Meat Demand under Rational Habit Persistence

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The objective of this paper is to explore the theoretical implications of a meat demand model with rational habit formation. The impact of food safety information on meat consumption is systematically analyzed. Important differences between myopic habits and rational habits are underscored. Both the adjustment path to the new equilibrium and new level of consumption are affected by consumers' perceptions of changes in meat quality. The analysis has implications for empirical demand estimation by incorporating consumers' expectations and use of event dummy variables rather than index measures of food safety.

Le présent article vise à explorer les implications théoriques d'un modèle de demande de viande avec formation d'habitudes rationnelles. Les répercussions de l'information concernant la sécurité alimentaire sur la consommation de viande ont été systématiquement analysées. Les différences importantes entre les habitudes rationnelles et les habitudes myopes ont été soulignées. Le chemin de rajustement du nouvel équilibre et du nouveau degré de consommation est affecté par la façon dont les consommateurs perçoivent les changements dans la qualité de la viande. L'analyse a des implications pour l'estimation empirique de la demande en raison de l'intégration des attentes des consommateurs et de l'utilisation de variables fictives plutôt que de mesures indicielles de la sécurité alimentaire.

INTRODUCTION

During the past two decades, meat consumption in developed economies and in the United States, in particular, has been the focus of much economic research. It is often hypothesized that a structural break occurred that shifted consumer preferences away from red meat toward chicken and fish (e.g., Chavas 1983; Thurman 1987; Chalfant and Alston 1988; Sakong and Hayes 1993). Although agricultural economists still debate whether consumption can be explained by variations in prices and income alone or that other factors are also responsible, findings of structural change are common. The most often speculated cause of preference change is the effect of health information on cholesterol and saturated fat in red meat. Kinnucan et al (1997) find that the number of published medical articles on cholesterol has a significant effect on meat demand and this variable has a larger elasticity than any of the price elasticities. McGuirk et al (1995) arrive at the same conclusion. But these observations do not completely dispel the skepticism. Most studies that do confirm a structural break suggest that it occurred somewhere between the middle and late 1970s. However, Robenstein and Thurman (1996) found that the red meat futures market did not respond to the release of articles in the *Wall Street Journal* on the adverse health effects of dietary cholesterol. Furthermore, all of the

"strong" and most of the "moderate" and "weak" articles on cholesterol were published after 1982. The newspaper index of cholesterol in McGuirk et al (1995) also indicates that consumers were not bombarded with such information until the early 1980s. Public concerns about food safety issues have recently stimulated research on the economic impacts of food contamination outbreaks (e.g., Thomsen and McKenzie 2001; Piggott and Marsh 2004). Unlike heart disease linked to cholesterol and dietary fats, ailments due to intake of contaminated food are much more acute and sustained consumption is not required to develop the symptoms.

In this paper, the underlying assumption of intertemporal separability is altered to allow for temporally interdependent preferences. It is shown that this modification implies consumption behavior that allows us to investigate the short- and long-run responses of meat consumption to transitory and permanent price and quality changes. If meat consumption is habit forming, the long-run response will be more elastic than the short-run response to a permanent change in price or quality. Moreover, myopic consumers and rational consumers react to transitory shocks in a qualitatively different way. In a habitual consumption model with rational agents, expectations about future prices and qualities play a vital role. In contrast, in a myopic habitual consumption model the primary use of expectations is only to keep the marginal utility of income constant over the life cycle. Therefore, a virtue of estimating a rational habit consumption model is that it explicitly accounts for the anticipated and unanticipated effects of price and quality changes, thereby allowing us to distinguish empirically transitory from permanent effects of price and quality changes.

The importance of distinguishing between perceived transitory and permanent effects of quality changes is that a food safety event, such as food contamination, can have significantly different quantitative effects depending not only upon consumers' ability to adjust to changes but also their perception of the events. If consumers are convinced that food quality is permanently affected by a food safety shock, then they will respond by permanently reducing consumption more than if they did not believe it was a long-term problem. Moreover, the gap between perceived transitory and permanent effects can be quite sensitive to the degree of habit persistence, the greater the degree of habit persistence the larger the difference between transitory and permanent food safety events in their effect on consumption. Moreover, if dynamics are present, then the timing of the information about food safety events is important, indicating that index measures constructed by aggregating number of news articles may not be adequate measures of food safety events on food consumption. With the rational consumer model we are able to quantify these differences and ascertain how much the food industry would be affected depending upon how one believed consumers would react to the food safety shock.

The following sections delineate the model, explore the implications of rational meat consumer behavior, compare with myopic consumer behavior, and discuss empirical implications.

ECONOMIC MODELS OF HABITS

Economic consumption models with habits differ from each other by their distinct approaches to two basic factors. The first factor concerns the constancy of consumer tastes. Endogenous taste models such as Ryder and Heal (1973) incorporate habits by invoking the concept of subsistence consumption. Dynamics is introduced as past consumption

increases current level of subsistence demand. Because subsistence consumption does not affect utility directly, a higher level of past consumption results in a lower current level of utility holding current consumption constant.

On the other hand, Stigler and Becker (1977) and Boyer (1978, 1983) posit that tastes do not change, but consumption knowledge does. In their models, habits are modeled as a learning-by-doing process. The individual learns from past consumption experience. The more he learns the more utility he can get out of a given level of current consumption.

Hence, past consumption is considered to be the consumption capital that results in better appreciation of current consumption. Despite this sharp distinction between the two model classes, the mathematics is the same and the characteristics of the optimal consumption path are not much different (Boyer 1978; Phlips 1983).

The second factor is related to consumer rationality. Early literature on habits tends to model habit formation as "myopic" or backward looking (e.g., Pollak and Wales 1969; Pollak 1970). The consumer is myopic in the sense that he is not aware of the impact of his current consumption decision on future preference. More recent models explore the implications of consumer rationality on the optimal consumption path of temporally interdependent preferences (e.g., Ryder and Heal 1973; Boyer 1978, 1983; Becker and Murphy 1988). This paper focuses on issues associated with the second factor and studies the theoretical implications of incorporating habits and rationality into the meat consumption model.

