pr\left(D^3 \le x \le y \le D^4\right) = \frac{1}{\overline{D}_i - \underline{D}_i}\left[\left(D^4 - D^3\right) - \left(\overline{D}_i - D^4\right) \ln\left(\frac{\overline{D}_i - D^3}{\overline{D}_i - D^4}\right)\right], & \text{Case} = (1,1,1,3) \\
\Pr\left(D^2 \le x < D^3 < D^4 < y\right) = \frac{\overline{D}_i - D^4}{\overline{D}_i - \underline{D}_i} \ln\left(\frac{\overline{D}_i - D^2}{\overline{D}_i - D^3}\right), & \text{Case} = (1,1,2,2) \\
\Pr\left(D^2 \le x < D^3 < y \le D^4\right) = \frac{D^4 - D^3}{\overline{D}_i - \underline{D}_i} \ln\left(\frac{\overline{D}_i - D^2}{\overline{D}_i - D^3}\right), & \text{Case} = (1,1,2,3) \\
\Pr\left(D^2 \le x \le y \le D^3\right) = \frac{1}{\overline{D}_i - \underline{D}_i}\left[\left(D^3 - D^2\right) - \left(\overline{D}_i - D^3\right) \ln\left(\frac{\overline{D}_i - D^2}{\overline{D}_i - D^3}\right)\right], & \text{Case} = (1,1,3,3) \\
\Pr\left(D^1 \le x < D^2 < D^4 < y\right) = \frac{\overline{D}_i - D^4}{\overline{D}_i - \underline{D}_i} \ln\left(\frac{\overline{D}_i - D^1}{\overline{D}_i - D^2}\right), & \text{Case} = (1,2,2,2) \\
\Pr\left(D^1 \le x < D^2 < D^3 < y \le D^4\right) = \frac{D^4 - D^3}{\overline{D}_i - \underline{D}_i} \ln\left(\frac{\overline{D}_i - D^1}{\overline{D}_i - D^2}\right), & \text{Case} = (1,2,2,3) \\
\Pr\left(D^1 \le x < D^2 < y \le D^3\right) = \frac{D^3 - D^2}{\overline{D}_i - \underline{D}_i} \ln\left(\frac{\overline{D}_i - D^1}{\overline{D}_i - D^2}\right), & \text{Case} = (1,2,3,3) \\
\Pr\left(D^1 \le x \le y \le D^2\right) = \frac{1}{\overline{D}_i - \underline{D}_i}\left[\left(D^2 - D^1\right) - \left(\overline{D}_i - D^2\right) \ln\left(\frac{\overline{D}_i - D^1}{\overline{D}_i - D^2}\right)\right], & \text{Case} = (1,3,3,3) \\
\Pr\left(x < D^1 < D^4 < y\right) = \frac{\overline{D}_i - D^4}{\overline{D}_i - \underline{D}_i} \ln\left(\frac{\overline{D}_i - \underline{D}_i}{\overline{D}_i - D^1}\right), & \text{Case} = (2,2,2,2) \\
\Pr\left(x < D^1 < D^3 < y \le D^4\right) = \frac{D^4 - D^3}{\overline{D}_i - \underline{D}_i} \ln\left(\frac{\overline{D}_i - \underline{D}_i}{\overline{D}_i - D^1}\right), & \text{Case} = (2,2,2,3) \\
\Pr\left(x < D^1 < D^2 < y \le D^3\right) = \frac{D^3 - D^2}{\overline{D}_i - \underline{D}_i} \ln\left(\frac{\overline{D}_i - \underline{D}_i}{\overline{D}_i - D^1}\right), & \text{Case} = (2,2,3,3) \\
\Pr\left(x < D^1 < y \le D^2\right) = \frac{D^2 - D^1}{\overline{D}_i - \underline{D}_i} \ln\left(\frac{\overline{D}_i - \underline{D}_i}{\overline{D}_i - D^1}\right), & \text{Case} = (2,3,3,3) \\
\Pr\left(y \le D^1\right) = \frac{D^1 - \underline{D}_i}{\overline{D}_i - \underline{D}_i} - \frac{\overline{D}_i - D^1}{\overline{D}_i - \underline{D}_i} \ln\left(\frac{\overline{D}_i - \underline{D}_i}{\overline{D}_i - D^1}\right), & \text{Case} = (3,3,3,3).
\end{cases}
\end{aligned}
$$

