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Measuring the impact of generic promotions of U.S. beef: an application of double-hurdle and time series models

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Generic promotions have become an integral part of the U.S. beef industry since the inception of the beef checkoff in 1986. Over the period from 1987 through the first quarter of 2000, the U.S. beef checkoff assessments to support these promotions totaled approximately $968 million. Half of these funds may remain with the states to support local programs and the other dollars are used to fund the Cattlemen's Beef Promotion and Research Board programs. At the national level, the board spent approximately $337 million on direct generic promotions within the domestic U.S. market and another $100 million on consumer and industry information. About half of the promotions were for national television while consumer information efforts included printed and supporting materials. State level programs generally paralleled these activities and they should be complementary with the national programs (Ward, 2001; Ward, Moon, & Jauregui, 1996). Recognizing that these assessments were on cattle producers, it is essential to measure any changes in beef demand that are attributed to the beef checkoff.

Within the general population, there are households that do and do not purchase beef, depending on economics circumstances, demographics, and the information available to consumers. Having reliable historical beef consumption data is essential to measure these changes as are the methods needed for measuring the drivers of beef demand. Models that measure both the propensity to consume and quantity after deciding to become a consumer are required in order to separate out the effects of generic promotions from other factors impacting beef demand. Double-hurdle and sample selection models offer appropriate methods for measuring both the propensity to consume and the quantity demanded among existing consumers.

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1. Beef consumption databases

Most economic analyses require analyzing actual market data to gain insight into the major factors driving demand. Drawing on recorded consumption data, statistical models were used to measure the effect of major factors causing movements in the demand for beef. For example, how much does the demand for beef differ across income groups, age, education, employment, and promotions?

Conclusions about the role of any of the demand drivers will depend on the databases used. It is desirable to have different data to replicate conclusions about the beef checkoff. Three independent databases are available for studying the domestic demand for beef. Two are based on consumer surveys, with information recorded across households and over time, and are referred to as the servings and meat purchasing data. Both series are collected and tabulated by the NPD Group (2000), a private company specializing in consumer surveys. These data account for in-home use but exclude away from home consumption. The third database is from aggregate market clearance information, giving average beef prices and volumes recorded on a quarterly basis.

Servings data report the number of servings of beef included in the household diet during a 2-week period. Household information has been recorded by waves (bimonthly) since 1984 and includes household demographics, attitudes, health concerns, behavioral concerns, and the use of competing meat products.

The *purchasing data* include the actual pounds and prices of beef purchases along with the demographics of the household. These data cover the months since 1993 through early 2000, giving more than 50,000 observations for the analysis.

In direct contrast, the *market clearance* data capture total sales of beef at both the boxed beef and liveweight levels. It is the aggregate across all beef users and hence cannot be used to deal with household demographics. All beef is reflected in the data and, unlike the household data, it is more useful for measuring beef demand at the producer level.

One must recognize that when using statistical models across different datasets, the results will never be exactly the same. If the checkoff is truly having an impact on beef demand, one would expect to draw similar broad conclusions while recognizing that the exact numbers will differ. Furthermore, there may be aspects of the promotion effects that are unique to each dataset that lead to differences in the model specification and conclusions.

2. The double-hurdle specification

While a household may be a beef consumer, consumption decisions may also include zero levels. For households that are not beef consumers, incidences of zero level should reflect non-users. The double-hurdle model facilitates zero consumption while traditional sample selection models differentiate between users and non-users (Heckman, 1979). Both models explicitly incorporate participation decisions in an equation separate from consumption decisions. Explanatory variables may have differential and even opposite effects in the two decision stages as suggested with X and Z in Eq. (1) (Lin & Schmidt, 1983; Jones, 1989;

Table 1
Estimated beef promotion coefficients in the beef purchasing and servings models and a liveweight time series model

