Impact of Changes in Dietary Preferences on U.S. Retail Demand for Beef: Health Concerns and the Role of Media

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The objective of this study is twofold: first, to determine if, in the long run, health concerns affect the retail demand for beef in the United States via changes in consumer dietary preferences, and second, to establish if media coverage of popular diets (media frenzy) causes the change in retail demand for beef or if it simply reports the facts about the changes in consumer dietary preferences. Data used in the analysis are the quarterly retail demand index for beef and the number of newspaper articles and magazine features on low-fat/low-cholesterol and low-carb diets published in the United States between 1990:I and 2004:IV. Johansen's (1991, 1995) cointegration method and vector error correction (VEC) model-based Granger causality test were used in the long-run and short-run analysis, respectively. The results indicate health concerns are an important demand shifter for beef in the long run. In the short run, the media serve as a trigger that will influence people to become followers of a certain diet.

Key Words: beef demand, cointegration, Granger causality, health concerns, media, vector error correction

U.S. beef producers faced significant and serious decline in the domestic demand for beef products between 1980 and 1998. According to Schroeder (2000) and Marsh (2003), per capita retail beef demand declined by almost 50% over this time period. In 1998, the Beef Demand Study Group (BDSG) was formed in an attempt to stabilize or increase consumer demand for beef. Since a measure of demand was needed, BDSG economists developed an annual retail beef demand index with the series starting in 1980 (Genho, 1998). The index measures yearly shifts in retail beef demand. Its purpose was to be used for planning and budgeting in accomplishing the BDSG goal. This index showed a steady decline in the retail demand for beef. Similar results can be found in the publications of Virginia Tech's Research Institute on Livestock Pricing (RILP).[1] Several studies have documented negative structural

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[1] The Institute can be accessed online at http://www.aaec.vt.edu/rilp/demandtop.html.

shifts in retail beef demand (e.g., Eales and Unneveher, 1988, 1993; Moschini and Meilke, 1989; Purcell, 1989; Purcell and Lusk, 2003; Schroeder, 2000). These negative structural shifts were attributed to a number of factors including changing demographics, changing consumer preferences (such as food safety, health, or inconsistent quality), and relative meat prices.

A different phenomenon emerged in the late 1990s, continuing through the first four years of this decade. According to BSDG data and as reported by RILP (2004), the retail demand index for beef increased rather significantly during that period of time. While this positive structural shift has not yet been formally analyzed, it has been speculated that the popularity of so-called low-carb diets is responsible for this trend (e.g., Plain, 2004). Results of the Centers for Disease Control (CDC) "Behavioral Risk Survey" (CDC, 2003) reveal that the majority of Americans (61%) today are either overweight or obese. It therefore comes as no surprise that many Americans are on a weight-reducing diet program of some sort.

While the early 1990s brought a low-fat/low-cholesterol bonanza, the New Diet Revolution of Dr. Robert Atkins has certainly been the most popular diet in the United States during the last five to six years. This diet is one of the so-called low-carb diets. Based on survey findings of the A.C. Nielsen Company, more than 17% of Americans were on the Atkins or some other low-carb diet in 2004. The low-carb diet limits the intake of carbohydrates (primarily grains and vegetables) while promoting the increase in consumption of other foods (primarily meat and dairy).

Cutler, Glaeser, and Shapiro (2003) argue that people are willing to spend large amounts of money in an attempt to lose weight. They present survey evidence that *desired* body mass index (BMI, i.e., weight in kilograms divided by height in meters squared) rises much more slowly than *actual* BMI—indicating most overweight people would like to weigh less than they actually do. If this finding is correct, there are two ways to accomplish the goal of losing weight. Considering the basic relationship of calories-in versus calories-out, people get heavier if they consume more calories or expend fewer calories. But because many individuals are unwilling or unable to make the sacrifice of eating less and/or exercising more, the actual question they are asking is: *How can I lose weight without eating less and/or exercising more?*

This is the point at which many dietary "wizards" emerge, touting various proposed diets—often based on questionable scientific studies—which will supposedly resolve this problem for obese and overweight people. The solution these "experts" often propose is to change the diet. The same foods have often been characterized as "healthy" at one time and "unhealthy" at another. One of the prime examples is beef: it has been impuned as the main culprit in the low-fat/low-cholesterol boom during the early and mid-1990s, and lauded as the food of choice during the low-carb diet domination in the late 1990s and early 2000s. As a consequence of this rollercoaster process, individual agricultural industries, including the beef industry, have experienced periods of both major adversity and significant prosperity.