Logarithmic likelihood: Multiple point observations (2)

$$\varphi\left(v_i^j \middle| \mathbf{Case}\right) = \int_{D_l(v_i^j)}^{D_h(v_i^j)} \frac{(200-\underline{v}_i)\left(D^j - x\right)}{\left(\overline{D}_y - \underline{D}_y\right)\left(200 - v_i^j\right)^2}\left(\frac{1}{\overline{D}_x - \underline{D}_x}\right) dx \tag{26}$$

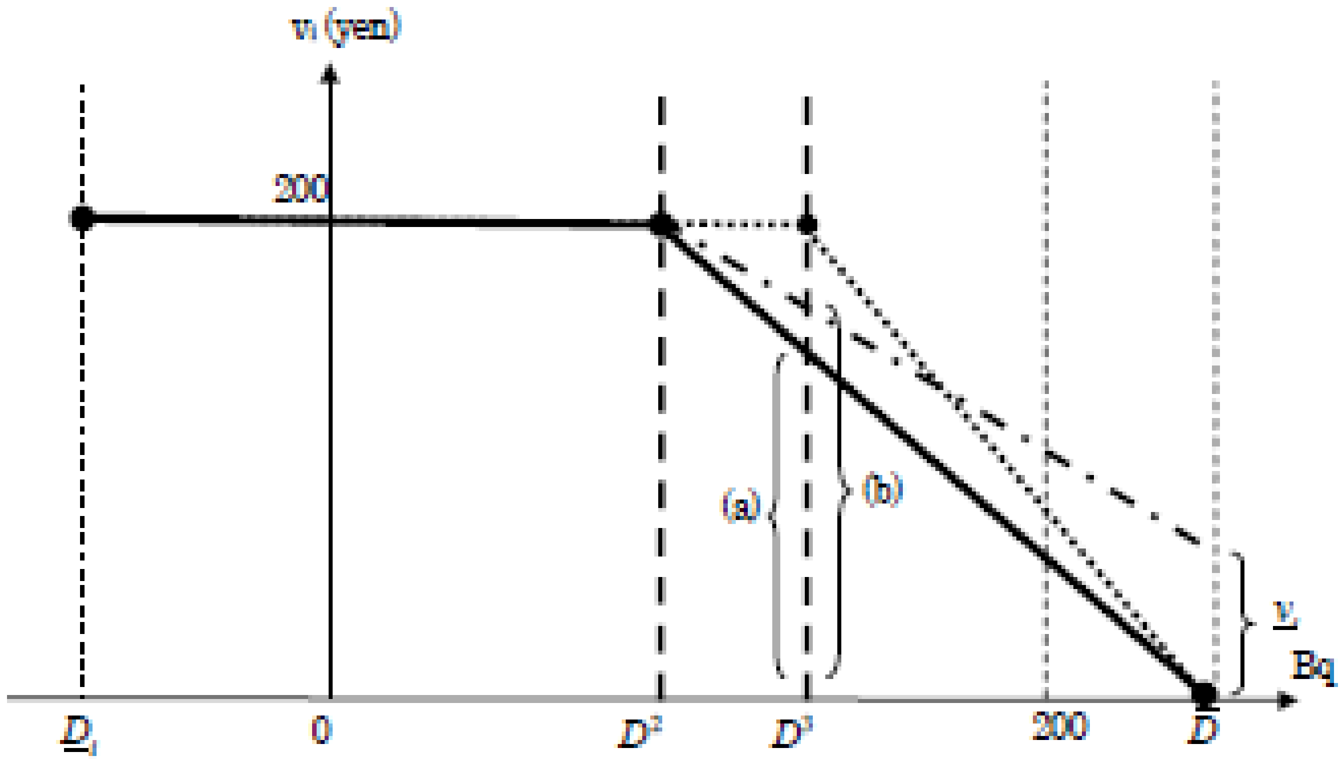
$$= \frac{200-\underline{v}_i}{2\left(\overline{D}_x - \underline{D}_x\right)\left(\overline{D}_y - \underline{D}_y\right)\left(200 - v_i^j\right)^2}\left[\left\{D^j - D_l\left(v_i^j\right)\right\}^2 - \left\{D^j - D_h\left(v_i^j\right)\right\}^2\right].$$

