Meat Demand under Rational Habit Persistence

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Abstract

The objective of this paper is to explore the theoretical implications of a meat demand model with rational habits. To introduce consumption dynamics, habit persistence is used to motivate intertemporally related preferences. The impact of food safety information on meat consumption is systematically analyzed. Important differences between myopic habits and rational habits are outlined.

Keywords: food safety, habit persistence, meat demand.

JEL codes: D110, I120, Q180

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1 Introduction

Food is one of the most crucial elements in sustaining human life. Meat, from which the majority of animal proteins are drawn, is an integral part of many people's diet. During the past two decades, meat consumption in several developed economies and in the U.S. in particular has been a hotspot of continual economic research. It is often hypothesized that structural break has 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 other factors are also responsible, findings of structural change are common. The suspected preference shift has more than academic interest. Understanding the causes of this change is of direct interest to the industry and policy makers. This has prompted some authors to estimate parameters apart from prices and incomes.

The most often speculated cause of preference change is the influx 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 has larger elasticities than price elasticities. McGuirk et al. (1995) arrive at similar conclusions. But these observations do not completely dispel the skepticism. Most studies that do confirm a structural break suggest that it occurred somewhere between mid- to late-1970s. However, Robenstein and Thurman (1996) find that red meat futures market does not respond to 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. also indicates that consumers were not bombarded with such information until the early 1980s.

Davis (1997) questions the methodological foundation of the research on structural break in meat consumption. He advocates that researchers should not be pinned down on testing for structural break per se, which, by the laws of logic, isn't at all valid. Instead, a more progressive and fruitful approach is to relax some of the theoretical assumptions embedded in the classical static consumption framework that has been predominantly used in meat demand studies. The aforementioned papers on cholesterol information effects are considered progressive because the list of potentially important determinants of meat demand is expanded.

In this paper and its empirical sequel, the underlying assumption of intertemporal separability is altered to allow for temporally interdependent preferences. It is shown that this modification implies a richer set of consumption behavior that is improbable within the static demand paradigm. By introducing habit formation into meat demand analysis, we are able to investigate the short- and long-run responses of consumption to transitory and permanent price and quality changes. If meat consumption is habitual, the long-run response will be more elastic than the short-run response to a permanent change in price or quality. The distinction between rational habits and myopic habits is also drawn. It is demonstrated that myopic and rational persons 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.

Economists recognize that people dine for entertainment as well as for nourishment (Muth 1966). Consumer preferences for different foods are based on their nutritional contents, palatability, consumer's social status, prestige and habits. If nourishment was the sole purpose of dining, the monetary cost of the diet would be very low. With the knowledge of nutrition at that time, Stigler (1945) estimates that the minimum cost of subsistence in 1944 was $59.88 (in current dollars). This accounts for only less than a quarter of the actual per capita food outlay in that year. Silberberg (1985) finds that as income rises, a lower proportion of food expenditure is allocated to pure nutrition.

Individuals may develop habits over certain food stuff because previous experience with it induces better appreciation. In the U.S., poultry consumption is a prominent example of evolving dietary pattern. During World War II, unlike many food commodities, poultry was not rationed because it was not an important component of people's diet. Poultry products marketed were primarily whole birds that not a lot of housewives knew what to do with. Starting from the 1950's the integrated form of production continuously drove down poultry prices. Poultry products started to be marketed in parts and deboned ready-to-cook forms. New chicken recipes were invented. Fast-food restaurants started to offer such a vast variety of chicken meals as nuggets, patties, breast filets and popcorn chicken. Franchised restaurants like the Kentucky Fried Chicken were configured to serve exclusively chicken. From 1960 to 1999, per capita consumption of poultry products has almost tripled from about 50% to roughly 150% of beef consumption. This observation has been the momentum behind the huge literature on structural break in meat demand.

It is postulated in this paper that past (learning) experience with a food product boosts consumer's current appreciation of this particular food—the essential argument made in Stigler and Becker (1977). The medical mechanism by which cigarettes and cocaine hook addicts up is not needed to induce habits, although recent research indicates that consumption of certain foods may be addictive in the same way as the use of harmful drugs (Wang et al. 2004).

The organization of the paper is as follows. Before indulging into the theoretical model, different approaches to the economic modeling of habits are briefly described in the next section. Section 3 details the meat consumption model with rational habits, where consumption dynamics are fully discussed. Section 4 concludes this paper.