The objective of this study is twofold. First, we seek to determine if, in the long run, health concerns affect the retail demand for beef in the United States via changes in consumer dietary preferences. Second, it is stipulated that popular diets (such as low-fat/low-cholesterol or low-carb diets) reflect the popular perception about the "healthy lifestyle." The related goal, therefore, is to establish if media coverage of popular diets (media frenzy) causes the change in retail demand for beef, or if it simply reports the facts about the changes in consumer dietary preferences.

The remainder of the paper is organized as follows. First, the long-run link between consumer health concerns and demand for beef is established. Next, we determine the causality between the media coverage of specific diet types and the demand for beef, focusing on the short-run linkage. Conclusions and a discussion of the implications of our findings are presented in the final section.

Health Concerns and Demand for Beef:
Long-Run Link

We first define the time frame and the variables representing retail demand for beef in the United States and consumers' dietary health concerns. The time span considered in the study is the five-year period between 1990:I and 2004:IV. The beginning of the period is chosen because it represents the time when obesity was identified as a potential health issue in the United States by the CDC's National Center for Chronic Disease Prevention and Health Promotion, and it is also the time the low-fat/low-cholesterol diet became the most popular diet to promote healthy eating habits and to fight obesity.

The quarterly retail demand index for beef developed by Virginia Tech's Research Institute on Livestock Pricing (RILP) is used in this study. To calculate the index, RILP used per capita consumption and retail beef price data available from the Livestock Marketing Information Center website. The index calculation is based on demand constant prices compared to 1980 (base year) using an elasticity of ! 0.67. Note that while the index values are a function of the ! 0.67 retail-level demand elasticity, the index does not change drastically for elasticity parameters of ! 0.5 to ! 0.8, which represent the range of own-price elasticities estimated in a number of influential studies on retail demand for beef (e.g., Marsh, 2003; Eales and Unneveher, 1988, 1993). The index is also rescaled to 1998 = 100 so that the improvements since demand bottomed in 1998 can be easily monitored. For example, an index of 121.962 for 2004:I would mean that demand in the first quarter of 2004 has increased by 21.962% since 1998. The index values show how demand is changing, but give no information on why it is changing.

Consumers' dietary health concerns, and in turn their related dietary preferences, are difficult to measure. Ideally, it would be preferable to have access to the number of individuals who were on low-fat/low-cholesterol and low-carb diets during the time period under consideration. Unfortunately, however, there are no reliable sources which could provide the time series needed for the analysis. Accordingly, a good approximation for the number of people on these diets would be the number

of newspaper articles and magazine features on low-fat/low-cholesterol, and low-carb diets published in the United States between 1990:I and 2004:IV. The assumption here is that the newspapers and magazines will report and inform about these diets only if they represent news, defined as "current information and happenings or new information about specific and timely events" (*Merriam-Webster's Collegiate Dictionary*, 2004).

The online source of this newspaper and magazine diet information is NewsLibrary.com, considered the world's largest news archive. Search words were "Low Carbohydrate Diets" and "Low Fat, Low Cholesterol Diets," while the corresponding search option chosen was "lead text/first paragraph." Approximately 600 major newspapers and magazines published in the United States were searched for articles and features related to low-fat/low-cholesterol and low-carb diets published between 1990:I and 2004:IV. The frequencies of articles published related to these two types of diets are therefore considered to be two variables measuring or approximating consumers' dietary health concerns, and in turn preferences. A graph of the time series for frequency of media articles published on low-carb diets and low-fat/low-cholesterol diets is presented in figure 1. The beef index for 1990:I–2004:IV is graphed in figure 2. Summary statistics including simple correlations are reported in table 1.

The underlying concept in testing for the existence of a long-run relationship between the variables representing consumers' dietary health concerns and their demand for beef is fairly straightforward. It has been long recognized that many time-series variables are nonstationary. Any equilibrium relationship among a set of nonstationary variables implies their stochastic trends must be linked. Specifically, the equilibrium relationship indicates the variables cannot move independently of one another. Therefore, the linkage among the stochastic trends necessitates that the variables are cointegrated (Enders, 1995; Engle and Granger, 1987; Hamilton, 1994).