	Beef purchasing model		Beef servings model		Liveweight model	
	Checkoff coefficient	Coefficient *t*-value	Checkoff coefficient	Coefficient *t*-value	Checkoff coefficient	Coefficient *t*-value
First stage (probability $D > 0$)						
Promotion and information	0.153174	1.36347	2.15834	4.33493	–	–
Promotion only	0.144018	1.64985	–	–	–	–
Consumer information	0.861036	1.89023	–	–	–	–
Second stage (quantity $Y > 0$)						
Promotion and information	0.23219	3.05358	6.72438	4.61148	–	–
Promotion only	0.16772	3.10207	–	–	–	–
Time series						
Seaonal adj.	–	–	–	–	0.12634	2.8290
No seasonal adj.	–	–	–	–	0.10543	2.3091

Write to Ward for the details of each model.

Haines, Guilkey, & Popkin, 1988; Burton, Tomlinson, & Young, 1994; Blisard & Blaylock, 1993; Blundell & Meghir, 1987; Jones, 1989).

$$Y = \begin{cases} Y_{\text{it}}^*, & \text{if } Y_{\text{it}}^* > 0 \text{ and } D_{\text{it}} > 0 \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

where

$$Y_{\text{it}}^* = X_{\text{it}}\beta + e_{\text{it}}, \qquad D_{\text{it}} = Z_{\text{it}}\theta + v_{\text{it}} \text{ with } D = 0 \text{ or } 1$$

One of the variables in X and Z is the generic promotion and information expenditures. Letting the variable k represent these expenditures, then θ_k in Eq. (1) is used to measure the change in probability of consuming beef as the expenditures on generic programs are increased. Once becoming a consumer (i.e., $D = 1$), then β_k measures the change in quantity of beef purchased with changes in beef promotions. Rather than concentrating on the technical estimates in this paper, emphasis is on the results without presenting all details of the models. Similarly there is limited discussion of those coefficients showing the effects of the other major demand drivers, including a wide array of demographic effects. Table 1 shows just the coefficients and statistical test for the generic promotion effect in the household and times series models. While the details follow, a quick overview shows the coefficients to have the expected signs and are statistically significant using a 95% confidence level.

3. Beef purchasing model

Household beef consumption was measured as the pounds of beef purchased per household member in a 2-week period. Some households did not include beef in their diet,

while among those consuming beef there was considerable variation in the pounds purchased. Effects of prices, demographics, health concerns, and promotions on both the likelihood of consuming and the amount purchased were estimated. Beef checkoff efforts were expressed in terms of deflated expenditures during the promotion period first with the promotions and consumer information program efforts combined. Then separate effects from the promotions and consumer information were considered in the beef purchasing model.

The statistical results in Table 1 show the beef checkoff to have a positive and statistically significant impact on the retail purchases of beef as seen with the *t*-values in the second stage estimates. Also, the checkoff is shown to attract new consumers to the beef market and the impacts are statistically significant when considering the separate effects of the promotions and consumer information (see the first stage estimates in Table 1) Using these estimates, one can then simulate the demand responses across reasonable ranges of beef promotion expenditures. Probabilities of consuming and the quantities consumed are going to differ depending on the values set for the other variables in the model. Generally, the most convenient procedure is to set all other variables to represent the average consumer and then show the promotion responses for over that average set of consumer characteristics and market assumptions.

Using the probability estimates from Table 1 and a reasonable range of expenditures on both promotions and information efforts, the ability for the beef industry to attract new users via the checkoff programs can be shown. In Fig. 1 these probabilities of buying beef are