For expository ease, the theoretical framework is set up in a deterministic and continuous-time environment. We assume that there exists a representative consumer who maximizes lifetime utility. For now, assume that there are only two goods, the food service that is potentially habit forming, and all other goods. The food service provides both nourishment and entertainment. To prepare the food, three inputs—the raw food material c, its quality k, and the consumption capital S—are needed. Consider the household food production function

$$f = g(c, k, S) \tag{1}$$

where f is the food service, and $g(\cdot)$ represents the production technology. The quality k measures the quality attributes of the food material. For instance, k can be an indicator of food contamination outbreaks, a higher value of which indicates more severe contamination incidences so that the perceived quality of c is lower while the incidence lasts. Its value is neither chosen nor priced but exogenous to the household. In this case, the outbreak can be considered as a public good that is a quality characteristic of the privately consumed good (Bockstael and McConnell 1993; Piggott and Marsh 2004). Plausible assumptions of the production function include $g_c > 0$, $g_{cc} < 0$, $g_k < 0$, $g_s > 0$, and $g_{ss} < 0$. Consider food preparation and consumption as a "learning-by-doing" process, the consumption capital S summarizes the experience and knowledge acquired from previous cooking and dining activities. Define the consumption capital stock to be an exponentially weighted sum of past levels of consumption: $S(t) = \int_0^t \mathrm{e}^{-\delta(t-\tau)} c(\tau) d\tau$, with δ being the rate of capital depreciation. Differentiating this with respect to t results in the equation of motion for the capital stock

$$\dot{S} = c(t) - \delta S(t) \tag{2}$$

The consumer maximizes the lifetime utility function:

$$U(0) = \int_0^T \mathrm{e}^{-\rho t} u[y(t), g(t)]dt \tag{3}$$

subject to (2) and the budget constraint:

$$\int_0^T \mathrm{e}^{-rt}[y(t) + p(t)c(t)]dt \leq w(0) \tag{4}$$

where ρ is the rate of time discount; $y(t)$ is the composite good consumed at time t whose price is normalized to unity; r is the real interest rate; $p(t)$ is the price of raw food material c at time t; and $w(0)$ is the period 0 value of lifetime wealth. For the utility-maximizing individual, the decision variables are $y(t)$ and $c(t)$. The budget constraint (4) is valid if there are perfect capital markets where consumers can borrow at the interest r.

The optimal paths of $c(t)$ and $y(t)$ are determined by the first-order conditions:

$$\mathrm{e}^{-\rho t} u_y(t) = \mathrm{e}^{-rt}\mu \tag{5}$$

$$\mathrm{e}^{-\rho t} u_c(t) = \mathrm{e}^{-rt}\mu p(t) - \mathrm{e}^{-\rho t}\left[\int_t^T \mathrm{e}^{-(\rho+\delta)(\tau - t)} u_s(\tau)d\tau\right] \tag{6}$$

Eq. (5) defines μ as the marginal utility of the discounted lifetime wealth. It can be shown that, at least under perfect foresight, μ is a constant, exactly what a rational consumer strives to achieve during the life cycle. The second term on the right-hand side of (6) is the sum of all future benefits (costs if $u_s < 0$) accrued through the effect of an infinitesimal increase in $c(t)$ on future capital stocks. Hence, Eq. (6) says that the marginal utility of $c(t)$ equals the marginal cost of buying one unit of consumption minus (plus) the utility value of future benefits (costs). If $u_s \neq 0$, we see from (6) that there is a wedge between current marginal utility of $c(t)$ and current marginal cost. In the absence of this wedge, consumption of the rational consumer responds immediately and fully to outside shocks. This is a fundamental distinction between myopic and rational consumer behavior.

Dynamic Behavior

For sake of convenience, assume that the rate of time preference is equal to the real interest rate. Assume also an instantaneous quadratic utility function in order to linearize the first-order conditions (5) and (6)[1]:

$$\begin{aligned} u(t) = {} & \alpha_y y(t) + \alpha_c c(t) + \alpha_s S(t) + \frac{\alpha_{yy}}{2}[y(t)]^2 + \frac{\alpha_{cc}}{2}[c(t)]^2 + \frac{\alpha_{ss}}{2}[S(t)]^2 \\ & + \alpha_{yc} y(t)c(t) + \alpha_{ys} y(t)S(t) + \alpha_{cs} c(t)S(t) + \alpha_{ck} c(t)k(t) \end{aligned} \tag{7}$$

Note that the product quality k enters jointly with c, consistent with the notion that this quality characteristic alone has no value to the individual. Next, differentiate (7) with respect to c, y, and S and substitute (5) into (6). Differentiate Eq. (6) with respect to t and

use (6) to substitute out the integral term from the result. Then use Eq. (5) to eliminate $y(t)$. Performing these operations yields a differential equation for $c(t)$ of the form

$$\begin{aligned} A_1\dot{c}(t) = {} & B_1 + B_2 + (\rho+\delta)A_1c(t) + [(\rho+2\delta)A_2 + A_3]S(t) \\ & - (\rho+\delta)\alpha_{ck}k(t) - \mu\dot{p}(t) + \alpha_{ck}\dot{k}(t) \end{aligned} \tag{8}$$

where

$$A_1 = \frac{\alpha_{yc}^2}{\alpha_{yy}} - \alpha_{cc}, \quad A_2 = \frac{\alpha_{ys}\alpha_{yc}}{\alpha_{yy}} - \alpha_{cs}, \quad A_3 = \frac{\alpha_{ys}^2}{\alpha_{yy}} - \alpha_{ss}$$

$$B_1 = (\rho+\delta)\left[\frac{\alpha_{yc}\alpha_y}{\alpha_{yy}} - \alpha_c\right] + \frac{\alpha_{ys}\alpha_y}{\alpha_{yy}} - \alpha_s, \quad \text{and}$$

$$B_2 = (r+\delta)\mu p(t) - \frac{\mu}{\alpha_{yy}}[(\rho+\delta)\alpha_{yc} + \alpha_{ys}]$$