Johansen's (1991, 1995) methodology is used to determine whether or not the group of nonstationary series (retail demand beef index, low-carb diet number of media articles, and low-fat/low-cholesterol diet number of media articles) are cointegrated. The presence of a cointegrating relation forms the basis of the vector error correction (VEC) specification. These are vector autoregressive (VAR)-based cointegration tests. Consider a VAR of order p:

$$(1) \qquad\qquad \mathbf{y}_t = A_1 y_{t-1} + ... + A_p y_{t-p} + B\mathbf{x}_t + \mathbf{\varepsilon}_t,$$

where $\mathbf{y}_t$ is a k-vector of nonstationary I(1) variables, $\mathbf{x}_t$ is a d-vector of deterministic variables, and $\mathbf{\varepsilon}$ is a vector of innovations. We may rewrite this VAR as:

$$(2) \qquad\qquad \Delta\mathbf{y}_t = \mathbf{\Pi} y_{t-1} + ... + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + B\mathbf{x}_t + \mathbf{\varepsilon}_t,$$

where
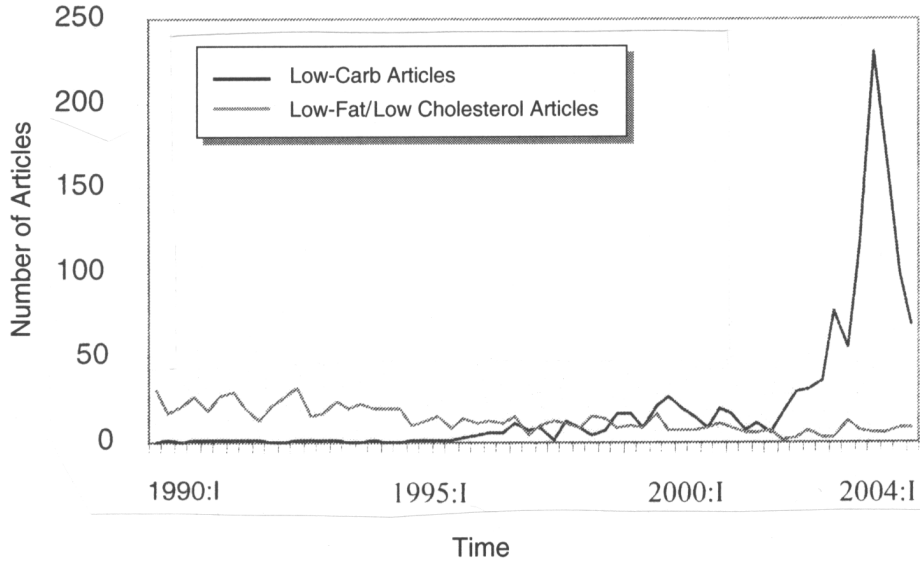
Figure 1. Frequency of media articles published on major diets between 1990:I and 2004:IV
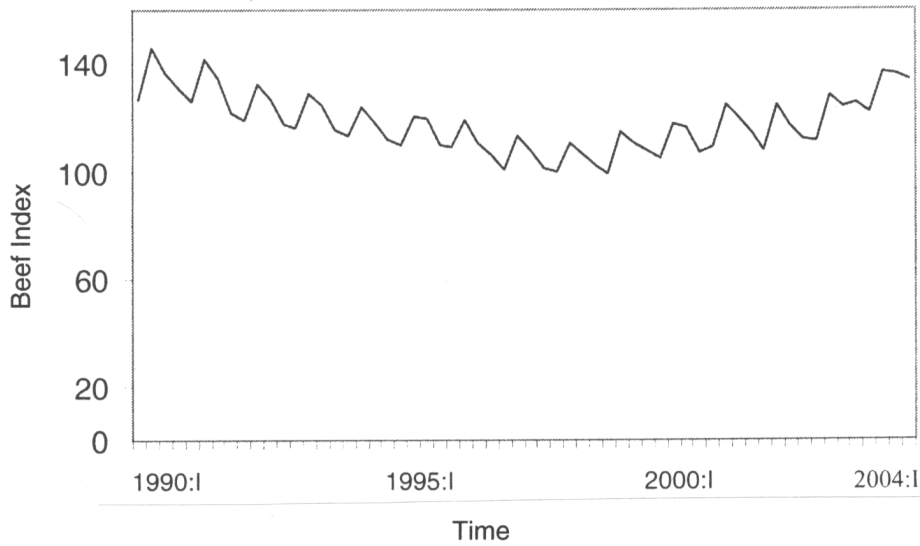
Figure 2. Beef Index, 1990:I−2004:IV (1998 = 100)

Table 1. Summary Statistics: Low-Carb and Low-Fat/Low-Cholesterol Diet Media Articles and Retail Demand for U.S. Beef Index

Description	Variable [a]		
	LC	*LFLC*	*BEEF$INDEX*
Mean	20.37	13.30	118.02
Standard Error	5.39	0.96	1.40
Median	5	12	116.98
Mode	3	7	N/A
Standard Deviation	41.82	7.44	10.87
Range	229	30	46.31
Minimum	1	2	99.34
Maximum	230	32	145.65
Simple Correlations	*LC*	*LFLC*	*BEEF$INDEX*
LC	1.00		
LFLC	! 0.39	1.00	
BEEF$INDEX	0.24	0.32	1.00