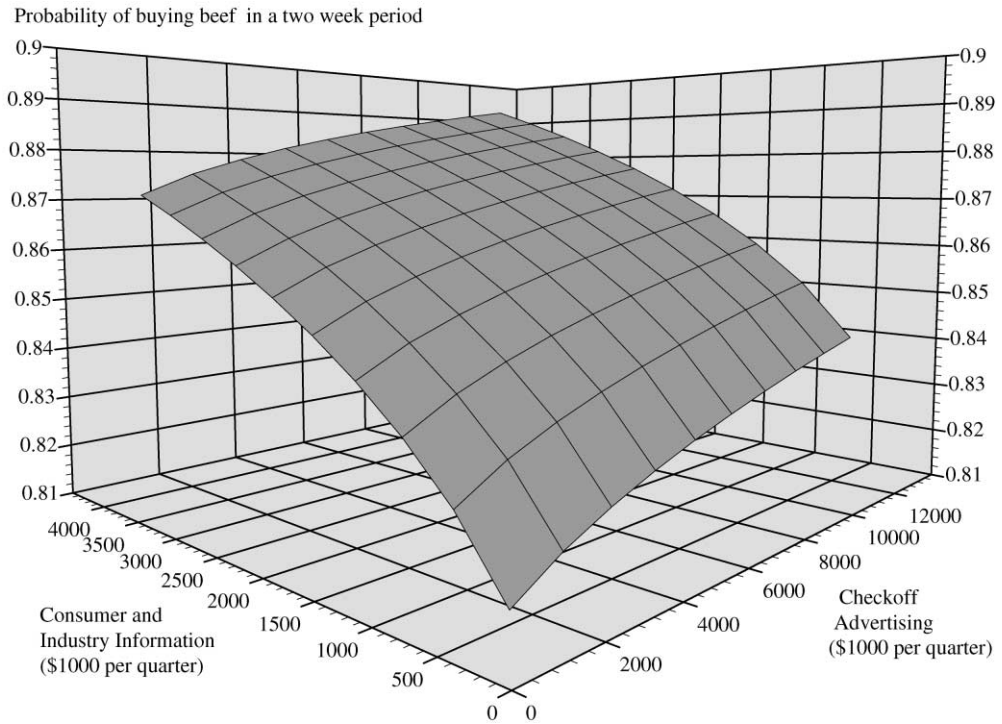

Fig. 1. Probability of purchasing beef as checkoff expenditures are changed.

estimated with the bottom left axis being the consumer information expenditures and the bottom right showing the promotion efforts. Quarterly expenditures of $2 million on information and $6 million for the television is near the average over the last several years. For these points and the average household, approximately 86% of the households consumed some quantity of beef. What is most apparent in Fig. 1 is the strong impact of the consumer information in comparison to the promotions to attract consumers. Generally an increase of around 6% points is near the maximum gain in attracting new consumers that could be expected with changes in both type programs. Consumer information produces up to a 4% point change in the probability of including beef in the diet while the promotions alone produce a range of about 2% points. Clearly the smaller expenditures on consumer information appear to be more effective in attracting buyers to the market than the promotion efforts. A combination of both the promotions and information at the maximum range in Fig. 1 points to the upper probability with the increase from 83% to 88%. Again, the difference is what is important since the actual probability depends on the values set for the other variables in the model.

Once becoming a consumer, then the second stage actually measures the typical demand curve with the promotions as captured in Fig. 2. The vertical axis shows the estimated pounds of beef purchased per household member in a 2-week period for the typical household. On the bottom left axis are the retail prices, ranging from $1.5 to $2.5 per pound. Quarterly checkoff expenditures are shown on the bottom right axis, with the average