Differentiate Eq. (2) with respect to t and use (2) and (8) to eliminate $c(t)$ and $\dot{c}(t)$, respectively, from the result. This procedure gives a second-order linear differential equation in $S(t)$:

$$(D^2 - \rho D - A)S(t) = A_1^{-1}[B_1 + B_2 - (\rho+\delta)\alpha_{ck}k(t) - \mu\dot{p}(t) + \alpha_{ck}\dot{k}(t)] \tag{9}$$

where $DS(t) = dS(t)/dt$, and $A = A_1^{-1}[A_1\delta(\rho+\delta) + A_2(\rho+2\delta) + A_3]$. Eq. (9) has two characteristic roots, $\lambda_1, \lambda_2 = \frac{\rho\pm\sqrt{\rho^2+4A}}{2}$, both of which are real. To see this, concavity of the utility function implies $A_1 > 0$, $A_3 > 0$, and $A_1A_3 > A_2^2$. Therefore, whatever sign A_2 takes, $\rho^2 + 4A = A_1^{-1}\left[A_1(\rho+2\delta)^2 + 4(\rho+2\delta)A_2 + 4A_3\right] > 0$. To obtain the solution to (9), set the right-hand side of (9) equal to $-A\psi(t)$ where $\psi(t)$ is a function of the exogenous variables in (9), and rewrite (9) as

$$(D-\lambda_1)(D-\lambda_2)S(t) = -A\psi(t) \tag{10}$$

The solution to Eq. (10) takes the positive unstable root (λ_1) forward and the negative stable root (λ_2) backward (Sargent 1987). Following this procedure yields

$$\begin{aligned} S(t) = {} & e^{\lambda_2 t}\left[S(0) - \frac{1}{\lambda_1-\lambda_2}\int_0^\infty A\psi(\tau)e^{-\lambda_1\tau}d\tau\right] \\ & + \frac{1}{\lambda_1-\lambda_2}\left[\int_t^\infty A\psi(\tau)e^{\lambda_1(t-\tau)}d\tau + \int_0^t A\psi(\tau)e^{\lambda_2(t-\tau)}d\tau\right] \end{aligned} \tag{11}$$

Eq. (11) is the calculus of variations solution to the consumer's dynamic optimization problem. It expresses the optimal time path of the state variable $S(t)$ as a two-sided distributed lag of the forcing function $\psi(t)$. Since $p(t)$ and $k(t)$ are elements of $\psi(t)$, current consumption capital stock depends on the entire time path of future and past prices and quality characteristics. The impact of the lead or lag forcing function on current consumption capital declines at an exponential rate. From Eq. (2), it is clear that $c(t)$ also depends on all past and future values of its own price and quality characteristic.

The stable root λ_2 is associated with the speed of convergence of the system to its steady state. To see this, suppose that the forcing function has been constant at $\bar{\psi}_1$, implying $\dot{k} = \dot{p} = 0$, such that the consumption capital stock has reached its corresponding steady-state value $S(t) = \bar{\psi}_1$. Now, let there be an unexpected permanent change in the price or quality characteristic that increases ψ to $\bar{\psi}_2$. Substituting $\psi(t) = \bar{\psi}_2$ into (11) results in the path by which $S(t)$ travels to its new steady-state $\bar{\psi}_2$:

$$S(t) = e^{\lambda_2 t}(\bar{\psi}_1 - \bar{\psi}_2) + \bar{\psi}_2 \tag{12}$$

Larger (absolute) values of λ_2 imply higher speeds at which $S(t)$ converges to its long-run steady state.

The relationship between $c(t)$ and $S(t)$, as $S(t)$ moves toward its new steady state, is obtained by using Eq. (12) in Eq. (2):

$$c(t) = (\delta + \lambda_2)S(t) - \lambda_2\bar{\psi}_2 \tag{13}$$

The term $(\delta + \lambda_2)$, or equivalently $-[(\rho + 2\delta)A_2 + A_3]$, has to be greater than, equal to, or less than zero for $c(t)$ and $S(t)$ to be positively related, unrelated, or negatively related, respectively. Eq. (13) indicates that the less negative λ_2 is, the higher the degree of adjacent complementarity for the consumption of c.[2] In other words, goods that are strongly adjacently complementary (habitual) adjust to their steady states relatively slowly.

In terms of the parameters of the utility function (7), adjacent complementarity requires

$$(\rho + 2\delta)\left(\frac{\alpha_{ys}\alpha_{yc}}{\alpha_{yy}} - \alpha_{cs}\right) < \left(\alpha_{ss} - \frac{\alpha_{ys}^2}{\alpha_{yy}}\right) \tag{14}$$

People develop habits on, say, beef if increased past beef consumption increases present consumption. However, $u_{cs} = \alpha_{cs} > 0$ alone is not sufficient to induce habitual consumption for rational consumers. Beef offers not only nourishment but also palatability. While the level of nourishment largely depends on the quantity of beef consumed (c), the degree of palatability relies on the knowledge (S) about how to prepare beef. The rational consumer realizes that as the quantity of beef consumed increases, consumption capital will also rise for all future periods. In other words, a rational consumer takes into account increases in future utility resulting from an increase in current beef consumption. Beef consumption will be habitual only if, ceteris paribus, an increase in the marginal utility of beef induced by a small increment in the consumption capital (α_{cs}) sufficiently outweighs the corresponding decrease in the marginal utility of the capital stock (α_{ss}).

Time preference and the rate of consumption capital depreciation are also important determinants of the degree of habits. Inequality (14) indicates that the more the rational consumer discounts future utility or the faster the consumption capital decays, the higher the degree of adjacent complementarity. By the first-order condition (6), a larger ρ and larger δ reduce future benefits and thus raise $u_c(t)$. Therefore, for beneficial habit formation, the level of consumption is lower if the time discount or capital depreciation rate is increased.

Intertemporal movement of consumption can be illustrated qualitatively by a phase diagram in the (c, S) space such as in Figure 1 (e.g., Abel 1982). The $\dot{S} = 0$ curve is the