[a] *LC* is number of media articles published on the low-carb diet, *LFLC* is number of media articles published on the low-fat/low-cholesterol diet, and *BEEF$INDEX* is index for retail demand for beef in the United States.

$$(3) \qquad \Pi = \sum_{i=1}^{p} A_i - I, \quad \Gamma_I = -\sum_{j=i+1}^{p} A_j.$$

Granger's representation theorem asserts that if the coefficient matrix **Π** has reduced rank $r < k$, then there exist $k \times r$ matrices **α** and **β**, each with rank r, such that $\Pi = \alpha\beta'$, and $\beta' y_t$ is I(0). Here, r is the number of cointegrating relations (the cointegrating rank), and each column of **β** is the cointegrating vector. The elements of **α** are the adjustment parameters in the VEC model. Johansen's method is to estimate the **Π** matrix from an unrestricted VAR and to test whether the restrictions implied by the reduced rank of **Π** can be rejected.

The augmented Dickey-Fuller test (Dickey and Fuller, 1979) is used to test if the time series under consideration are stationary. The null hypothesis is one of non-stationarity, or the variable having a unit root. We were unable to reject the null hypothesis for any of the three variables when tested at the 5% significance level. After first-differencing, each of the three variables of the null hypothesis was rejected at the 1% significance level. Thus, each variable is I(1). Notice that in all three cases, exogenous variables were constant and linear in trend. The lag lengths, based on both the Schwartz information criterion (SIC) and the Akaike information criterion (AIC), were 6 for the beef index (*BEEF$INDEX*), 1 for the low-fat/low-cholesterol (*LFLC*) variable, and 9 for the low-carb (*LC*) variable.

Having established that all three time series under consideration are I(1), we can now pursue the cointegration analysis. The results of the cointegration analysis are reported in table 2. The multivariate cointegration test was carried out with one lag

Table 2. Results of Cointegration Analyses: Multivariate Johansen Test

H_0: Rank = p	Trace Test			Maximum Eigenvalue Test		
	Trace Test Statistic	0.05 Critical Value	p-Value[a]	Max. Eigen-value Statistic	0.05 Critical Value	p-Value[a]
$p = 0$**	67.17430	35.01090	0.0000	37.62279	24.25202	0.0005
$p \# 1$**	29.55124	18.39771	0.0009	25.42513	17.14769	0.0025
$p \# 2$**	4.126115	3.841466	0.0422	4.126115	3.841466	0.0422

Notes: Double asterisks (**) denote rejection of the hypothesis at the 0.05 level. Both the Trace Test and the Maximum Eigenvalue Test indicate three cointegrating equations at the 0.05 level.

[a] MacKinnon, Haug, and Michelis (1999) *p*-values.

in differences (two lags in levels). Based on the results of both trace statistics and maximum eigenvalue statistics, it can be concluded that the three variables representing consumers' dietary health concerns and their demand for beef are cointegrated, with *p*-values below 0.01 when considering one cointegrating vector and below 0.05 when considering two cointegrating vectors.[2]

When more than one cointegration vector is found in a multivariate system, the estimated cointegration vectors are often difficult to interpret. According to Johansen and Juselius (1994), restrictions motivated by economic theory can be used to detect structural relationships in the cointegration vectors. In this case, however, there is no economic theory that would direct us toward looking more deeply into structural relationships. The lack of a more precisely defined structural relationship would not represent a problem if the sole purpose of this portion of the analysis was to determine that these three variables are not moving independently of one another. Nevertheless, we are able to confirm that the two variables approximating the health-dietary concerns (i.e., newspaper and magazine articles published concerning low-fat/low-cholesterol and low-carb diets) and retail demand for beef in the United States follow the same stochastic trend and are not moving independently of one another. This finding indicates that U.S. consumers are health concerned. Americans perceive how changing their dietary habits and reducing their weight is one way of improving their health. In turn, this change in dietary habits leads to a change in demand for beef.

Moreover, the time-series analysis can be pursued even further in order to answer not only the question whether media and health/diet changes have impacted beef demand, but also how media and health/diet changes have impacted beef demand. In other words, focus can be shifted from identifying whether these events are correlated to quantifying the measure of how they are related. The vector error correction (VEC) model is appropriate in the case with nonstationary series that are known to be cointegrated.[3] As in traditional vector autoregression (VAR) analysis,

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[2] Bivariate Engle-Granger tests between *LFLC* and *BEEF$INDEX*, and between *LC* and *BEEF$INDEX* also confirm the presence of cointegration in both cases. Results are available from the authors upon request.