$$\ln L\left(\mathbf{v}_i \middle| \Theta, D^1, D^2, D^3, D^4\right) = \begin{cases} \ln \Pr\left(\mathbf{Case}\right), & if\ k^j \neq 2\ for\ j = 1,2,3,4 \\ \ln \Pr\left(\mathbf{Case}\right) + \ln \varphi\left(v_i^{j^*} \middle| \mathbf{Case}\right), & otherwise, \end{cases} \tag{27}$$

where

$$j^* = \max\left\{ j \middle| \underline{v}_i < v_i^j < 200 \right\}. \tag{28}$$

Figure 6-1: Lower upper limit of the valuation (v_i) with two observations included in Case 2



Introducing measurement errors

The second type of measurement errors: As the second method, we specify a simple density function for measurement errors $(g_1(v_i \mid v_i^*))$ by two linear functions.

$$g_1(v_i \mid v_i^*) = \begin{cases} \frac{200-v_i^*}{100 v_i^{*2}} v_i, & if\ v_i \leq v_i^*, \\ \frac{v_i^*}{100(200-v_i^*)^2}(200 - v_i), & otherwise. \end{cases} \quad (29)$$

By construction, $\int_0^{200} g_1(v \mid v_i^*)dv = 1$ and $\int_0^{200} [v g_1(v \mid v_i^*)]\, dv = v_i^*$ hold. Hence, the above formulation of measurement errors does not yield any systematic bias. See Figure 7-1 for a shape of the above density function.

Given the above type of measurement errors, the logarithmic likelihood is defined as follows:

$$\ln \Pr(\mathbf{Case}) + \ln \int_{\underline{v}_i}^{\max v_i^*} \left[\varphi(v| \mathbf{Case})\, g_k(v_i^{j^*} \mid v)\right] dv, \quad (31)$$

where k is 1 or 2. It is possible to compute analytically the integral in equation (31) in both cases ($k = 1$ and 2).

Figure 7-1: A shape of a density function of measurement errors (linear functions)

