Mixing messages: health news and consumer reactions

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1. Introduction.

2. A two stage AI demand system

2.1. An AI system.

We consider the demand for three goods: fatty fish, lean fish and meat. Take the subscripts $\{a, l, m\}$ for the three goods respectively. We assume that preferences over the two types of fish are separable from meat so that:

$$U = W\left(\nu\left(q_a, q_l\right), q_m\right) \tag{2.1}$$

where $\{q_a, q_l, q_m\}$ are quantities with corresponding absolute prices $\{p_a, p_l, p_m\}$.

For each stage we take a (simplified) AI demand system. For the bottom stage, the budget share of fatty fish, ω_a, is given by:

$$\begin{aligned}\omega_a &= \alpha_a + \theta_a \ln\left(\frac{p_a}{p_l}\right) + \beta_a\left\{\ln x_f - \alpha_a \ln p_a - (1-\alpha_a)\ln p_l\right\} \\ &= \alpha_a + (\theta_a - \beta_a\alpha_a)\ln\left(\frac{p_a}{p_l}\right) + \beta_a \ln\left(\frac{x_f}{p_l}\right) \end{aligned} \tag{2.2}$$

where x_f is i's total expenditure on fish in period t. The principal novel feature of this structure is that we allow that the three parameters $\{\alpha_a, \theta_a, \beta_a\}$ are heterogeneous with, possibly, some dependence between the three parameters. This equation can also be written as:

$$\omega_a = \pi_{1a} + \pi_{2a} \ln\left(\frac{p_a}{p_l}\right) + \pi_{3a} \ln\left(\frac{x_f}{p_l}\right) \tag{2.3}$$

which has three right hand side variables. The form with p_l deflating total expenditure is more convenient to work with than the usual form which deflates by a price index since it is linear in known transformations of the data. Given estimates for the joint distribution of $\{\pi_{1a}, \pi_{2a}, \pi_{3a}\}$ we can recover the distribution of the structural parameters from:

$$\{\alpha_a, \theta_a, \beta_a\} = \{\pi_{1a}, \pi_{2a} + \pi_{1a}\pi_{3a}, \pi_{3a}\} \tag{2.4}$$

The price elasticity is given by (ignoring the t subscript):

$$\epsilon_a = \frac{\partial \ln q_a}{\partial \ln p_a} = \frac{\pi_{2a}}{\omega_a} - 1 = \frac{(\theta_a - \beta_a\alpha_a)}{\omega_a} - 1 \tag{2.5}$$

so that the consumer has a unit price elasticity if $\theta_a = \beta_a\alpha_a$ which is equivalent to $\pi_{2a} = 0$.

The 'price' of fish for consumer i is given by:

$$\ln p_f = \alpha_a \ln p_a + (1 - \alpha_a) \ln p_l \tag{2.6}$$

This is used in the top stage of the expenditure model which gives the budget share of fish as a proportion of total expenditure:

$$\omega_f \equiv \frac{x_a + x_l}{x_a + x_l + x_m} = \frac{x_f}{x_c} \tag{2.7}$$

where the total expenditure on fish and meat is denoted as x_c (the 'c' is for combined). The top stage for the allocation problem is:

$$\begin{aligned}\omega_f &= \alpha_f + \theta_f \ln\left(\frac{p_f}{p_m}\right) + \beta_f \{\ln x_c - \alpha_f \ln p_f - (1-\alpha_f)\ln p_m\} \\ &= \alpha_f + [(\theta_f - \beta_f\alpha_f)\,\alpha_a] \ln\left(\frac{p_a}{p_l}\right) + (\theta_f - \beta_f\alpha_f) \ln\left(\frac{p_l}{p_m}\right) + \beta_f \ln\left(\frac{x_c}{p_m}\right)\end{aligned} \tag{2.8}$$

This can be written:

$$\omega_f = \pi_{1f} + \pi_{2f} \ln\left(\frac{p_a}{p_l}\right) + \pi_{3f} \ln\left(\frac{p_l}{p_m}\right) + \pi_{4f} \ln\left(\frac{x_c}{p_m}\right) \tag{2.9}$$

Under the assumptions below this equation serves to identify the joint distribution of the parameters $\{\alpha_f, \theta_f, \beta_f, \alpha_a\}$. However the identification of the distribution of α_a is likely to be tenuous since this equation does not use information on the budget share for fatty fish, ω_a. However, this distribution is also identified from the bottom stage (2.2).