[3] A more detailed discussion about the VEC is provided in the next section, where the short-run links among the variables are discussed.

Lutkepohl and Reimers (1992) showed that innovation accounting (i.e., impulse responses) can be used to obtain information concerning the interactions among the variables. As a practical matter, the two innovations g_{y_t} and g_{z_t} may be contemporaneously correlated if $\mathbf{y}_t$ has a contemporaneous effect on $\mathbf{z}_t$ and/or $\mathbf{z}_t$ has a contemporaneous effect on $\mathbf{y}_t$. In obtaining impulse response functions, Choleski decomposition is used to orthogonalize the innovations. Results from the impulse response analysis are presented in figure 3.

The graphs in figure 3 trace out the effects of one-unit shocks to all g's on the time paths of the *BEEF$INDEX, LFLC*, and *LC* sequences. While all results are informative, we are naturally most interested in the effects of one-unit shocks in $g_{LFLC,t}$ and $g_{LC,t}$ on the *BEEF$INDEX* sequence. This is also the reason we ordered the variables as follows: *BEEF$INDEX, LFLC*, and *LC*. The impulse responses are sensitive to the ordering of variables. Economic theory usually provides the rationale for the ordering. However, due to lack of economic theory in this case, the ordering was determined solely based on the research questions asked.

It is clear from the graphs in figure 3 titled, "Response of *BEEF$INDEX* to *LFLC*" and "Response of *BEEF$INDEX* to *LC*" that the contemporaneous effect in the case of a one-unit shock in low-fat/low-cholesterol diet reports on the beef demand index is three times smaller than the effect of a one-unit shock in low-carb diet reports on the beef demand index. Moreover, the contemporaneous effect of a shock in low-fat/low-cholesterol diet media reporting on beef demand is very modest—perhaps suggesting a sudden shock in writing about low-fat/low-cholesterol diets does not represent "big" news that would significantly alter the beef demand pattern. The same cannot be said about the shock to the low-carb diet media reports variable, revealing how contemporaneous beef demand is much more affected by this shock. Also, the autoregressive nature of the system is such that $t+1$ values of the *BEEF$INDEX* do not immediately return to their long-run values. However, the response of *BEEF$INDEX* to the *LFLC* graph indicates that demand for beef remains very close to (while slowly converging) its long-run values throughout 20 quarters following the time of the shock. In contrast, the response of *BEEF$INDEX* to the *LC* graph indicates a very slow convergence pattern following the shock, where no full convergence is reached, i.e., the values of the demand for beef (*BEEF$INDEX*) do not return to the long-run values completely even after 20 quarters following the shock. Thus, the effects of a sudden increase in the low-carb diet's popularity had a long-lasting effect on demand for beef.

**Causality Between Media Coverage of Specific Diet
Types and Demand for Beef: Short-Run Link**

While we have established the long-run link between consumers' health concerns and dietary preferences for beef, it is not clear what mechanism triggered people to change their diet from the low-fat/low-cholesterol diet scarce in beef to the low-carb diet rich in beef. Some would argue that more frequent media reporting on these diets changed consumers' perceptions about certain foods, including beef, which in
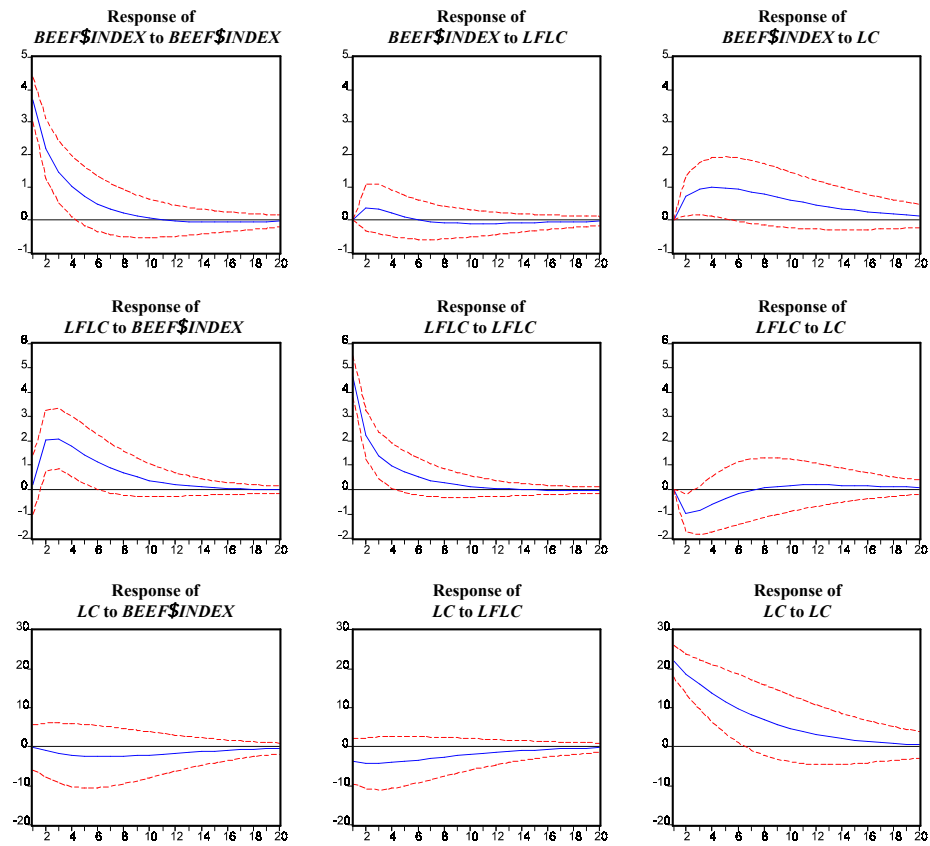
Notes: LFLC is the number of media articles published on the low-fat/low-cholesterol diet,
LC is the number of media articles published on the low-carb diet, and *BEEF$INDEX* is the
index for retail demand for beef in the United States.