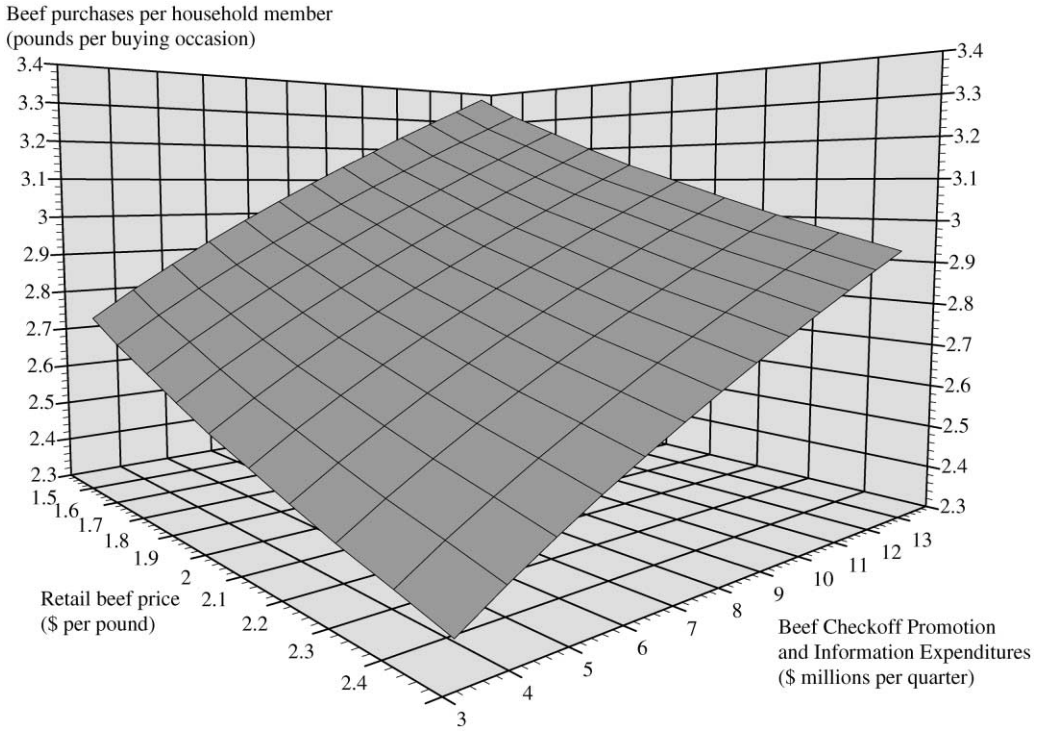

Fig. 2. Beef demand based on the household purchasing data.

expenditures being in the vicinity of $8 million. These checkoff expenditures include both promotions and consumer information activities at the national level.

The downward slope of the graph on the left side illustrates the declining demand for beef as prices increase. Moving from the left to right on the checkoff axis (right side), the graph is rising in direct response to increases in checkoff expenditures. The positive and statistically significant slope shows direct empirical evidence that the beef checkoff is having a measurable impact on the beef demand based on the household purchasing data (i.e., see the second stage beef purchasing coefficients in Table 1).

To illustrate, consider the retail price of $2.49 per pound and promotions near $3 million, the per member quantity purchases are estimated to be 2.38 pounds. Extending the checkoff dollars to $13 million, the pounds increase to 2.93, giving a 0.55 pounds gain in demand. Based on the purchasing model, one could reasonably expect to see the maximum change of about 1.5 pounds over the historical range of checkoff expenditures. Smaller changes in the checkoff obviously produce less change in the pounds purchased and, in general, the 0.55 pounds gain is close to the outer limits of the checkoff impact on demand based on the meat purchasing data.

The checkoff expenditures in Fig. 2 are the combined effects of promotions and information programs kept in historical proportion. With the purchasing model, separate effects of the promotion and information programs were estimated. Generally, the consumer information programs were most effective in attracting new consumers into the market and had little additional effect on the poundage beyond bringing in more households. Whereas, the promotions showed a greater impact on the amount purchased once becoming a beef consumer. Since the demand responses to both type of checkoff programs are known, it is possible to calculate the relative gains attributed to the advertising and information activities as presented in Table 2. Columns one and two show the marginal purchasing gains with incremental increases in retail beef demand associated with fixed increases in the expenditures on either the promotions or information programs. Column one includes the marginal quantity gains attributed to increments in the promotion programs. Since both columns are in equivalent units, they are comparable for evaluation purposes. On an average, promotions totaled around $6 million and information activities equaled $2 million. Comparing these midpoints, marginal gains from the promotions generally exceed those from the consumer and industry information programs. Fundamentally, the marginal gains