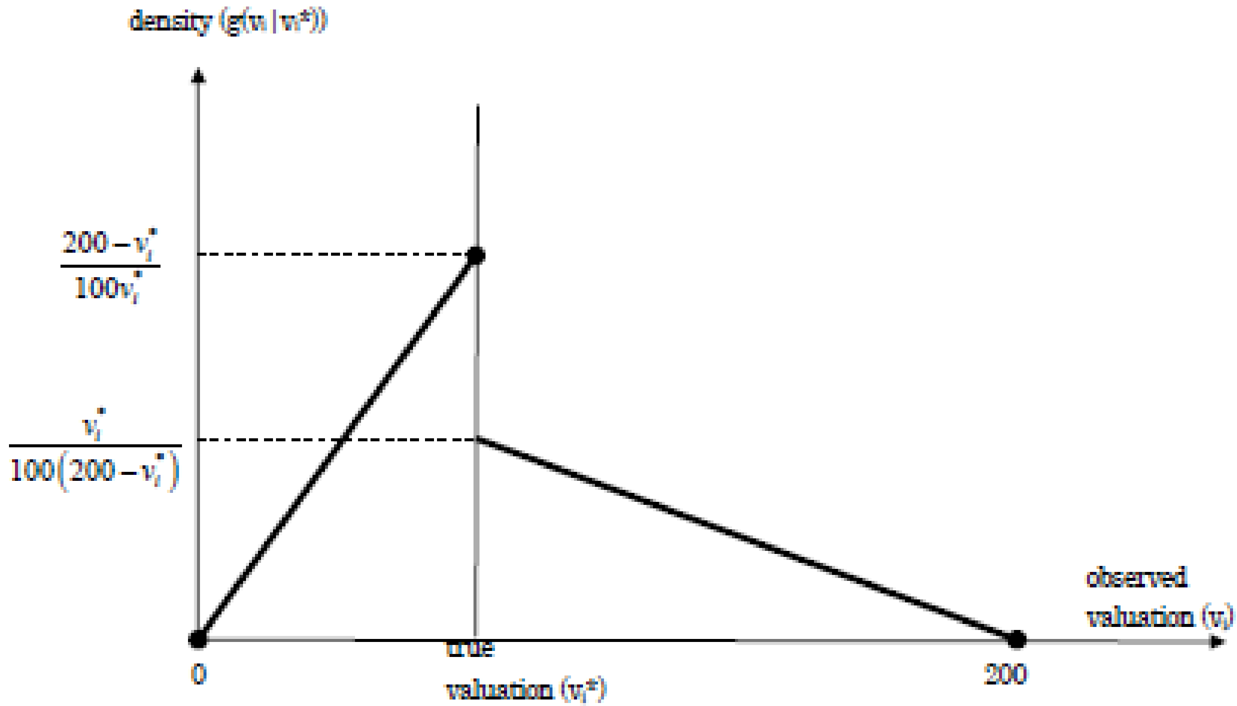


Table 3: Descriptive statistics of explanatory variables

	Mean	Standard Deviation
male dummy	0.5	
age dummy		
(twenties)	0.2	
(thirties)	0.2	
(fourties)	0.2	
(fifties)	0.2	
income class	2.607	0.855
spouse dummy	0.618	
the number of children	1.643	0.904
the age of the youngest child		
without any child	0.601	
younger than 3 years old	0.067	
between 3 and 10	0.086	
between 11 and 15	0.054	
between 16 and 20	0.060	
over 20	0.132	
smoker dummy	0.203	
drinker dummy	0.246	
no habit of eating organic vegetables	0.474	
participation in cancer insurance	0.439	
regular health checkup	0.536	
no habit of drinking milk	0.199	
the predicted cancer risks based on the logit estimation	0.268	

Table 1: The share of the respondents classified according to the three cases

	Case 1: a purchase without any discounting	Case 2: a purchase with discounting	Case 3: no purchase at any price	total
10 Bq	1,189	2,934	3,477	7,600
	(15.6%)	(38.6%)	(45.8%)	
50 Bq	892	2,137	4,571	7,600
	(11.7%)	(28.1%)	(60.1%)	
100 Bq	670	1,516	5,414	7,600
	(8.8%)	(19.9%)	(71.2%)	
200 Bq	428	1,000	6,172	7,600
	(5.6%)	(13.2%)	(81.2%)	

The observed fifteen patterns in valuation

- Among 7204 respondents who reveal consistent valuation over four points of contamination levels.

- No change in valuation
  - (1,1,1,1): **5.3%**
  - (2,2,2,2): **9.6%**
  - (3,3,3,3): **46.5%**

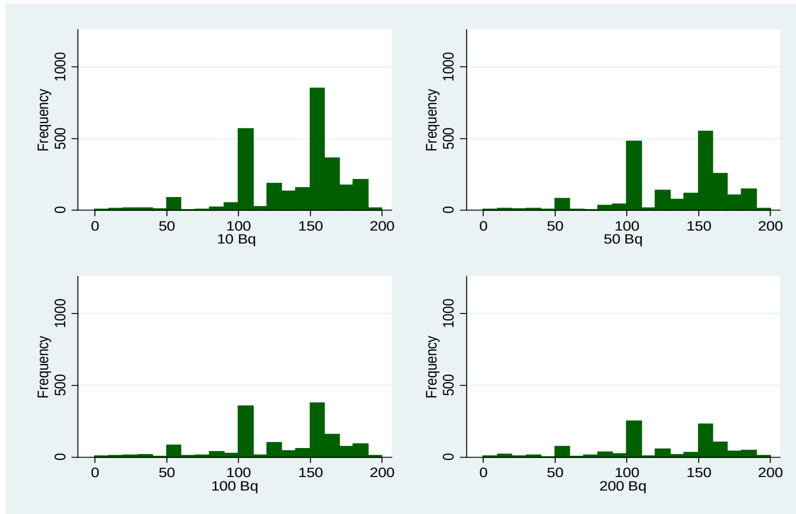
- Skipping Case 2
  - (1,1,1,3), (1,1,3,3), (1,3,3,3): **6.2%**