**Figure 3. Impulse response functions (response to Cholesky
one S.D. innovations ± 2 S.E.)**

turn caused a change in the amount of beef consumed. In other words, frequent news articles about low-fat/low-cholesterol diets during the early to mid-1990s induced consumers to lower their intake of all red meats, and especially beef. In the late 1990s, the number of articles on low-fat/low-cholesterol diets decreased, while the number of articles on low-carb diets increased. This, many believe, led to an increase in the consumption of beef. Some researchers have noted the importance of distin-guishing between "positive," "neutral," and "negative" articles when using media reports as a measure of representation or frequency of a certain phenomenon (Kalaitzandonakes, Marks, and Vickner, 2004; Marks et al., 2003). We argue that unless the reporting about a certain diet is extremely negative in terms of either its effectiveness or its potentially negative health side effects, many among the 61% (or over 150 million) overweight or obese people in the United States today are willing to change their diet (e.g., increase or decrease their consumption of beef or any other food) in the hope of reducing their weight and thus improving their health.

An alternative line of reasoning would suggest that media do not create the news, but only report what they observe. This would mean that consumers obtain the dietary and health information about the latest research from medical professionals and dieticians. Consumers further follow the medical and dietary advice and change their diet accordingly. The media then pick up and report the change at this point only. This line of reasoning would imply that the decrease in beef consumption was followed by an increase in the number of articles on low-fat/low-cholesterol diets, while the increase in beef consumption was followed by an increase in the number of articles on low-carb diets.

The causality between the media coverage of specific diet types and demand for beef can be tested using the Granger approach (Granger, 1969; Hamilton, 1983, 1994). In general, the Granger approach to the question of whether x causes y is to determine how much of the current y can be explained by past values of y, and then to see whether adding lagged values of x can improve the explanation. Under this approach, y is said to be Granger-caused by x if x helps in the prediction of y, or equivalently if the coefficients on the lagged x's are statistically significant. Note that two-way causation is frequently the case: x Granger-causes y, and y Granger-causes x. This bivariate causality is exactly what we attempt to determine in this case: Does the causality run: (*a*) from the change in the number of articles published to the change in demand for beef? (*b*) from the change in demand for beef to the change in the number of articles published? or (*c*) both ways?

Our previous results, however, prevent us from using the standard version of the Granger causality test—i.e., it would be inappropriate to test for causality in levels with nonstationary series that are known to be cointegrated. The vector error correc-tion (VEC) model is appropriate in this case because cointegration relations are built into the specification, restricting the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjust-ment dynamics. The cointegration term is denoted the "error correction" term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

Here, we consider a simple case of a two-variable (y_1 and y_2) system with one co-integrating equation and lagged difference terms:

$$(4) \qquad \Delta y_{1,t} = \alpha_{1,0} + \alpha_1 (y_{2,t-1} - \beta y_{1,t-1})$$
$$+ \sum \alpha_{1,1}(i) \Delta y_{1,t-i} + \sum \alpha_{1,2}(i) \Delta y_{2,t-i} + g_{1,t}$$

and

$$(5) \qquad \Delta y_{2,t} = \alpha_{2,0} - \alpha_2 (y_{2,t-1} - \beta y_{1,t-1})$$
$$+ \sum \alpha_{2,1}(i) \Delta y_{1,t-i} + \sum \alpha_{2,2}(i) \Delta y_{2,t-i} + g_{2,t}.$$