Table 2
Marginal gains from the beef checkoff using the purchasing model

Checkoff $1000	Marginal gains from promotions	Marginal gains from information
1219.14	0.2505	0.1035
2438.28	0.1112	0.0415
3657.42	0.0885	0.0312
4876.56	0.0768	0.0259
6095.70	0.0694	0.0224
7314.84	0.0641	0.0200
8533.98	0.0601	0.0182
9753.12	0.0570	0.0167
10972.26	0.0545	0.0155
12191.40	0.0524	0.0145

from the promotions are larger in part because of its impact on both the first and second stages whereas the information effect tended to be during the first stage. Both programs show a measurable impact on beef demand with the marginal gains pointing to the larger allocation to the promotions relative to the information efforts. The retail model establishes that households have responded to both the promotions and information programs with the payoff being greater from the promotions. Furthermore, the marginal gains indicate that the beef industry's historical allocation between promotions and consumer/industry information has been relatively close to what would be suggested with the marginal analysis.

4. Beef servings model

Beef servings were measured with a household survey that is totally independent of the meat purchasing data. Statistical models were estimated showing the probability of becoming a beef consumer and the level of frequency of including beef in the household meals. Along with the promotions, differences in demand were measured across demographics, health concerns, prices, and consumer attitudes and behavior. Estimates for the effect of the checkoff on the number of servings are positive and statistically significant as initially shown in Table 1.

Similarly to Fig. 2, Fig. 3 depicts the demand for beef (servings) across retail prices and checkoff expenditure levels. In this case, the model is measuring beef servings in contrast to

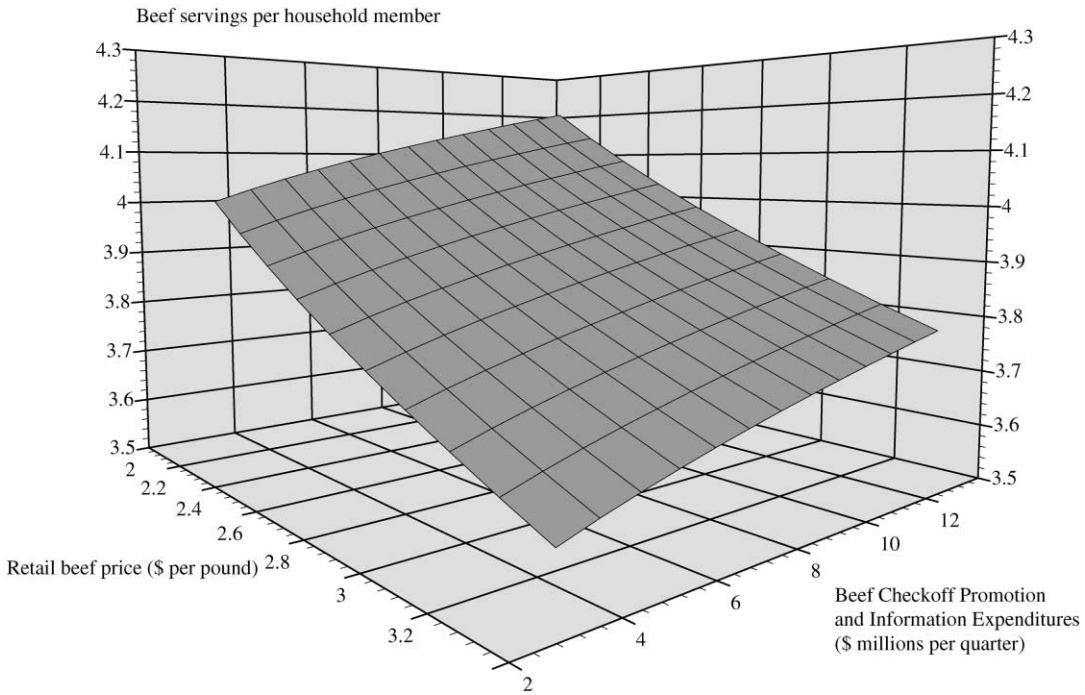

Fig. 3. Beef demand measured with the beef servings model.