2 Economic Models of Habits

For consumer demand models, perhaps the most natural way to break intertemporal separability is to allow for 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 tastes 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 produce felicities, higher level of past consumption results in 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, consumption knowledge does. In their models, habits are modeled as a learning-by-doing process. The individual learns from his past consumption experience. The more he learns the more felicities 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 are the same and the characteristics of the optimal consumption path are not much different (Phlips 1983; Boyer 1978).

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 preference (e.g., Ryder and Heal 1973; Boyer 1978, 1983; Becker and Murphy 1988). This paper takes on issues associated with the second factor and studies the theoretical implications of incorporating habits and rationality into the meat consumption model.

3 The 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 his lifetime utilities. For now, assume that there are only two goods, the food service that is potentially habit-forming, and all-other-goods. In the empirical sequel, we allow for multiple potentially habitual food commodities. The food service provides both nourishment and entertainment. To prepare the food, three inputs—the raw food material c and 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 incidence 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 a public good that is a quality characteristic of the privately consumed good (Bockstael and McConnell 1993). 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 encapsulates 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:

$S(t) = \int_0^t e^{-\delta(t-\tau)} c(\tau) d\tau$, 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:

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

subject to (2) and the budget constraint:

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

where ρ is the rate of time preference; $y(t)$ is the composite good consumed at time t whose price is normalized to unity; r is the real interest rate; $p(t)$ is the time t price of raw food material c; 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:

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

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

Equation (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 datum, exactly what a rational consumer strives to abide by 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, equation (6) says that the marginal utility of $c(t)$ equals the marginal cost of buying one unit of it minus (plus) the utility value of future benefits (costs). If $u_s \neq 0$, from (6), this drives a wedge between the current marginal utility of $c(t)$ and its contemporaneous marginal cost. In the absence of such wedge, consumption of the rational consumer responds immediately and fully to outside shocks.

3.1 Dynamic Behaviors

To simplify the study of the optimal path of $c(t)$ around its steady state, suppose that the rate of time preference is equal to the real interest rate. Use the following instantaneous quadratic utility function to linearize the first-order conditions (5) and (6):

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

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. Differentiate the linearized version of (6) with respect to t, and use (6) to substitute out the integral term from the result. Then use the linearized (5) to maximize $y(t)$ out. Performing these operations yields a differential equation for $c(t)$

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

where $A_1 = \frac{\alpha_{yc}^2}{\alpha_{yy}} - \alpha_{cc}$, $A_2 = \frac{\alpha_{ys}\alpha_{yc}}{\alpha_{yy}} - \alpha_{cs}$, $A_3 = \frac{\alpha_{ys}^2}{\alpha_{yy}} - \alpha_{ss}$, $B_1 = (\rho+\delta)[\frac{\alpha_{yc}\alpha_y}{\alpha_{yy}} - \alpha_c] + \frac{\alpha_{ys}\alpha_y}{\alpha_{yy}} - \alpha_s$, and $B_2 = (r+\delta)\mu p(t) - \frac{\mu}{\alpha_{yy}}[(\rho+\delta)\alpha_{yc} + \alpha_{ys}]$. Differentiate (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 terms of $S(t)$

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

where $DS(t) = \frac{dS(t)}{dt}$, and $A = A_1^{-1}[A_1\delta(\rho+\delta) + A_2(\rho+2\delta) + A_3]$. Equation (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, $\rho^2 + 4A = A_1^{-1}[A_1(\rho+2\delta)^2 + 4(\rho+2\delta)A_2 + 4A_3] > 0$. To demonstrate the solution to (9), it is convenient to set the right-hand side of (9) equal to $-A\psi(t)$ and rewrite (9) as

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

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

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

The solution (11) expresses $S(t)$ 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 characteristic. The impact of the lead or lag forcing function on current consumption capital declines at an exponential rate. By equation (2), it is clear that $c(t)$ also depends on all past and future values of its own prices and quality characteristic.