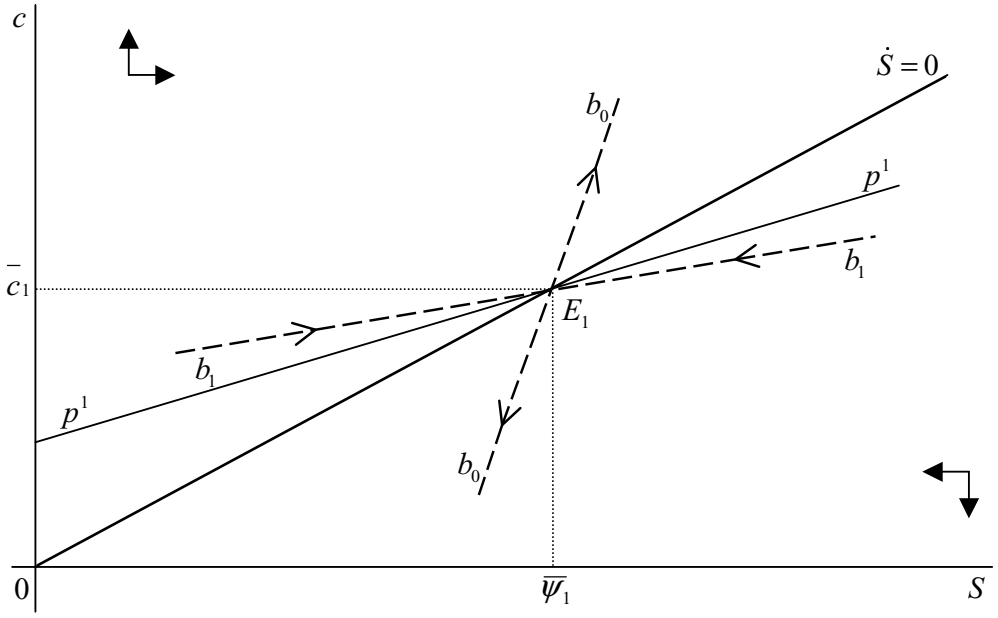

Figure 1. Local structure of a steady state

loci where consumption capital is stationary, i.e., $c = \delta S$. The p^1p^1 curve represents the loci where $\dot{c} = 0$. It is clear from Eq. (8) that the p^1p^1 curve is positively sloped when consumption of c displays adjacent complementarity. The system has a saddle-point structure with a stable (b_1b_1) and an unstable (b_0b_0) manifold. The stable manifold leads to the long-run equilibrium point E_1, while the unstable one breaks away from that point. The rational consumer always stays on the stable manifold.

There are a number of factors that affect the dynamics of consumption of meat when habit persistence is present. A key concept is adjacent complementarity that defines whether the commodity in question is habit forming or not. The dynamic analysis, in the presence of habit persistence, shows that adjustment to equilibrium meat consumption will not be instantaneous but will adjust over time in response to a food safety shock. Adjustment to the new equilibrium would be expected to be monotonic from above or below, as is the case in partial adjustment demand models. The next two sections, however, show that consumption changes are also dependent on how the consumer views the shocks—whether temporary or permanent. Moreover, the effect on consumption can be different depending upon whether the shock affects capital stock of habits or parameters of the utility function.

Impacts of Permanent Price and Quality Shocks on Consumption

The most salient feature of the time nonseparable consumption model is its distinction between short-run and long-run response to permanent price and, in our example, quality changes. In the United States, the real price of poultry relative to beef has steadily declined from one-half of that of beef to about one-third over the last 40 years. Meanwhile, the

dispersion of health information on cholesterol and saturated fat during the last two decades may have altered consumers' perception of the quality of poultry and red meat.

Assume that the drop in relative poultry price and rise in perceived quality relative to red meat are permanent. The size of the long-run response to such changes depends on the degree of adjacent complementarity. Differentiate (10) with respect to the quality characteristic k at the steady state and make use of the steady-state condition $\bar{c} = \delta \bar{S}$. This operation yields the long-run response of consumption to a permanent shift in product quality, which is income compensated to hold the marginal utility of wealth constant:

$$\frac{d\bar{c}}{dk} = \frac{(\rho + \delta)\alpha_{ck}}{A_1 A} < 0 \tag{15}$$

where $\bar{c}$ denotes the steady-state value of consumption, and "good" news is represented by a drop in the value of k. The term $A_1 A$ has to be positive so that $\lambda_2 < 0$ for the system to be stable. Recall from Eq. (13) that a higher degree of adjacent complementarity implies lower $A_1 A$. Hence, food commodities that are more habit forming respond more to permanent quality change in the long run. In the case of a permanent price change, the income-compensated long-run response of consumption is

$$\frac{d\bar{c}}{dp} = -\frac{\delta(r + \delta)\mu}{A_1 A} < 0 \tag{16}$$

Graphically, the time path of $c(t)$ is illustrated in Figure 2. Suppose the individual is initially on point E_1, the long-run equilibrium associated with $\bar{S} = \bar{\psi}_1$. When the unanticipated news that higher cholesterol is linked to greater chance of heart attack is announced, consumption of poultry products jumps vertically to point F on the stable manifold associated with the new long-run equilibrium E_2 and moves toward the new steady state over time. The quantity in (15) measures the vertical distance between E_1 and E_2. For red meat, the cholesterol information may cause a permanent drop in product quality. So its demand works in the opposite direction—a vertical drop followed by gradual movement toward a lower steady-state equilibrium.

The hazard associated with cholesterol and saturated fats in red meat is long term and chronic and requires sustained consumption. This information may not only affect quality but also consumption capital in the utility function. In fact, it is plausible that cholesterol information causes little or no change in k, but a much greater change in the parameter values of the utility function. Negative health news for red meat may have reduced the value of α_s, α_{ys}, and possibly α_{ss}. Taking the differential of $A_1 A$ with respect to α_{ys} and α_{ss} yields

$$d(A_1 A) = \left[(\rho + 2\delta)\frac{\alpha_{yc}}{\alpha_{yy}} + \frac{\alpha_{ys}}{\alpha_{yy}}\right] d\alpha_{ys} - d\alpha_{ss} \tag{17}$$

If $\alpha_{yc} \geq 0$ and $\alpha_{ys} > 0$, the term in the brackets on the right-hand side of (17) is negative. Since a higher $A_1 A$ is associated with a lower degree of adjacent complementarity, negative health news could lower the degree of habit formation of red meat.