Again, $g_{1,t}$, $g_{2,t}$, and all terms involving $\Delta y_{1,t-i}$ and $\Delta y_{2,t-i}$ are stationary. Thus, the linear combination of two variables ($y_{2,t-1} - \beta y_{1,t-1}$) must also be stationary. In this simple model, the only right-hand-side variable is the error correction term. In the long-run equilibrium, this term is zero. However, if y_1 and y_2 deviate from the long-run equilibrium, the error correction term will be nonzero, and each variable adjusts to partially restore the equilibrium relation. Finally, the coefficient of α_i measures the speed of adjustment of the *i*th endogenous variable toward the equilibrium.

After estimating the VEC model, the pairwise Granger causality tests can be performed. In the context of a cointegrated system, the Granger causality test must be reinterpreted (Enders, 1995, p. 371). For instance, in a cointegrated system, y_2 does not Granger-cause y_1 if lagged values $\Delta y_{2,t-i}$ do not enter the $\Delta y_{1,t}$ equation and if $y_{1,t}$ does not respond to the deviation from long-run equilibrium. The appropriate test statistic is the Wald χ^2 statistic for the joint significance of each of the other lagged endogenous variables in that equation.

The results of the Granger causality tests are provided in table 3. Two sets of results of particular interest are the pairwise Granger causality tests between *LFLC* (number of media articles published on the low-fat/low-cholesterol diet) and *BEEF\$INDEX*, and *LC* (number of media articles published on the low-carb diet) and *BEEF\$INDEX*. Originally it was not our intent to emphasize the third set of pairwise Granger causality test results—between *LFLC* and *LC*. However, these results proved to be interesting and worthy of our attention. The lag length was set at 9 to match the highest number of lags selected according to AIC or SIC criteria.

In the first case presented in table 3, the causality between *LFLC* and *BEEF\$INDEX* is examined. The presence of bivariate causality is identified. Based on the test results, we reject at the 5% significance level the hypothesis that *BEEF\$INDEX* does not Granger-cause *LFLC*. The hypothesis that *LFLC* does not Granger-cause *BEEF\$INDEX* cannot be rejected at any standard significance level. These results seem to be intuitive. The low-fat/low-cholesterol diet has been around for many years. Most medical professionals will routinely advise their patients to decrease the intake of high-cholesterol foods such as beef. And most patients will comply, at least to some extent. However, the media cannot ignore an audience comprised of a steady but large number of people who follow this type of diet. These individuals consider such diet information to be relevant and newsworthy, and

Table 3. Results of Pairwise Granger Causality Tests

Null Hypothesis [a]	χ^2 Statistic	*p*-Value	d.f.
LFLC does not Granger-cause *BEEF$INDEX*	5.807	0.76	9
BEEF$INDEX does not Granger-cause *LFLC*	18.097**	0.03	9
LC does not Granger-cause *BEEF$INDEX*	23.153***	0.01	9
BEEF$INDEX does not Granger-cause *LC*	36.667***	0.00	9
LC does not Granger-cause *LFLC*	29.559***	0.00	9
LFLC does not Granger-cause *LC*	29.007***	0.00	9

Note: Double and triple asterisks (*) denote statistical significance at the 5% and 1% levels, respectively.

[a] *LFLC* is number of media articles published on the low-fat/low-cholesterol diet, *LC* is number of media articles published on the low-carb diet, and *BEEF$INDEX* is index for retail demand for beef in the United States.

therefore it is being reported by the media. Reverse causality, on the other hand, running from news reports on the low-fat/low-cholesterol diet to beef demand, is not statistically significant. This result is intuitive because most people are likely to have been exposed multiple times to the information on medical benefits of the low-fat/low-cholesterol diet either through continuous coverage in the media over an extended period of time or through their medical and dietary advisors. Because coverage of this information does not represent anything new to most consumers, they may be willing to acknowledge the information but not to change their dietary habits—i.e., it does not influence them to decrease beef consumption.