Roughly speaking, the stable root λ_2 is associated with the speed of convergence of the system to its steady state. To see this, conduct a conceptual experiment: suppose that the forcing function has been constant at $\overline{\psi}_1$, implying $\dot{k} = \dot{p} = 0$, over a long span of time such that $S(t)$ reaches its corresponding steady-state value $\overline{\psi}_1$. Now, there is an unexpected permanent change in the price or quality characteristic that pushes ψ to $\overline{\psi}_2$. Substituting $\psi(t) = \overline{\psi}_2$ into (11) results in the path by which $c(t)$ travel to its new steady-state $\overline{\psi}_2$

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

Larger (absolute) value of λ_2 implies higher speed at which $c(t)$ 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 implied by equations (2) and (12)

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

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. A commodity that is positively related over time is said to display adjacent complementarity (Ryder and Heal 1973). Equation (13) suggests that the less negative λ_2 is, the higher the degree of adjacent complementarity. In other words, goods that are strongly adjacently complementary (habitual) adjust to their steady states relatively slowly.

To further explain the condition for adjacent complementarity, it is useful to write this condition explicitly in terms of the parameters of the utility function (7). Adjacent complementarity requires

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

People develop habits on, say, beef if larger beef consumption in the past increases present consumption. However, $u_{cs} = \alpha_{cs} > 0$ alone is not sufficient to induce habitual consumption for rational persons. Beef service offers not only nourishment but also palatability. While the level of nourishment largely depends on the amount of beef consumed (c), the degree of palatability relies on the knowledge (S) about how to prepare beef. The rational eater realizes that as the quantity of beef consumed increases, consumption capital will also rise for all future periods. In other words, when deciding how much beef to eat, a rational person takes into account increases in all future utilities resulting from an infinitesimal 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) suggests that the more the rational person discounts future utilities or the faster consumption capital decays, the higher the degree of adjacent complementarity. By the first-order condition (6), ceteris paribus, greater ρ and δ reduce future benefits and thus raise $u_c(t)$. Therefore, for rational beneficial habits, 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 (Abel 1982). The $\dot{S} = 0$ curve is the 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 equation (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.

3.2 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 as well. In the U.S., the real price of poultry products relative to beef has steadily declined from one-half that of beef to about one-third over the last forty years. Meanwhile, the dispersion of health information on cholesterol and saturated fat during the last two decades has perhaps altered consumer's perception of the quality of poultry and red meat.

Assume the drop in poultry price and rise in 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 $\bar{c} = \delta\overline{S}$. 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 equation (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 $\overline{S} = \overline{\psi}_1$. 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 a 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_1A with respect to α_{ys} and α_{ss} gets

$$d(A_1A) = \left[(\rho + 2\delta)\frac{\alpha_{yc}}{\alpha_{yy}} + \frac{\alpha_{ys}}{\alpha_{yy}}\right]d\alpha_{ys} - d\alpha_{ss}. \tag{17}$$

If $\alpha_{yc} \geq 0$ and $\alpha_{ys} > 0$, the term in the brackets on the right-hand side of (17) is guaranteed to be negative. Since a higher A_1A is associated with a lower degree of adjacent complementarity, negative health news could lower the degree of habitual consumption of red meat.

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 $\overline{c} = \delta\overline{S}$

$$\frac{d\overline{c}}{d\mu} = -\frac{\delta}{A_1A}\left[(r + \delta)p - \frac{(\rho + \delta)\alpha_{yc} + \alpha_{ys}}{\alpha_{yy}}\right]. \tag{18}$$

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_1A, equation (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) finds that demand for red meats has become less own-price and income elastic in the 1990s than in the 1950s and 1970s.

3.3 Time Path of Consumption in Response to Temporary Changes

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. This section is aimed at characterizing the theoretical time path of meat consumption, under rational habits, in response to food safety events that result in temporary quality change.

Suppose there is an unanticipated outbreak of bird fluenza in East Asia. Reliable sources estimate that clean-up effort will take time $\hat{T}$ after which the quality of chicken products will return to its normal level. If the consumer is at a steady state $S = \overline{\psi}_1$ at $t = 0$, the moment right before the incidence, and if the jump in k results in $\psi(t) = \overline{\psi}_2$ for $t \in (0, \hat{T}]$ in equation (11), and $\psi(t) = \overline{\psi}_1$ for $t \in (\hat{T}, \infty)$, the initial response of consumption capital to the postulated square wave pulse in $k(t)$ is obtained by taking the unstable positive root λ_1 foward and rearranging terms:

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

Because $\frac{\partial \psi(t)}{\partial k(t)} < 0$, 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 more permanent (higher $\hat{T}$). Equation (12) implies that the initial response of S to a permanent jump in k is $\lambda_2(\overline{\psi}_1 - \overline{\psi}_2)$. 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 equation (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 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 illustrated in figure 3. Before the news of a fluenza outbreak the consumer is at the steady state point E_1. The unexpected incidence induces the individual to reduce poultry consumption to J_2 right after the news is reported. The curve p^2p^2 represents the $\dot{c} = 0$ loci corresponding to the declined quality of poultry products as the incidence lasts. Since the consumer is aware that the event will be temporary, point J_2 will not be on the stable manifold associated with the lower equilibrium E_2 but somewhere above it. Suppose 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_1—the point on the stable manifold leading toward 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 pre-outbreak level. The effect of a temporary price hike would be analogously analyzed.

3.4 Rationality vs. 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 change. 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) find 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, Green and Eales (1980) and Holt and Goodwin (1997) explicitly model myopic habit persistence and find it to be an important feature of consumer preference for meat product. 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.

Unless there are sizable transaction costs associated with forward-looking behavior or lagged consumption actually proxies omitted variables such as demographics that change slowly, the paucity of a forward-looking meat demand model with habits appears to be at odds with the unquestioned consumer rationality (in the static and myopic habits models) about the preference structure underlying the demand analysis. If substantial consumption habits indeed exist, it is unlikely that such knowledge—acquirable with repeated observations and experience—can be ignored by rational individuals.

In a myopic habits model the consumer is not aware of the impact of his current level of consumption on his future utilities. 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 re-planning of intertemporal demand conditional on the current level of consumption capital stock. 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 *de facto* 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: $\frac{\partial u_t}{\partial \tilde{y}_t} = (\frac{1+\rho}{1+r})^t \mu_0$ and $\frac{\partial u_t}{\partial \tilde{c}_t} = (\frac{1+\rho}{1+r})^t \mu_0 p_t$ $\forall t \geq 0$. The tilde over y and c denotes that these are planned quantities that may or may not be the same as the realized 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, at 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 utility (7) to linearize the first-order conditions assuming $\rho = r$, and maximize y out. 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 consumption of rational individuals, 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 ($\alpha_{ys} > 0$) 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 persons 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 individuals behave as if preferences are intertemporally separable.

Our approach has been 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) shows that, conditional on this latter specification of preference, myopic persons tend to experience habitual consumption less than rational agents 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 persons respond differently from rational individuals to quality or price shocks, apply the scenario associated with figure 3 to a myopic consumer. Suppose that at period 0 the individual is at a steady state. At the beginning of period 1, the quality characteristic jumps upward due to a meat contamination accident, and remains at this level until the crisis is salvaged $\hat{T}$ periods later. Note that unlike rational habits, whether this event is anticipated or not does not affect the magnitude of the initial reaction by myopic consumers since there is no lead price or quality characteristic in the determination of consumption. In other words, expectations play little 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 period $1 + \hat{T}$ when the accident comes to an end. Hence, in sharp contrast with a rational agent, a myopic person continuously lowers consumption *until* meat quality goes back to its original level.

In principle this distinction could be used to empirically distinguish 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 agents 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 have been a small number of studies on meat demand in reaction to food safety concerns. Marsh et al. (2004) find, using the Rotterdam model, that the USDA meat product recall events significantly impact U.S. consumer demand for meat, while newspaper reports of food safety events do not. 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 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 people 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 trust-worthy food safety information is damaged, it may be extremely costly to restore consumer confidence. Since expectations play a more critical role in consumption with rational habits than in consumption with myopic habits, dissemination of credible information seems to be more welfare-enhancing in a society with rational individuals.

3.5 Empirical Strategies

Equation (2) specifies current capital stock as a weighted average of all past level of consumption. For practical purposes, an empirically feasible structure for consumption capital has to be assumed. Following the vast majority of econometric model of rational habit persistence, it is assumed that current consumption capital is equal to the quantity consumed in the last period, i.e. $S_t = c_{t-1}$. Suppose the consumption decision is made at the beginning of each period. Under uncertainty, the representative person maximizes the following discrete-time intertemporal value function

$$V_t(w_t, c_{t-1}) = \max_{y_t c_t}\{u_t(y_t, c_t, c_{t-1}) + \beta^{-1}E_t[V_{t+1}(w_{t+1}, c_t)]\} \tag{21}$$