the beef purchases and the analysis is totally independent from the purchasing model. If the checkoff had no effect on demand, the graph would be flat across the checkoff expenditures. Whereas, the positive slope seen in Fig. 3 (right side) clearly points to an impact on retail beef demand. Using the middle column in Table 1, the *t*-value of 4.61 establishes that this positive slope is statistically significant.

Using the retail price of $2.49 in Fig. 3, servings are shown to increase from 3.84 to 4.03 per household member in the 2-week reporting period. At this price level, beef demand increases by an estimated 0.20 servings, depending on the range of the checkoff expenditures. As a general rule in Fig. 3, the maximum gain in servings that could result from the promotions and information efforts approaches 0.25 servings. While not shown, the servings model also indicates that the checkoff efforts attracted new buyers to the market with the maximum change in probability of serving beef attributed to the checkoff being near 5% points. This gain in the probability of using beef is very near to that measured in Fig. 1 with the beef purchasing model, thus adding confidence to the conclusions about the beef checkoff impact on beef demand.

A problem with the servings data is that the exact equivalence between a serving and pounds of beef is not known. However, the pound equivalent can be approximated by matching the pounds in Fig. 2 with the servings in Fig. 3. For the $2.49 retail price and a checkoff level of around $8 million, the demand measured from Fig. 2 is 2.70 pounds and the servings value is 3.94 (Fig. 3), giving an equivalence of one serving = 0.68 pounds. It is emphasized that this is an approximation and not a statistically derived number. Over the range of checkoff expenditures in Fig. 3, the change in equivalent pounds would be 0.20 servings times the 0.68 pounds, or 0.136 pounds per household member. Note that these pounds are less than those estimated with the beef purchasing data in Fig. 2.

Using the estimated gains with the servings model, these results can be expressed in a liveweight equivalent value, drawing on accepted industry standards for conversions among the retail, boxed beef, and liveweight quantities. Retail pounds are converted to liveweight equivalent and retail prices are expressed in comparable liveweight dollars. Changes in the liveweight revenues can then be calculated over the range of checkoff expenditures in Fig. 3. Furthermore, the promotion and information expenditures must be converted back to a near-equivalent assessment basis, using the value that promotions and information is 80% of the national budget and half of the total assessments are at the national level.

Table 3 shows the calculated marginal gains over a range of checkoff expenditures and the equivalent assessments. Since the equivalent servings to pounds is an approximation, other conversions using 0.50 and 0.40 are also shown. For a national assessment of $21 million per quarter and the equivalent national promotions of $8.4, the marginal rate-of-return to the beef checkoff ranges from 5.6 to 9.6 based on the servings data and the assumption about the servings-to-pounds conversion. While recognizing that the liveweight conversion is an approximation, the marginal gains are quite high. Under the most restricted assumptions of 0.40 pounds per serving, the beef checkoff has a positive and important economic impact on beef demand as derived with the beef servings model. For the national level of $8.43 million per quarter, the servings model indicates a marginal return of $5.68 for each additional dollar spent. Even for higher checkoff levels the marginal gains are still above four, suggesting that the programs are underfunded when just comparing the gains without consideration of

Table 3
Calculated marginal gains to the checkoff based on the beef servings model

Assessment ($ million per quarter)	National promotions ($ million per quarter)	Marginal gain to $ million increases		
		Serving pound equivalent = 0.40	Serving pound equivalent = 0.50	Serving pound equivalent = 0.68
12.648	5.060	7.329	9.162	12.460
16.863	6.750	6.339	7.923	10.776
21.079	8.430	5.681	7.102	9.658
25.295	10.120	5.205	6.506	8.848
29.511	11.800	4.838	6.048	8.225
33.727	13.490	4.546	5.682	7.728

alternative uses of the assessments. Similarly, 0.40 is the most conservative calculation among the values in Table 3.