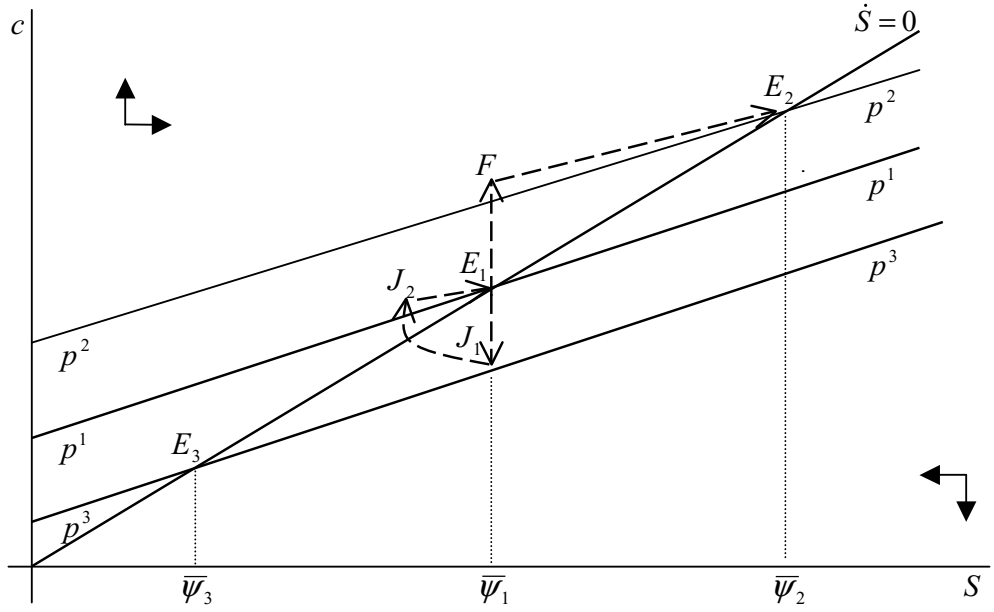

Figure 2. Consumption responses to price and quality shocks

The long-run response of consumption to a change in wealth is derived by differentiating (9) with respect to μ at the steady state and using the condition $\bar{c} = \delta\bar{S}$:

$$\frac{d\bar{c}}{d\mu} = -\frac{\delta}{A_1 A}\left[(r+\delta)p - \frac{(\rho+\delta)\alpha_{yc} + \alpha_{ys}}{\alpha_{yy}}\right] \tag{18}$$

Because greater wealth lowers the marginal utility of wealth μ, the food commodity c is a normal good if (18) is less than zero. If the cholesterol information has reduced α_{ys} but raised $A_1 A$, Eq. (18) should be less negative for red meat consumption. The same argument applies to demand response to quality shock (15) and price change (16). Indeed, Sarmiento (2005) found that U.S. demand for red meat has become less price responsive and less income elastic in the 1990s than in the 1950s and 1970s.

Time Path of Consumption Responses to Temporary Changes

As an example, suppose there is an unanticipated outbreak of bird influenza in Southeast Asia, the cleanup effort will take time $\hat{T}$ after which the quality of chicken products is expected to return to its normal level. If the consumer is at a steady state $S = \bar{\psi}_1$ at $t = 0$, the moment right before the incidence, and if the jump in k results in $\psi(\tau) = \bar{\psi}_2$ for $\tau \in (0, \hat{T}]$ in Eq. (11), and $\psi(\tau) = \bar{\psi}_1$ for $\tau \in (\hat{T}, \infty)$, the initial response of consumption capital to the postulated square wave pulse in $k(\tau)$ is obtained by taking the unstable positive root λ_1 forward and rearranging terms:

$$\dot{S}(0) = \lambda_2(\bar{\psi}_1 - \bar{\psi}_2)(1 - \mathrm{e}^{-\lambda_1 \hat{T}}) \tag{19}$$

Because $\frac{\partial \psi(\tau)}{\partial k(\tau)} < 0$, the food safety incidence that raises k will cause an initial drop in consumption capital. The size of this drop is larger if the incidence is expected to be more permanent (higher $\hat{T}$). Eq. (12) implies that the initial response of S to a permanent jump in k is $\lambda_2(\bar{\psi}_1 - \bar{\psi}_2)$. For the initial response to a temporary outbreak to be κ percent of the initial impact response to a permanent quality change, the incidence has to last for time $\hat{T} = -\frac{\ln(1-\kappa)}{\lambda_1}$.

Note that Eq. (19) equals the size of the initial jump in consumption c when the individual is assumed to be at its long-run equilibrium before the outbreak. The initial response to a temporary shock is smaller than that due to the permanent change because a rational consumer knows that food consumption is habitual and that quality of the product will eventually return to its initial value.

The path of poultry consumption is also illustrated in Figure 2. Before the news of an influenza outbreak the consumer is at the steady-state point E_1. The unexpected incidence induces the individual to reduce poultry consumption to J_1 right after the news is reported. The curve p^3p^3 represents the $\dot{c} = 0$ loci corresponding to the declined quality of poultry products as the incidence lasts. Since the consumer believes that the event will be temporary, point J_1 will not be on the stable manifold associated with the lower equilibrium E_3 but somewhere above it. Suppose the duration of the outbreak is precisely foreseen, then the size of the initial reduction will be calculated such that by the moment the incidence comes to a halt, the individual is already on J_2—a point on the stable manifold leading back to the initial steady state E_1. The time path of consumption in response to temporary quality deterioration is characterized by an initial drop in consumption followed by gradual return to its preoutbreak level. The effect of a temporary price hike would be analogously analyzed.

Rationality versus Myopia

The prediction that the long-run response to a permanent shock is larger than the short-run response is not unique to the rational habit persistence model. Myopic habits similarly imply sluggish adjustment of consumption to permanent price or quality changes. The more elastic long-run demand is also a possible outcome under myopic habit persistence. For example, in their test of myopic habit persistence, Heien and Durham (1991) found that consumption adjusts to permanent price change more in the long run than in the short run. In fact, there has been a long history to include lagged consumption in the system of demand analysis (e.g., Pollak and Wales 1969; Houthakker and Taylor 1970). The success of using lagged consumption in predicting current consumption has been accredited to habit effects, cost of adjustment, or simply ignorance on the part of the researcher. In the meat demand literature, Pope et al (1980) and Holt and Goodwin (1997) explicitly modeled myopic habit persistence and found it to be an important feature of consumer preferences for meat products. Some studies also recognize the importance of consumption dynamics by first differencing the data (e.g., Eales and Unnevehr 1988), because the use of first-differenced data implicitly assigns a massive weight to lagged consumption.

In a myopic habits model the consumer does not take into account the impact of current consumption on future utility. Because of this ignorance, he makes systematic errors in his intertemporal optimization. The individual is constantly surprised in each

period to learn that his past consumption of the good contributes to the buildup of the capital stock. This leads to period-by-period replanning of intertemporal demand conditional on the current level of consumption capital. This ignorance implies that the consumption path of a myopic individual is qualitatively different from the demand path of a rational consumer when faced with a transitory price or quality shock.

