Assessing U.S. Household Purchase Dynamics for Dietary Fiber

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Introduction

- The health-enhancing functional properties of dietary fiber has received considerable attention from nutritionists and food scientists and most recently from the U.S. government. Indeed, Hasler (1998) notes that in the last decades there has been a "revolution in the health-enhancing role of specific foods or physiologically-active food components."
- Nevertheless, despite well-established disease-reversal benefits of this physiologically-active food component, along with the fact that nutrition labels mandate that fiber content be listed on the "Nutrition Facts" panel and that dietary fiber has received widespread publicity, the average fiber intake for children and adults in the U.S. is still less than half of the recommended amounts (Slavin, 2005; Anderson *et al.*, 2009).
- Nayga (1996) indicates that this low intake may be a result of consumers' difficulties in translating their awareness into appropriate food choices. Smith (2004) argues that the current dietary choice outcomes may actually be the result of choosing the foods sub-optimally due to an "evolutionary mismatch."
- To date all the existing studies on dietary fiber have focused at the consumer level and in a static context, ignoring the effect of price on fiber consumption, and intertemporal dependence decision over time and its sources (habit persistence and household preferences heterogeneity), which leads to inconsistent parameter estimates and spurious demand elasticities.
- This research updates existing literature on consumer/household demand for fiber, capturing the effect of price on fiber consumption and allowing past purchase occasions to affect current purchase decisions for fiber in a framework that captures simultaneously habit persistence, unobserved household preferences heterogeneity, and serial correlation caused by a first order Gaussian choice process.

Research Objectives

- Investigate what drives demand for dietary fiber in a dynamic choice process at the household level context, controlling for temporal correlations between current and previous purchases over time and censoring of observations across households and time.
- Understand U.S. household consumption dynamic decisions regarding fiber, analyzing their intertemporal purchasing behavior.

Data and Variables

- **Data**
  - Unique panel dataset, created by merging the Dry grocery module—2009 Nielsen Homescan panel dataset (excluding pet foods) and the 2005-2011 Gladson nutritional databases, using heuristic algorithms and a multiple sequential imputation procedure based on product information (e.g. UPC).
  - Weekly basis to reduce computational burden (Average No. purchase weeks across households = 36.7 with standard deviation of 9.13).
  - N = 46,935 households (x 52 weeks), which does not capture fiber-containing foods from dairy products, fresh or frozen fruits and vegetables and from food-away-home, but it does from those contained in the dry grocery module (e.g. cereals and legumes).
- **Variables**
  - **Household demographic and socio-economic variables** (household income; household size; residence type; ethnicity; age, education, employment. Of female head, household participation in the WIC program, and age and number of children).
  - **Seasonal and regional factors.**
  - **Marketing variables faced by the household** (Total quantity of fiber* (from all food items containing fiber and purchased during a week); coupon value; **fiber average price**).

Modeling and Estimation Framework

Dynamic Panel Tobit Model:

$$q_{it}^{*} = \underset{1\times k}{X_{it}}\,\beta + q_{it-1}\gamma + u_{it},$$

$$q_{it} = \max\left(q_{it}^{*}, 0\right),$$

$$u_{it} = \alpha_i + \varepsilon_{it},\ \ \varepsilon_{it} = \rho\varepsilon_{it-1} + e_{it},$$

$\underset{T\times 1}{u_i} \sim \mathbf{N}(\mathbf{0}, \mathbf{\Omega})$

$\underset{T\times T}{\Omega_i}$: VCOV matrix of composite error

Dynamic feature

Assumed to be Gaussian white noise: $e_{it} \sim N(0, \sigma_e^2)$

- q_{it} : Fiber purchases made by household *i* at week *t*
  Non-negative
  Its value is determined by q_{it}^{*}
- q_{it-1} : Fiber purchases made by household *i* at week *t-1* (**the lag purchase**)
- u_{it} : Composite error component
- α_i : Unobserved household heterogeneity effect; constant over time
  $\alpha_i \sim N(0, \sigma_\alpha^2), \forall i$ ⇨ Random effect assump. holds ⇨ $E(\alpha_i, X_{it}) \neq 0$
- ε_{it} : Serially correlated 1st-order autoregressive error component for each *t*
  It varies across time and households; $\varepsilon_{it} \sim N(0, \sigma_\varepsilon^2)$
- $\rho \in [-1, 1]$: Autocorrelation coefficient

Likelihood Function for N households:

$$L\left(\underset{m\times 1}{\boldsymbol{\theta}}\right) = \prod_{i=1}^{N} l_i(\boldsymbol{\theta}) = \prod_{i=1}^{N} \underbrace{f_1(u_{i1})}_{\text{Multivariate Normal PDF of } u_{i1} \text{ (error term associated w/purchase time periods)}} \overbrace{\int_{-\infty}^{-x_{i0}\beta - q_{i0-1}\gamma}}^{\text{T-fold integral}} \overbrace{f_{0|1}(u_{i0})}^{\text{Conditional multivariate Normal PDF of } u_{i0} \text{ given } u_{i1}} du_{i0}$$

$\left(\left[\underset{(k\times 1)}{\beta}\ \gamma\ \sigma_\varepsilon^2\ \sigma_\alpha^2\ \rho\right];\ m = k+4\right)$

⇨ To avoid the multidimensional Integration nature of the model and make it estimable

⇩

GHK simulator

Major Results and General Conclusions

- Household purchase decisions for fiber are characterized by significant unobserved heterogeneity, significant positive serial correlation, and negative and significant state dependence.
- Lagged purchases have a strong effect on current household decisions so that household purchasing at time period t-1 would buy less fiber at time t.
- Demand elasticities of current purchases vary depending on whether purchases are conditioned or not on previous purchase occasions and upon a previous fiber occur or not.
  - ❖ Purchase probability elasticity results conditional on the purchase incidence [purchase or no-purchase]:

    $P(q_{it} > 0 \mid q_{it-1} > 0)$
    $P(q_{it} > 0 \mid q_{it-1} = 0)$ ⇨ demand for fiber is inelastic, behaving more elastic when it is conditioned to a non-purchase occasion at time period t-1.
  - ❖ When conditioning the probability of purchasing on a non-purchase occasion at time t-1, the household's purchase timing becomes shorter relative to the case in which $P(q_{it} > 0 \mid q_{it-1} > 0)$
- Dietary fiber purchase responsiveness to household income, the age and presence of children between 0 and 12, being Hispanic, being African American, seasonality, and region is small.
- Covariates that are not integral determinants of fiber purchases are household participation in the WIC program, the age and presence of children between 13 and 17, not being Hispanic, and the employment level of the female head.

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Further Information

Comments are very welcome and for additional information please contact mhenryo@wsu.edu. The views expressed in this research are those of the authors and do not necessarily reflect the positions or policies of VCU and ERS.