5. Market clearance model

The third approach was to directly measure the checkoff impact at the liveweight market level. The approach was to use a liveweight model to predict quarterly liveweight cattle prices while accounting for supplies of the major meats (beef, pork, and poultry), income, inflation, health concerns, and the beef checkoff promotions and information expenditures. Checkoff expenditures were included in a time series model and resulting promotion coefficients and *t*-values are shown in the right portion of Table 1. This third approach to evaluating the beef programs is independent of the two previous models.

Using these time series model estimates (see Table 1), cattle prices were simulated with and without the checkoff expenditures. Liveweight revenues with and without the beef checkoff efforts were then calculated over the full life of the program since 1987 with and without the beef checkoff (Ward & Lambert, 1993). The liveweight estimates in Table 1 show the checkoff programs to have a positive and statistically significant impact on demand at the producer level. From 1987 through the first quarter of 2000, total revenues back to cattle producers were predicted to be $321.18 billion. These revenues were calculated to drop to $314.72 billion without the beef checkoff, giving a difference of $6.46 billion. The $6.46 billion represents the added revenues directly attributed to the beef checkoff. Next, for the same period, all checkoff assessments were totaled and subtracted from the total gains and then the net gains were divided by the same assessments. This method of calculating the rate-of-return gave a value of 5.67 to the beef checkoff. On average, for each dollar spent on the checkoff assessments, an additional 5.67 net gain to producers was estimated based on the time series approach. This is the average rate of gain attributed to the beef program over the full life of the beef checkoff. Recall from Table 3 using the beef servings model, the marginal gain at the average expenditure level was 5.68. While the average rate and marginal rate are different, at these average expenditure points they are comparable and are nearly equal. Using two independent methods for calculating the benefits of the beef checkoff lead to very similar conclusions, recognizing again that the results will never be exactly the same using different

databases and models. While the rate-of-return is impressive, it is comparable to what has been shown previously and to that seen for many other commodities.

It is equally important to put these gains in perspective. The model predicted a gain of $6.46 billion over what would have existed in the absence of the beef checkoff using the time series approach. This $6.46 billion compared to the total producer revenues of $314 billion without the checkoff represents a 2% increase in producer revenues directly attributed to the beef checkoff. Hence, while the rate-of-return is high, the total gains are quite small when put in perspective to total the industry size.

6. Conclusion

Generic promotions are increasingly being challenged on legal grounds, as are the current beef checkoff programs. Having an ongoing evaluation of the economic impacts of the programs is essential to determine if any benefits are worth the investment by producers. If they are not, then clearly they should be terminated. If they benefit the total industry then there is good reason to continue the programs even though a few producers and industry groups oppose the checkoff. For programs that work, terminating a program to protect one individual's rights infringes on the rights of the larger group since it would generally be impossible for any one producer to underwrite a promotion program. This becomes the classic free-rider issue when programs work but some choose not to share in the costs. If they do not work, then the free-rider is no longer an issue.

For the beef checkoff, an ongoing evaluation of the promotions' influence on demand continues to show the promotions to have a positive impact on demand. Unlike most other evaluations, this is the only case where three independent approaches using three different databases confirm that the checkoff has had a positive and statistically significant impact. Each model points in the same direction and gives similar signals as to the magnitude of the impact. Replication is often a luxury in economic studies because of data limitations. In the beef case, the analysis provides an additional level of confidence when drawing inferences about the program benefits. Reliability of the conclusions is important and these three separate analyses show that U.S. consumers have responded to the beef promotions and supporting information materials.

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