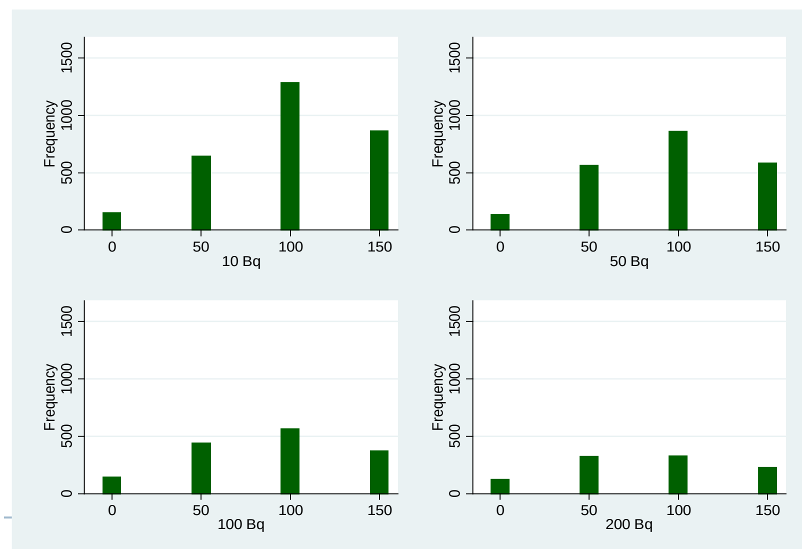
- Including Case 2
  - One time, (1,1,1,2), (1,1,2,3), (1,2,3,3), (2,3,3,3): **16.4%**
  - Two times or more, (1,1,2,2), (1,2,2,2), (1,2,2,3), (2,2,2,3), (2,2,3,3): **15.9%**

Table 2: Distribution and statistics of discount prices quoted in Case 2

The contamination level (Bq)	total	quoted discount prices (yen)										mean	median	kurtosis
		～19	20～39	40～59	60～79	80～99	100～119	120～139	140～159	160～179	180～199			
10 Bq	2,934	20	33	99	11	72	595	323	1,010	540	231	134.9	150	4.15
		(0.7%)	(1.1%)	(3.4%)	(0.4%)	(2.5%)	(20.3%)	(11.0%)	(34.4%)	(18.4%)	(7.9%)			
50 Bq	2,137	20	26	90	11	76	500	218	670	364	162	130.8	150	3.60
		(0.9%)	(1.2%)	(4.2%)	(0.5%)	(3.6%)	(23.4%)	(10.2%)	(31.4%)	(17.0%)	(7.6%)			
100 Bq	1,516	21	32	90	23	63	370	145	437	231	104	125.4	140	3.10
		(1.4%)	(2.1%)	(5.9%)	(1.5%)	(4.2%)	(24.4%)	(9.6%)	(28.8%)	(15.2%)	(6.9%)			
200 Bq	1,000	27	21	77	19	57	259	74	263	145	58	119.9	120	2.79
		(2.7%)	(2.1%)	(7.7%)	(1.9%)	(5.7%)	(25.9%)	(7.4%)	(26.3%)	(14.5%)	(5.8%)			

Figures 8-1 and 8-2: Histograms of the distribution of quoted discount prices at 10/50 yen intervals





Individual perception of life-time cancer risks

- Asking life-time cancer incident
  - The national average: about 30%

- Responses to such a delicate question:
  - Unlikely: 8.3%
  - Below the national average: 18.3%
  - Around the national average: 36.8%
  - Above the national average: 16.3%
  - Unable to judge: 19.9%
  - Unable to answer: 0.4%

Table 4: Estimation result of the logit model for respondents' perception of cancer risks

explanatory variables	A dummy variable of those who perceive cancer risks to be lower than the national average			
	Coefficient		Marginal effect	
male dummy	0.135	**	0.026	**
	(0.055)		(0.011)	
age dummy (twenties)	-0.467	***	-0.085	***
	(0.086)		(0.014)	
(thirties)	-0.481	***	-0.087	***
	(0.084)		(0.014)	
(fourties)	-0.364	***	-0.067	***
	(0.082)		(0.014)	
(fifties)	-0.068		-0.013	
	(0.079)		(0.015)	
smoker dummy	-0.314	***	-0.058	***
	(0.071)		(0.012)	
drinker dummy	-0.039		-0.008	
	(0.064)		(0.012)	
no habit of eating organic vegetables	-0.137	**	-0.026	**
	(0.054)		(0.011)	
participation in cancer insurance	-0.365	***	-0.070	***
	(0.056)		(0.011)	
regular health checkup	0.046		0.009	
	(0.055)		(0.011)	
constant	-0.545	***		
	(0.075)			
Number of observations	7573			
Wald chi-squared	125.5			
P-value of chi-square test	0.0000			
Pseudo R squared	0.0143			
Log likelihood	-4335.5			