To demonstrate this difference, it is helpful to describe the myopic consumer's problem in a discrete time environment so that the period-by-period replanning of consumption schedule is clearly defined. To preserve comparability with the rational habits model, assume that the myopic consumer maximizes the discrete time version of the lifetime utility (3) subject to the lifetime budget constraint (4). This setup actually retains the minimal consumer rationality in allocating limited resources across time periods. So the only myopia on the part of the individual is about how the consumption capital is seen to evolve over time. Myopic agents believe that the capital stock is static while it evolves according to the discrete time version of (2), $S_{t+1} = c_t + (1-\delta)S_t$. Suppose at the beginning of period 0, the consumer initially plans according to the first-order conditions: $\frac{\partial u_t}{\partial \tilde{y}_t} = \left[\frac{1+\rho}{1+r}\right]^t \mu_0$ and $\frac{\partial u_t}{\partial \tilde{c}_t} = \left[\frac{1+\rho}{1+r}\right]^t \mu_0 p_t \; \forall t \geq 0$. The tilde over y and c denotes that these are planned quantities that may or may not be the same as the realized levels of consumption for $t > 0$. The first and second first-order conditions are, respectively, the discrete time equivalents of (5) and (6), except that the second term on the right-hand side of (6) is absent from its myopic discrete time counterpart. The subscript 0 on μ emphasizes that, in period 0, the myopic consumer expects the marginal utility of wealth to be fixed during the life cycle.

Use the discrete time version of the quadratic utility function (7) to obtain the first-order conditions, assume $\rho = r$, and eliminate consumption of other goods y. Upon completing these steps, one is able to write the following equation for planned consumption:

$$\tilde{c}_t = A_1^{-1}\left[\mu_0\left(\frac{\alpha_{yc}}{\alpha_{yy}} - p_t\right) - A_2 S_0 + \alpha_{ck}k_t + \left(\alpha_c - \frac{\alpha_{yc}\alpha_y}{\alpha_{yy}}\right)\right] \tag{20}$$

If the myopic consumer is not initially in a steady state, the realized c_t will be different from the one planned for at the beginning of period 0 because the capital stock S_t will not be the same as S_0. Replacing S_0 in (20) with S_t gives the realized consumption at t that is income compensated to hold the marginal utility of discounted wealth fixed at μ_0.

Unlike rational consumers' consumption, the demand by myopic consumers is largely backward looking. The only forward-looking component is the marginal utility of discounted wealth that is implicitly a function of the money endowment, prices, and quality characteristics in all periods. For c and S to be positively related, one needs $A_2 < 0$ since $A_1 > 0$ by the strict concavity of the utility function. From the definition of A_2, adjacent complementarity requires $\frac{\alpha_{ys}\alpha_{yc}}{\alpha_{yy}} < \alpha_{cs}$. If consumption of meat is considered to be beneficial even after negative information becomes available (i.e., $\alpha_{ys} > 0$) and if $\alpha_{yc} \geq 0$, this inequality will hold insofar as greater past consumption increases present marginal utility of consumption, i.e., $\alpha_{cs} > 0$.

While $A_2 < 0$ is a sufficient condition for people to develop myopic habits, it is necessary but not sufficient to induce habitual consumption for rational consumers who

also evaluate future benefits derived from the current level of consumption. The magnitude of $-A_1^{-1}A_2$ in (20) relative to $\delta + \lambda_2$ in (13) is indeterminate, i.e., the degree of adjacent complementarity of a myopic person relative to that of a rational individual is unknown *a priori*. Nevertheless, it is possible to have the case where $-A_1^{-1}A_2 > 0$ but $\delta + \lambda_2 = 0$. When $\delta + \lambda_2$ is equal to zero, rational consumers behave as if preferences are intertemporally separable. Therefore, with truly rational behavior, the dynamic relationship between c and S is different from that of myopic consumers.

Our approach is to model past quantities consumed as part of the consumption capital that induces better present appreciation of the good. But it has been a popular practice to let current utility level depend on the difference between present consumption and a weighted sum of past levels of consumption (e.g., Constantinides 1990; Dynan 2000). Under this formulation, the good must display adjacent complementarity regardless of the values of other parameters in the utility function (see Becker 1996, p. 122). Muellbauer (1988) showed that, conditional on this latter specification of preferences, myopic persons tend to experience habitual consumption less than rational consumers do. The real possibility that myopic consumption may be more habitual than rational consumption under our preference setup qualifies Muellbauer's result.

To see how myopic consumers respond differently from rational individuals to quality or price shocks consider the poultry contamination scenario applied to a myopic consumer. Suppose that in period 0 the individual is at a steady state. At the beginning of period 1, quality k increases immediately due to the contamination accident, and remains at this level until the crisis is salvaged $\hat{T}$ periods later. Unlike rational habit formation, whether this event is anticipated or not has no effect on the magnitude of the initial reaction by myopic consumers because there is no lead price or quality characteristic in the determination of consumption. In other words, expectations play no role in myopic persons' consumption decision except for their role in the calculation of μ. The initial quality deterioration causes c to drop instantly and consequently lowers S. This in turn further decreases the level of c until the end of period $\hat{T}$ when the accident comes to an end. Hence, in contrast with a rational consumer, a myopic consumer continuously reduces consumption until poultry quality goes back to its original level.

In principle this distinction could be used to distinguish empirically rational habits from myopic habits. But the temporary nature of the incidence has to be known *a priori* for the rational and myopic individuals to react differently. It is not immediately clear how uncertainty about the future of an outbreak or price hike will play in the consumer's decision making. But if this uncertainty makes rational consumers respond as if shocks were permanent, behavioral differences between rational and myopic consumers facing a truly transitory event will be much less clear-cut. In this case both types of consumption paths are characterized by gradual adjustment over time, although there is no reason to expect that the size and speed of adjustment will be identical.

There are a few studies on meat demand in reaction to food safety concerns. Marsh et al (2004) found, using the Rotterdam model, that the USDA meat product recall events significantly affect U.S. consumer demand for meat. But the impacts of recalls on meat demand are small in magnitude. Using the AIDS model, Piggott and Marsh (2004) are able to estimate statistically significant but small effects of newspaper articles on food safety issues on consumer preferences for meat. The upshot from these two studies is that information on meat product quality has a very small influence on U.S.

meat demand. But, this does not necessarily suggest that consumers do not care about food safety. If meat consumption is habitual and if consumers are rational, meat quality shocks that are believed to be transitory will have much smaller effects on quantity consumed than shocks thought to persist for much longer periods. This raises the question of how the credibility of government agencies and the food industry in dealing with food contamination situations interacts with consumer demand. Government health and agricultural agencies and the food industry may often be the only sources of information for the wider public. If their reputation for offering trustworthy food safety information is damaged, it may be extremely costly to restore consumer confidence.