The total expenditure term in the bottom stage, x_f, is given in the top stage by:

$$x_f = \omega_f x_c \tag{2.10}$$

Thus we have a triangular system (written with prices set to unity to clarify the point):

$$\begin{aligned} \omega_a &= \pi_{1a} + \pi_{3a} \ln x_f && (2.11) \\ &= \pi_{1a} + \pi_{3a} \ln \omega_f + \pi_{3a} \ln \omega_c && (2.12) \\ \omega_f &= \pi_{1f} + \pi_{4a} \ln x_c && (2.13) \end{aligned}$$

The dependent variable ω_f in the fatty fish equation (ω_a) is a right hand side variable in the bottom stage. We return to this when we discuss the stochastics.

3. Allowing for health information

3.1. News as a price effect

A conventional way to capture the effect of health announcements is to assume that a negative signal for fatty fish (relative to lean fish) increases the perceived price of fatty fish. This is equivalent to the news lowering the quantity of fish. Similarly, positive news about fish in general, g_t, can be captured by allowing it to lower the prices of fatty and lean fish. A convenient parameterisation for adjusted prices for fatty and lean fish is:

$$\begin{aligned} \tilde{p}_a &= p_a \left(1 + d_t\right)^{\delta_a} \left(1 + g_t\right)^{\gamma_a} \\ \tilde{p}_l &= p_l \left(1 + d_t\right)^{\delta_l} \left(1 + g_t\right)^{\gamma_l} \end{aligned} \tag{3.1}$$

The parameters give a consumer's perception of the impact of the two types of news on prices. We postpone discussion of the likely sign of the parameters until we have incorporated them into the budget share equations.

Type	Name	Restriction
I	Inattentive, dioxin	$\delta_a = \delta_l = 0$
II	Inattentive, good news	$\gamma_a = \gamma_l = 0$
III	Sophisticated, good new generic	$\delta_l = 0, \delta_a > 0, \gamma_a = \gamma_l = \gamma < 0$
IV	Sophisticated, good news specific to fatty fish	$\delta_l = 0, \delta_a > 0, \gamma_l = 0, \gamma_a < 0$

Table 3.1: Types of consumers

3.2. Types of consumers

We are concerned with the information processing of households as regards information about fish. We shall consider four types of consumers:

The inattentive consumers are self-explanatory. A wholly inattentive consumer would have all parameters zero. Sophisticated consumers realise that information on dioxins is relevant only for fatty fish ($\delta_a > 0$ since more bad news raises the price more) and consequently they do not adjust the perceived price of lean fish ($\delta_l = 0$). As we have discussed, the positive news about fish is sometimes generic in the sense that it simply states that fish is good relative to meat. This is captured by $\gamma_a = \gamma_l < 0$. However, some sophisticated consumers may perceive that all positive news is related to omega-3 and fish oils in which case the news is perceived to state that fatty fish is better, $\gamma_a < 0$. For such consumers news about dioxins may be cancelled out by positive news about fish generally.

We also wish to allow for 'confused' consumers who give a response that we rationalise by any of the schemes above. The types are: $\delta_a < 0$ and γ_a and γ_l both positive.

3.3. The fatty fish equation

Let $\tilde{\omega}_a$ denote the budget share equation if prices are not adjusted (that is, the right hand side of 2.2) and let $\tilde{\theta}_a = (\theta_a - \beta_a \alpha_a)$ (see (2.5)). Substituting $\tilde{p}_a$ and $\tilde{p}_l$ into the fatty fish budget share equation, (2.2), we have:

$$\begin{aligned} \omega_a &= \tilde{\omega}_a + \left\{ \tilde{\theta}_a \left(\delta_a - \delta_l \right) - \beta_a \delta_l \right\} \ln \left(1 + d \right) + \left\{ \tilde{\theta}_a \left(\gamma_l - \gamma_a \right) - \beta_a \gamma_l \right\} \ln \left(1 + g \right) \\ &= \tilde{\omega}_a + \pi_{ad} \ln \left(1 + d \right) + \pi_{ag} \ln \left(1 + g \right) \qquad (3.2) \end{aligned}$$

Thus the impact of the news on on the consumers budget share depends on how their perception of the news and income and price elasticities. In particular, if for a given consumer the own price elasticity of fatty fish is minus unity ($\tilde{\theta}_a = 0$) and the income elasticity is unity ($\beta_a = 0$), then the news has no effect on the budget share of fatty fish.

Type	π_{ad}	π_{ag}
I	0	$\tilde{\theta}_a(\gamma_l - \gamma_a) - \beta_a\gamma_l$
II	$\tilde{\theta}_a(\delta_a - \delta_l) - \beta_a\delta_l$	0
III	$\tilde{\theta}_a\delta_a$	$-\beta_a\gamma$
IV	$\tilde{\theta}_a\delta_a$	$\tilde{\theta}_a\gamma_a$

Table 3.2: Types of consumers

The parameters β_a and $\tilde{\theta}_a$ are identified from $\tilde{\omega}_a$. The four 'news' parameters cannot be identified solely from the fatty fish budget share equation since we only have two reduced form parameters, π_{ad} and π_{ag}. However we can identify some effects for the different types, as follows:

Thus the parameters for the sophisticated types can always be recovered from the fatty fish budget share equation.