	Specification 1						Specification 2					
	lower D		lower v		upper D		lower D		lower v		upper D	
male dummy	361.24	***	-10.11	***			412.81	***	-14.01	***		
	(47.08)		(1.28)				(45.26)		(1.09)			
age dummy (twenties)	-124.55	*	-28.89	***			-249.92	***				
	(69.68)		(2.19)				(75.33)					
(thirties)	-207.50	***	-30.69	***			-341.00	***				
	(72.99)		(2.07)				(83.29)					
(fourties)	-171.42	**	-25.91	***			-285.03	***				
	(72.12)		(2.36)				(78.72)					
(fifties)	-135.68	**	-17.11	***			-171.09	***				
	(64.22)		(1.44)				(64.15)					
income class	-24.76		1.79	**			-23.29		0.67			
	(25.46)		(0.72)				(24.50)		(0.65)			
spouse dummy	-55.06		-1.69				-80.77		11.38	***		
	(54.03)		(1.60)				(53.48)		(1.38)			
the number of children	52.03		-4.24	***			53.40		-3.06	**		
	(55.33)		(1.21)				(55.43)		(1.21)			
youngest child age dummy (between 0 and 2)	-392.62	**	22.98	***			-394.43	**	8.84	***		
	(155.25)		(2.24)				(157.40)		(2.18)			
(between 3 and 10)	-207.55		16.48	***			-189.61		0.70			
	(138.22)		(4.02)				(138.85)		(3.35)			
(between 11 and 15)	-192.77		21.81	***			-176.25		12.41	***		
	(150.21)		(4.02)				(149.15)		(4.21)			
(between 16 and 20)	-237.26	*	15.31	***			-232.93	*	9.17	***		
	(141.89)		(3.09)				(141.36)		(2.94)			
(over 20)	-192.70	*	10.18	***			-225.10	**	19.75	***		
	(109.01)		(2.15)				(108.71)		(2.03)			
smoker dummy	81.59	*	-0.48									
	(46.56)		(1.43)									
drinker dummy	90.36	**	1.39									
	(44.16)		(1.34)									
no habit of eating organic vegetables	48.76		-1.29									
	(41.18)		(1.17)									
participation in cancer insurance	10.58		1.52									
	(42.08)		(1.12)									
regular health checkup	-0.08		-0.13									
	(42.24)		(1.11)									
The predicted cancer risks based on the logit estimation							-1003.82	**	40.98	***		
							(450.00)		(10.09)			
no habit of drinking milk	-681.61	***	-1.26				-671.62	***	-1.90			
	(85.76)		(1.82)				(85.49)		(1.64)			
constant	-913.90	***	134.28	***	260.84	***	-513.25	***	100.98	***	260.95	***
	(85.87)		(2.31)		(2.02)		(166.03)		(3.03)		(2.04)	
Number of observations	7204						7204					
Wald chi-squared	215.6						218.3					
P-value of chi-square test	0.0000						0.0000					
Log Likelihood	-29465.6						-29507.9					

gender	age	income level	marriage	number of children	age of the youngest child	smoking	drinking	habit of eating organic vegetables	participation in cancer insurance	having regular health checkup	habit of drinking milk	κ_i	(95% interval)	
male	20-29	0-200	no	0	-	no	yes	no	no	no	yes	**0.683**	**0.635**	**0.732**
male	30-39	500-1000	yes	1	0-2	no	no	yes	yes	yes	yes	**0.824**	**0.793**	**0.855**
male	40-49	500-1000	yes	2	16-20	no	no	yes	yes	yes	yes	**0.789**	**0.750**	**0.828**
male	over 60	200-500	yes	0	-	yes	yes	no	no	no	yes	**0.626**	**0.553**	**0.699**
female	20-29	200-500	yes	1	0-2	no	no	yes	no	yes	yes	**0.850**	**0.827**	**0.874**
female	40-49	500-1000	yes	2	16-20	no	no	yes	yes	yes	yes	**0.837**	**0.813**	**0.860**
female	over 60	200-500	yes	3	over 20	no	no	no	no	no	yes	**0.794**	**0.757**	**0.832**