Empirical Implications

Eq. (2) specifies current capital stock as an exponentially weighted sum of all past levels of consumption. Following Becker et al (1994), suppose that current consumption capital is equal to the quantity consumed in the last period, i.e., $S_t = c_{t-1}$, the current utility level at time t becomes $u_t = u(y_t, c_t, c_{t-1})$. If the consumption decision is made at the beginning of each period, under uncertainty the representative consumer maximizes the following discrete time intertemporal value function

$$V(w_t, c_{t-1}) = \max_{y_t, c_t}\{u_t + \beta \mathrm{E}_t[V(w_{t+1}, c_t)]\} \tag{21}$$

where w_t is the lifetime wealth discounted to the beginning of period t, the discount factor $\beta = (1+\rho)^{-1}$, and E_t is the expectations operator conditional upon the information available at t. The wealth equation of motion is $w_{t+1} = (1+r_t)(w_t - y_t - c_t p_t)$, where r_t is the risk-free interest rate at t. The standard Euler equation for the expected utility maximizing consumer who revises plans according to newly available information is $\gamma_t = \beta(1+r_t)E_t[\gamma_{t+1}]$, where γ_t is the marginal utility of wealth in period t. The first-order conditions are

$$\frac{\partial u_t}{\partial y_t} = \beta(1+r_t)\mathrm{E}_t[\gamma_{t+1}] \tag{22}$$

$$\frac{\partial u_t}{\partial c_t} + \beta \mathrm{E}_t\left[\frac{\partial u_{t+1}}{\partial c_t}\right] = p_t \beta(1+r_t)\mathrm{E}_t[\gamma_{t+1}] \tag{23}$$

Using (22) to eliminate $\mathrm{E}_t[\gamma_{t+1}]$ from the right-hand side of (23) and replacing expectations at t with their corresponding realized values yields

$$\frac{\partial u_t}{\partial c_t} + \beta\frac{\partial u_{t+1}}{\partial c_t} - p_t\frac{\partial u_t}{\partial y_t} = \varepsilon_t \tag{24}$$

where ε_t contains the part of $\frac{\partial u_{t+1}}{\partial c_t}$ that is unanticipated at the beginning of period t. If consumers form rational expectations, ε_t will be orthogonal to I_t—the information set at the beginning of period t, i.e., $\mathrm{E}[\varepsilon_t \cdot z_{it}] = 0\ \forall z_{it} \in I_t$. In principle, any price, income, and quality variable dated at t or earlier, and quantity at $t-1$ or earlier could be included in I_t. The generalized method of moments of Hansen (1982) can be used for consistent

estimation of the parameters in (24), given some parametric form chosen for the utility function (e.g., quadratic or Translog).

Alternatively, we could follow the method of solution by Becker et al (1994) by noting that when the marginal utility of wealth is constant over time, $\rho = r$, and the utility function (as before) is quadratic, Eq. (22) can be used to eliminate consumption of other goods, y_t, from the marginal utility of consumption in Eq. (23) to yield the estimating equation corresponding to Eq. (24):

$$c_t = \theta c_{t-1} + \beta\theta \mathrm{E}_t\,[c_{t+1}] + \theta_1 \mathrm{E}_t\,[p_t] + \theta_2 \mathrm{E}_t\,[k_t] + e_t \tag{25}$$

where

$$\theta = \frac{-(\alpha_{cs}\alpha_{yy} - \alpha_{yc}\alpha_{ys})}{\left(\alpha_{cc}\alpha_{yy} - \alpha_{yc}^2\right) + \beta\left(\alpha_{ss}\alpha_{yy} - \alpha_{ys}^2\right)}$$

$$\theta_1 = \frac{\alpha_{yy}\gamma}{\left(\alpha_{cc}\alpha_{yy} - \alpha_{yc}^2\right) + \beta\left(\alpha_{ss}\alpha_{yy} - \alpha_{ys}^2\right)}$$

$$\theta_2 = \frac{-\alpha_{yy}\alpha_{ck}}{\left(\alpha_{cc}\alpha_{yy} - \alpha_{yc}^2\right) + \beta\left(\alpha_{ss}\alpha_{yy} - \alpha_{ys}^2\right)}$$

Eq. (25) and its parametric restrictions succinctly subsume the dynamic properties of rational habit formation discussed in the previous sections. While this specification is for a single equation, it can be easily generalized to the multiple goods case inherent in meat consumption (beef, pork, poultry, and fish) by regarding the variables c, p, and k as vectors of consumption, prices, and quality characteristics, respectively.[3] Clearly, rational consumption behavior has a forward-looking dimension that is absent from myopic consumption behavior. Shocks to consumption in this period, whether through prices or perceived quality changes affect not only current consumption but also future consumption.

Using the method of Sargent (1987), the solution to the second-order difference Eq. (25), assuming the error term e_t is serially uncorrelated, can be characterized as follows:

$$(1 - \phi_1 B)c_t = \phi_1\theta^{-1}(1 - \phi_2^{-1}B^{-1})^{-1}(\theta_1 \mathrm{E}_t[p_t] + \theta_2 \mathrm{E}_t[k_t]) + e_t \tag{26}$$

where ϕ_1, ϕ_2 are the characteristic roots of the second-order homogenous difference equation associated with (25) such that $\phi_1\phi_2 = \beta^{-1}$, $\phi_1 + \phi_2 = (\beta\theta)^{-1}$, with $0 < \phi_1 < 1 < \beta^{-1} < \phi_2$. The operator B is the backward shift operator. Consumption in the current period is a function of initial period consumption, all future expected prices, and all future expected quality changes. The effects on current consumption have two dimensions: (a) adjustment costs (as reflected in θ) from changing consumption, and (b) expectations of current and future price and quality changes. It is necessary to specify both dimensions in order to determine whether quality changes, like food safety occurrences, are perceived to be transitory or permanent.