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

$$\frac{\partial u_t}{\partial y_t} = \beta^{-1}(1 + r_t)E_t[\gamma_{t+1}] \tag{22}$$

$$\frac{\partial u_t}{\partial c_t} + \beta^{-1}E_t\Big[\frac{\partial u_{t+1}}{\partial c_t}\Big] = p_t\beta^{-1}(1 + r_t)E_t[\gamma_{t+1}]. \tag{23}$$

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

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

where ε_t is the part of $\frac{\partial u_{t+1}}{\partial c_t}$ that is unanticipated at the beginning of period t. If agents form rational expectations, ε_t will be orthogonal to I_t—the information set at the beginning of period t, i.e. $E[\varepsilon_t \cdot z_{it}] = 0$ for all $z_{it} \in I_t$. 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. Equation (24) remains to be parameterized. In the sequel, we estimate a more parsimonious specification of the preference structure that permits multiple habitual goods. The generalized method of moments of Hansen (1982) can be used for consistent estimation of the parameters in (24).

There is still one very visible empirical difficulty to be dealt with. Econometric models of rational addiction to harmful substances are often interested in the short- and long-run demand response to tax changes. Unfortunately, unlike taxes 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' perceptions 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. If news indices are incorporated into the estimation, extra caution should be exercised in interpreting these results.

3.6 Does the Model Match Reality?

Traditionally, macroeconomists have been interested in the role of rational habit persistence in solving the "equity premium puzzle" of Mehra and Prescott (1985) or 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 empirical studies with micro data test the significance of rational habit persistence in food consumption. Naik and Moore (1996) use the Panel Study of Income Dynamics (PSID) data and find rational habits being an important feature of household food consumption. But Dynan (2000) fails to estimate statistically significant rational habit effect on the consumption of food in the PSID data. Meghir and Weber (1996) also do not find evidence of rational habits in food consumption at home in the Consumer Expenditure Survey (CEX). Guariglia and Rossi (2002) use data from the British Household Panel Survey for the period 1992-97. Their results indicate significant nonseparability in consumer preferences. But this consumption interdependence takes the form of durability as opposed to habit persistence. Carraso, Labeaga and López-Salido (2005) improve on the econometric technique used in Meghir and Weber and provide evidence that rational habits are important characterization of food-at-home consumption for a panel of Spanish households.

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, Grossman and Murphy 1994; Gruber and Kszegi 2001). Richards, Patterson and Tegene (2004) employ a panel data of the U.S. households' snack consumption and find evidence of rational addiction to carbohydrates. However, Adda (2001) uses 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.

4 Concluding Remarks

The meat consumption behavior has drawn substantial resources from the agricultural economists. Interests in this area include identifying factors besides income and prices that are important in explaining the pattern of meat demand. However, most empirical models are based on some variant of the classical static demand model. It is demonstrated that there are some novel theoretical implications from incorporating habits and consumer rationality into the meat consumption model. Specifically, we have made the distinction between short-run and long-run demand response to permanent or temporary price and quality shocks. The difference between myopic and rational habits is also highlighted. These tasks are achieved with a modified Becker and Murphy model of intertemporally optimizing agents with consumption habits. Future research is needed to assess the quantitative importance of these distinctions in order to establish the efficacy of molding rational consumption habits into the standard meat demand models.

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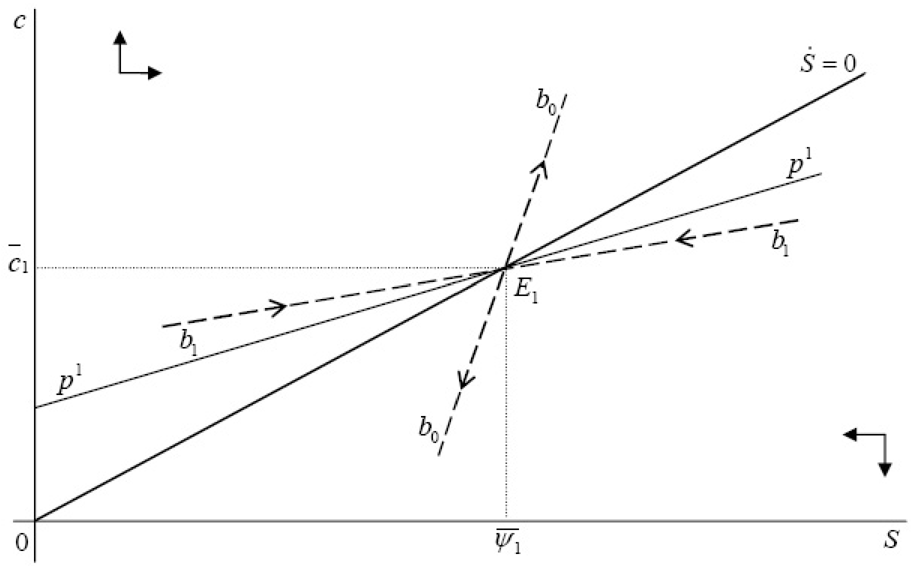