gender	age	income level	marriage	number of children	age of the youngest child	smoking	drinking	habit of eating organic vegetables	participation in cancer insurance	having regular health checkup	habit of drinking milk	**risk-adjusted weight**	(95% interval)	
male	20-29	0-200	no	0	-	no	yes	no	no	no	yes	1.95	1.87	2.03
male	30-39	500-1000	yes	1	0-2	no	no	yes	yes	yes	yes	2.42	2.30	2.54
male	40-49	500-1000	yes	2	16-20	no	no	yes	yes	yes	yes	2.23	2.08	2.38
male	over 60	200-500	yes	0	-	yes	yes	no	no	no	yes	2.69	2.54	2.85
female	20-29	200-500	yes	1	0-2	no	no	yes	no	yes	yes	2.70	2.53	2.88
female	40-49	500-1000	yes	2	16-20	no	no	yes	yes	yes	yes	2.51	2.32	2.70
female	over 60	200-500	yes	3	over 20	no	no	no	no	no	yes	2.96	2.74	3.18

gender	age	income level	marriage	number of children	age of the youngest child	perception of cancer risk	habit of drinking milk	κ_i	(95% interval)	
male	20–29	0–200	no	0	–	high	yes	**0.589**	**0.429**	**0.749**
male	30–39	500–1000	yes	1	0–2	low	yes	**0.881**	**0.842**	**0.920**
male	40–49	500–1000	yes	2	16–20	low	yes	**0.865**	**0.815**	**0.914**
male	over 60	200–500	yes	0	–	high	yes	**0.466**	**0.145**	**0.787**
female	20–29	200–500	yes	1	0–2	low	yes	**0.895**	**0.865**	**0.925**
female	40–49	500–1000	yes	2	16–20	low	yes	**0.888**	**0.854**	**0.922**
female	over 60	200–500	yes	3	over 20	high	yes	**0.730**	**0.634**	**0.826**

gender	income level	marriage	number of children	age of the youngest child	perception of cancer risk	habit of drinking milk	**risk-adjusted weight**	**(95% interval)**	
male	0–200	no	0	–	high	yes	**1.78**	**1.70**	**1.87**
male	500–1000	yes	1	0–2	low	yes	**3.88**	**2.61**	**5.14**
male	500–1000	yes	2	16–20	low	yes	**3.66**	**2.66**	**4.66**
male	200–500	yes	0	–	high	yes	**2.00**	**1.88**	**2.11**
female	200–500	yes	1	0–2	low	yes	**5.31**	**2.69**	**7.92**
female	500–1000	yes	2	16–20	low	yes	**4.96**	**3.09**	**6.84**
female	200–500	yes	3	over 20	high	yes	**2.65**	**2.38**	**2.91**

Findings

- The degree of zero risk preferences as well as the risk-adjusted weight differ substantially among respondents, depending on whether he/she perceives his/her own cancer risk to be rather low.

  - An old male who perceives his cancer risk to be high carries $\kappa_i = 0.466$ *much lower than 0.632,* and applies risk-adjusted weights around two times as large as his subjective probability.

  - On the other hand, a young female with an infant who perceives her cancer risk to be low has $\kappa_i = 0.895$ *much higher than 0.632, and applies risk-adjusted weights more than* five times as large as her subjective probability.

Conclusion

- If the individual characteristics are conditioned by respondents' perception about cancer risks, then how a preference for zero risks is strong, and how the risk-adjusted weight is large depend critically on whether a respondent perceives his/her cancer risk to be low.

- There are consumers whose degree of zero risk preferences is on either side of the critical value below which a secondary market partially substitutes for a primary market.

  - Those who originally perceive their own cancer risks to be rather low are unlikely to purchase contaminated milk at even heavily discount prices.

  - Those who are regarded as having already carried considerable cancer risks, including heavy smokers and regular drinkers, are relatively generous to radiation-contaminated milk.

Possible policy implications

- Have to consider heterogeneity in risk attitude among consumers in determining how much radiation risk is mitigated and to which extent resulting radiation damages are removed.

- May apply our analytical framework to other types of resulting damages such as mark-to-market of non-performing loans, brown field, and goods with minor defections (バッタ物？).