If instead one estimated the myopic, reduced form, relationship

$$c_t = \pi_1 c_{t-1} + \pi_2 p_t + \pi_3 k_t + \upsilon_t \tag{27}$$

there would be no reason *a priori* to believe that we could identify either transitory or permanent effects from quality changes and/or price changes. The reason we would not expect (27) to equal (26) is because the variable, or variables, used to explain quality may not have historically evolved over time in the same way consumers might view quality shocks to occur in the future. This can be seen most clearly by assuming that quality changes evolve over time according to the first-order autoregressive process $k_t = \varphi k_{t-1} + v_t$, where $0 \leq \varphi \leq 1$, and v_t is a nonserially correlated disturbance term with zero mean and constant variance. If shocks to quality are permanent, $\varphi = 1$; if shocks are transitory, $\varphi = 0$. Using this specification for quality shocks in (26) yields the short-run and long-run effects of a change in quality as follows:

$$\left.\frac{\partial c_t}{\partial k_t}\right|_{c_{t-1}} = \frac{\phi_2\theta_2}{(\phi_2 - \varphi)} \tag{28}$$

$$\frac{\partial c_t}{\partial k_t} = \frac{\phi_2\theta_2}{(1-\phi_1)(\phi_2 - \varphi)} \tag{29}$$

The corresponding short-run and long-run effects of the reduced form model (27) are as follows:

$$\left.\frac{\partial c_t}{\partial k_t}\right|_{c_{t-1}} = \pi_3 \tag{30}$$

$$\frac{\partial c_t}{\partial k_t} = \frac{\pi_3}{(1-\pi_1)} \tag{31}$$

Note carefully that in general the short-run result for the reduced form, Eq. (30), does not tell us whether the result is a transitory shock (cf. Eq. (28)); and the long-run result, Eq. (31), does not tell us whether the result is a permanent shock (cf. Eq. (29)). The effect of quality changes, if measured by some index of food safety or cholesterol intake, only shows the impact of the historical effect of past health information on consumption. It most likely would be a mix of transitory and permanent shocks and therefore, the result estimated by (27) would be some hybrid of transitory changes and permanent changes. In order to determine what the impact of transitory or permanent effect would be, we would need to estimate the deeper structural parameters in Eq. (25) and then derive the results using Eqs. (28) and (29) when $\varphi = 0$, for transitory effects, and $\varphi = 1$, for permanent effects.

To complicate the analysis further, the consumer-perceived quality characteristic k is not observable by econometricians. Newspaper article indices, as have been used in a number of studies, are one way to proxy the quality information available to the public. But the amount of public information may not match perfectly with consumers' perception of product quality. For instance, a one-month-only skyrocketing of the news reporting of BSE incidences may change the perceived beef quality for more than a month. How news information is processed by consumers and is transformed into quality perception is

complex and difficult to quantify, even if the rational model of consumption behavior is used. This result has important implications for using a measure like number of newspaper articles to proxy food safety information. Given that the dynamic adjustment can be different for different shocks because of the different values placed on the information by consumers, it may be preferable from an econometric perspective to estimate the model as an event study where dummy variables are used to indicate when the food safety information became available.

CONCLUDING REMARKS

Traditionally, macroeconomists have been interested in the role of rational habit persistence in solving the "equity premium puzzle" of Mehra and Prescott (1985) and other relevant issues. Empirical tests of rational consumption habits deliver mixed results. As practitioners attempt to use micro level data for such tests, they usually find that most of the available data sets contain very limited information on household consumption. Nevertheless, food consumption is readily available and reported. Actually, all of the only five published empirical studies with micro data test the significance of rational habit persistence in food consumption. Naik and Moore (1996) used the Panel Study of Income Dynamics (PSID) data and found rational habits being an important feature of household food consumption. But Dynan (2000) failed to estimate statistically significant rational habit effects on the consumption of food in the PSID data. Meghir and Weber (1996) also did not find evidence of rational habits in food consumption at home in the Consumer Expenditure Survey (CEX). Guariglia and Rossi (2002) used data from the British Household Panel Survey for the period 1992–1997. Their results indicate significant nonseparability in consumer preferences. But this consumption interdependence takes the form of durability as opposed to habit persistence. Carrasco et al (2005) improved on the econometric technique used in Meghir and Weber (1996) and provided evidence that time nonseparability is an important characterization of food-at-home consumption for a panel of Spanish households.[4]

For more disaggregated commodities, the rational addiction literature offers much evidence in favor of modeling some harmful addictive substances such as cigarettes in a rational habits framework (e.g., Chaloupka 1991; Becker et al 1994; Gruber and Köszegi 2001). Richards et al (2004) employed a panel data of the U.S. households' snack consumption and found evidence of rational addiction to carbohydrates. However, Adda (2001) used the 1996 "mad cow" crisis as a natural experiment to study the attitudes of a panel of French households toward health risks. He largely rules out intertemporal nonseparability in consumer preferences for beef. Instead, his results are interpreted in favor of a theory of endogenous discount rate, such as Grossman (1972). Clearly more research is needed to shed more light on the issue of habit persistence in food consumption.

The model of rational consumer behavior developed in this paper offers substantive insight into how food safety concerns as manifested in perceived quality changes can affect consumer response in the short run and the long run. We have shown that the effects are both qualitatively and potentially quantitatively different than models based on myopic, static consumer behavior. Not only are the time paths of adjustment between rational and myopic models different, but consumers' expectations of how permanent or transitory they believe food safety and other quality changes to be can influence the level of

consumption. Being able to identify and quantify expectations separate from adjustment costs associated with habit persistence and other adjustment costs is absolutely essential to quantifying how permanent or transitory effects of changes in food safety events and/or cholesterol concerns will be on consumption in the short run and long run. In addition, the importance of dynamics suggests that timing of information is important and that consumer reaction to food safety shocks can be different depending upon the type of food safety information. Thus, using dummy variables to capture the quality and timing of such information may be preferable to use of food safety indices that are based on adding up number of news articles on health and food safety information.

NOTES

[1]Linearization of the first-order conditions is done only to examine local dynamic behavior of the optimal consumption strategies. More general functional forms can be used in empirical work.

[2]The concept of adjacent complementarity first appeared in Ryder and Heal (1973), where consumption behavior is said to display adjacent complementarity if an increase in current consumption of a commodity raises future consumption of the same commodity. This property of consumption dynamics is more commonly known as habit formation.

[3]Empirically, estimating such a system of equations would be straightforward using say the generalized method of moments. However, the dynamics of consumption to a perceived food safety shock could be much more involved than indicated here for a single commodity case. This is an area for further study.

[4]Their parameter estimate on the food habit term is interpreted as evidence of habit formation. But it is really an indication of durability because it implies that food demand in the previous period reduces the marginal utility of current food consumption.

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