Current fatty estimates - model IV.

3.4. The fish equation

For the fish budget share, (2.8) we have:

$$\begin{aligned}\omega_f &= \hat{\omega}_f + \gamma_i(\theta_f - \beta_f\alpha_f)\ln(1+g) \\ &\quad + \delta_i\alpha_a(\theta_f - \beta_f\alpha_f)\ln(1+d) + e_f\end{aligned}$$

One attractive feature of this formulation is that if the budget share for fatty fish is small ($\alpha_a \simeq 0$) then the coefficient on dioxin news in the fish budget share equation, $\alpha_a(\theta_f - \beta_f\alpha_f)$, is also small. That is, warnings about dioxin do not impact on the fish consumption of consumers who only eat lean fish.

4. Heterogeneity

4.1. Factor model.

We now address how to introduce heterogeneity into the models above. If we had a long panel then we could estimate the parameters for each household and then take the empirical distribution as the joint distribution. Since we only have 24 observations per household we have to resort to a random coefficients model. To implement this we adopt a factor structure model.

To allow for heterogeneity in the structural parameters for the bottom (fatty fish budget share) stage, $(\alpha_a, \theta_a, \beta_a, \delta_a, \gamma_a)$ we adopt a three factor structure model.[1]

[1] Preliminary investigations showed that three factors were enough.

Let η_1, η_2 and $\eta_3$be independent standard Normals. Parameterise the structural parameters by:

$$\begin{aligned}
\alpha_a &= \phi_\alpha + \psi_{a1}\eta_1 \\
\theta_a &= \phi_\theta + \psi_{\theta 1}\eta_1 + \psi_{\theta 2}\eta_2 \\
\beta_a &= \phi_\beta + \psi_{\beta 1}\eta_1 + \psi_{\beta 2}\eta_2 + \psi_{\beta 3}\eta_3 \\
\delta_a &= \phi_\delta + \psi_{\delta 1}\eta_1 + \psi_{\delta 2}\eta_2 + \psi_{\delta 3}\eta_3 \\
\gamma_a &= \phi_\gamma + \psi_{\gamma 1}\eta_1 + \psi_{\gamma 2}\eta_2 + \psi_{\gamma 3}\eta_3
\end{aligned} \tag{4.1}$$

Thus we assume that the sturctural parameters are independent of the prices and total expenditure as well as the taste shifter, e. This gives a nonlinear random coefficients (or 'mixed'). The 'cross terms' $\psi_{..}$ allow that the structural parameters may be correlated. For example, if $\psi_{a1} \neq 0$ and $\psi_{\delta 1} \neq 0$ then the concern for dioxins is correlated with the amount consumed. WE shall also consider a form in which all consumers are sophisticated by taking:

$$\begin{aligned}
\delta_a &= \exp\left(\phi_\delta + \psi_{\delta 1}\eta_1 + \psi_{\delta 2}\eta_2 + \psi_{\delta 3}\eta_3\right) \\
\gamma_a &= -\exp\left(\phi_\gamma + \psi_{\gamma 1}\eta_1 + \psi_{\gamma 2}\eta_2 + \psi_{\gamma 3}\eta_3\right)
\end{aligned} \tag{4.2}$$

so that $\delta_a > 0$ and $\gamma_a < 0$, see Table 3.1.

4.2. Mixture model

The factor model above has a continuous joint distribution for δ_a and γ_a. The hypotheses in Table 3.1 suggest an alternative mixture model with some agents who are wholly inattentative and others who only react to dixoin news and/or god news. To capture this for the fatty fish equation, we posit four types of consumers; see Table 4.1. Probabilities are given by:

$$\begin{aligned}
\pi_\delta &= \ell\left(\phi_\delta + \psi_{\delta 1}\eta_1 + \psi_{\delta 2}\eta_2 + \psi_{\delta 3}\eta_3\right) \\
\pi_\gamma &= \ell\left(\phi_\gamma + \psi_{\gamma 1}\eta_1 + \psi_{\gamma 2}\eta_2 + \psi_{\gamma 3}\eta_3\right)
\end{aligned} \tag{4.3}$$

where $\ell(.)$ is the logistic function. This gives $4 + 8$ parameters.

Model	δ	γ	Probability
a	δ_1	γ_1	$\pi_\delta \pi_\gamma$
b	δ_2	0	$\pi_\delta (1 - \pi_\gamma)$
c	0	γ_2	$(1 - \pi_\delta) \pi_\gamma$
d	0	0	$(1 - \pi_\delta)(1 - \pi_\gamma)$

Table 4.1: Types for mixture model