Figure 1: Local structure of a steady state

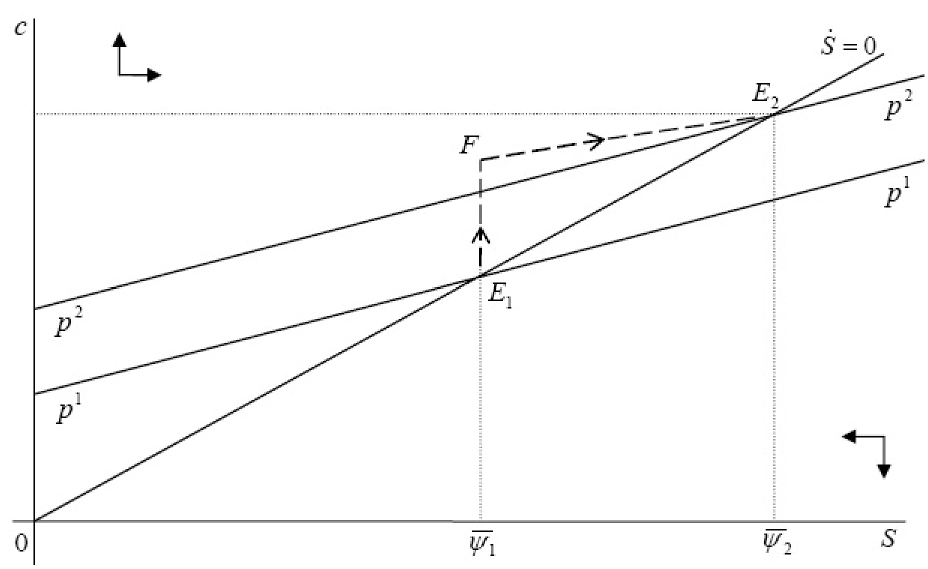

Figure 2: Consumption response to permanent price and quality shocks

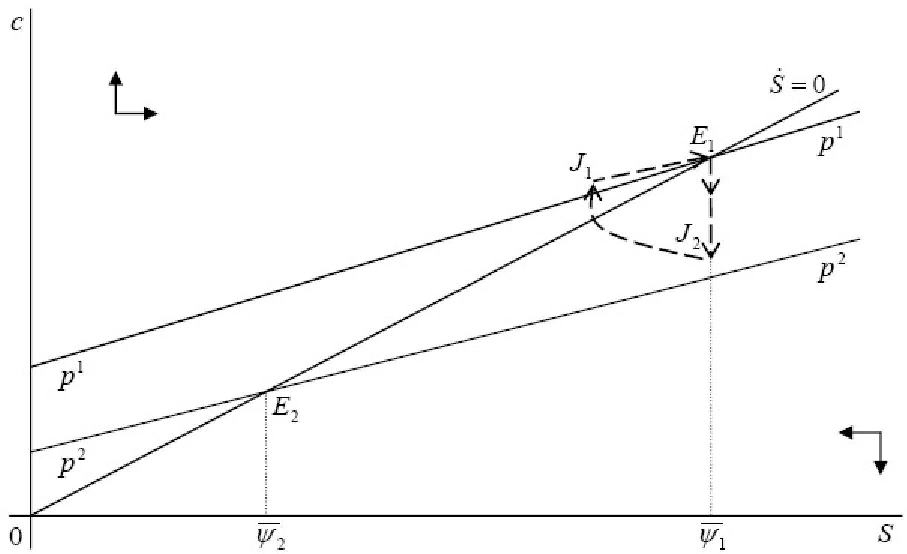

Figure 3: Consumption response to temporary price and quality shocks