The causality between *LC* and *BEEF$INDEX* is examined next (table 3). Again, bivariate causality is shown to exist. Specifically, based on the test results, the hypothesis that *LC* does not Granger-cause *BEEF$INDEX* is rejected at the 1% level of significance. This result confirms what many have suspected: more frequent writings in newspapers and magazines about low-carb diets led to an increase in beef consumption. The writings about the Atkins Diet or similar low-carb diets represent a typical case of herding behavior by the media. Once the news on low-carb diets was picked up by media leaders, no newspaper or magazine could afford to ignore the information. This type of herding behavior may be classified as either information- or reputation-based herding (e.g., Bikhchandani and Sharma, 2000). Once the media overwhelmed the public with the information on low-carb diets, many people responded by entering one of the formal low-carb diet programs or by trying to adjust their diets on their own. Low-carb diets are unorthodox and have a great deal of appeal to many of the most affected segments of the population (very overweight and obese people): they can lose weight while not eating less overall, and by consuming even more of some foods such as meats and dairy. While medical researchers have some doubts about long-term viability, success, and health consequences of this diet, many among the more than 150 million overweight and obese Americans are unwilling to wait for the "jury verdict." Ultimately, by the end of the study period in 2004, the demand for meats (and beef in particular) soared to levels higher than in any previous year. This trend, in turn, did not go unnoticed by the

media. Higher consumption and demand for beef and other "healthy foods" led to more newspaper articles and media reports about low-carb diets. This conclusion is supported by the rejection of the hypothesis, at the 1% significance level, that *LC* does not Granger-cause *BEEF$INDEX*.

Finally, bivariate causality is determined to exist, at the 1% significance level, between *LC* and *LFLC* (table 3). This result is an interesting by-product of our investigation. Media reports on low-carb diets are often coupled with writings (often comparisons) about competing diets, including the low-fat/low-cholesterol diet. Thus, this contemporaneous bivariate causality is a logical consequence of the newspaper and magazine writings.

Conclusions and Implications

During the last 15 years, obesity has become one of the main health and social concerns in the United States. The most commonly preferred way to fight obesity is by changing dietary habits and preferences. This change is frequently guided by medical professionals based on knowledge in medical research accumulated over many decades. Sometimes, however, people who are most endangered—the most overweight and obese—do not have the will or ability to follow medical advice and make certain sacrifices. As an alternative to exercising more and eating less, there are many special diets that emphasize changing dietary preferences rather than decreasing the amount of food consumed. Two of the most popular, and competing, diets during the last 15 years have been first the low-fat/low-cholesterol diet, and later the low-carb diet. As a large number of Americans adopted these diets, the consumption of different foods changed. In this research, we have focused on beef, showing that it represents one of those foods whose demand fluctuated as the perception about its healthfulness changed. Our results confirm that many Americans are indeed health concerned, and have changed their diets from "healthy" low-fat/low-cholesterol (which implies low-beef consumption) to "healthier" low-carb (which implies high-beef consumption).

The focus of this study was to determine (*a*) whether media and health/diet changes have impacted beef demand, and (*b*) if so, how these changes have impacted beef demand. Pure time-series methods, including testing for unit roots, cointegration and impulse response analysis, Granger causality tests, and VEC analysis, were employed in order to answer these questions. We acknowledge there may be concerns about the absence in this analysis of some important economic and socio-demographic determinants that are usually included in structural meat demand models (e.g., Marsh, 2003; Eales and Unneveher, 1988, 1993). However, we believe this methodology is powerful and appropriate for addressing the questions posed. Imposing a structure on a model provides qualitatively different answers. The main concern is then about appropriate model specification and its behavioral characteristics. Because our primary concern was to establish the nature of the relationship between media and health/diet changes and demand for beef over time, we argue that time-series analysis is the most appropriate method for responding to these kinds of questions.

We found that media reports over time, including newspaper articles and magazine features on low-carb diets, have been the trigger for change in consumers' dietary preferences. Further, media frenzy was shown to induce consumers to change their diets. This phenomenon led to an increase in demand for beef when the low-carb diet became trendy. It was also determined that an increase in popularity of low-carb diets had a longer-lasting effect on demand for beef compared to the effect of an increase in the popularity of the low-fat/low-cholesterol diets.

The implications of these findings are twofold. First, health concerns are an important demand shifter for beef (and likely some other food products) in the long run. Findings reveal that demand for beef first decreased and then increased due to the same reason—concerns about health. Thus, maintaining the current positive image of beef as a healthy food is certainly very beneficial for the beef industry. It is even more critical for the beef industry to promote this image given the dependence of the beef industry on domestic markets: less than 8% of beef produced in the United States is exported (Miljkovic, Brester, and Marsh, 2003).

Second, overweight and obese people represent a consumer group whose health is most eroded. These individuals are generally more vulnerable and likely to be influenced by various dietary or other programs offering a "quick fix" for their problem. The media serve as a trigger that will influence people to become followers of a certain diet. Given the number of people in the United States afflicted with obesity, it is irrelevant if media coverage about diets (such as the low-carb diet) is presented in a positive, neutral, or moderately negative way (as long as the reporting is not extremely negative). Many people are willing to try these diets, and an increase in publicity will surely lead to the higher adoption rate of a potentially beneficial diet.

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