RETURN TO STAKEHOLDERS FROM THE AMERICAN LAMB BOARD CHECKOFF PROGRAM: A SUPPLY CHAIN ANALYSIS

Report to the American Lamb Board
Denver, Colorado

Agribusiness, Food, and Consumer Economics Research Center (AFCERC)
Department of Agricultural Economics
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June 2014

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ACKNOWLEDGEMENTS

The research reported here was conducted under contract with the American Lamb Board. The lamb advertising and promotion data used in this study were collected with the assistance of the American Sheep Industry Association, Inc. (ASIA) and the American Lamb Board (ALB). We gratefully acknowledge the helpful comments of Dr. David Anderson and Dr. Oral Capps, Jr. of Texas A&M University. The conclusions reached and any views expressed, however, are those of the authors and may not represent those of ASIA, ALB, the reviewers, or Texas A&M University.

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EXECUTIVE SUMMARY

Following decades of almost continual decline in sheep inventories and lamb production and various industry-led and government support initiatives, the Lamb Promotion, Research, and Information Order, better known as the American Lamb Checkoff Program, was established in 2002 under the Commodity Promotion, Research and Information Act of 1996 in an effort to bolster the U.S. sheep and lamb industry through promoting the retail demand for lamb. In years prior to the establishment of the Lamb Checkoff Program, the sheep industry diverted funds from the subsidies received under the Wool Incentive Program to lamb promotion activities until that program was discontinued in 1996/97.

Like the advertising and promotion activities funded by most commodity checkoff programs, lamb promotion efforts over the years have intended to enhance the profitability of the associated industry through retail level promotion activities. Unlike those of most other commodity promotion programs, however, the promotional activities of the American Lamb Board are dedicated to increasing not only the demand for lamb but also the industry's share of domestic consumption, an effort to "brand" the domestically produced product (lamb) in the face of rapidly growing imports from Australia and New Zealand. Retail promotion under the current Lamb Checkoff Program also differs from that of other checkoff programs in that producers are only one of several groups along the supply chain who are required to contribute to the funding of the program. Besides sheep producers, lamb feeders and lamb packers are the other two big groups who are assessed checkoff fees. Producers are assessed a fee on each feeder lamb sold while feeders are assessed a fee on every slaughter sheep they sell to packers. In turn, packers are assessed a fee on each slaughter sheep they purchase.

The general goal of this study is to determine whether the lamb promotion efforts over the years, including the current Lamb Checkoff Program and previous efforts to promote the retail demand for lamb, have achieved their objectives and, in the process, benefited industry stakeholders along the sheep-lamb supply chain. The study focused on answering three interrelated questions within the context of that supply chain: (1) What have been the effects of the American lamb checkoff program on U.S. and foreign sheep and lamb prices, sheep inventories, feeding, and slaughter, and lamb production, consumption, and trade? (2) Has the checkoff program effectively increased U.S. consumption of "American" lamb as opposed to imported lamb? (3) What have been the returns to U.S. sheep and lamb industry stakeholders from their investment in the checkoff program?

To conduct the analysis, a 70-equation econometric simulation model of world sheep, lamb, and wool markets, referred to as LamMod, was constructed and validated over the 1987-2013 period,

covering both the period before and after the establishment of the current Lamb Checkoff Program. LamMod includes econometric representations of the U.S., Australian, and New Zealand sheep, lamb, and wool industries and trade and includes endogenous variables representing supply, demand, prices, trade, and other market activities in all three countries and industries. After estimating the parameters, the model was simulated over the sample period as a means of model validation. The model was then used to simulate two lamb checkoff expenditure scenarios. First, a *"with expenditures"* scenario simulation assumed that the checkoff expenditures to enhance U.S. lamb demand were made as actually occurred over time. Then, a second *"without expenditures"* scenario simulation assumed that the checkoff expenditures to enhance U.S. lamb demand were not made as actually occurred over time. In that second scenario simulation, lamb checkoff expenditures were set to zero in every year. That change in expenditures impacted the levels of prices and quantities in the model over time. The differences between the simulated values of the corresponding model variables representing the U.S. and global sheep, wool, and lamb markets in the two scenarios provided a measure of the changes in the global sheep-lamb-and wool supply chain that have occurred over time as a direct result of the U.S. lamb checkoff program.

With respect to the first question above, the simulation analysis demonstrates clearly that the U.S. lamb checkoff program has impacted U.S. and foreign sheep and lamb markets. Some of the more salient results are the following:

- In the U.S., the average annual lift of the current checkoff program (how much higher production, price or other variables were in each year since 2003 than would have been the case in the absence of the program) was:
  - breeding sheep inventories: 3.2%;
  - lamb crop: 4.4%;
  - lambs on feed: 3.0%;
  - sheep slaughtered: 5.0%;
  - lamb production: 5.4%;
  - lamb imports: 0.8%;
  - lamb consumption: 3.7%;
  - price of live sheep: 3.3%; and
  - retail price of lamb: 0.9%.

- Checkoff expenditures under the current checkoff program (2003-2013) created somewhat more lift along the U.S. sheep-lamb-wool chain than was the case under the preceding lamb promotion program operated by the American Sheep Industry Association.

- The import-increasing effect of the current checkoff program has been somewhat smaller than was the case under the preceding lamb promotion program.

- The current lamb checkoff program also created some lift in Australia and New Zealand as well but to a much lesser extent than in the U.S. The average annual lift in Australia and New Zealand since 2003 was, respectively:
  - breeding sheep inventories: 0.04% and 0.07%;
  - lamb crop: 0.3% and 0.07%;
  - sheep slaughter: 0.05% and 0.08%;
  - lamb production: 0.05% and 0.07%;
  - lamb consumption: -0.02% and -0.04%;
  - live sheep price: 2.6% and 1.7%; and
  - price of lamb exported to the U.S.: 2.3% (both countries).

With respect to the question of whether the lamb checkoff program actually promoted consumption of American lamb as intended rather than imported lamb, the study finds that the lamb program increased total U.S. lamb consumption by more than lamb imports over the period of analysis implying that that the program has effectively worked to reduce the lamb import share of domestic consumption.

As to whether or not the lamb checkoff program returned more to those who paid for the lamb checkoff program (primarily sheep producers and feeders and lamb packers) than the program cost them in checkoff assessments, the study finds that the program has returned to stakeholders a profit much in excess of the cost. Specifically the study finds:

- The Benefit-Cost Ratio (the dollars of net returns per dollar of checkoff expenditure) to the lamb industry as a whole over the entire period of analysis (1987-2013) was $7.10, considerably lower than the $44.14 reported by Williams, Capps and Dang (2011) at the retail level. When discounted to present value, the BCR was still a healthy $3.46. In other words, for every dollar invested by industry stakeholders in lamb promotion through the checkoff program, they realized $7.10 in additional profit ($3.46 on a discounted basis).

- Under the current lamb checkoff program (2002-2013), the industry BCR was $14.40 compared to the BCR of $3.03 in preceding years when the promotion expenditures were funded by the now defunct Wool Incentive Program.

- Returns to stakeholder groups (BCRs) under the current checkoff program were quite similar:
  - BCR to producers: $13.84 (non-discounted) and $7.86 (discounted);
  - BCR to feeders: $14.88 (non-discounted) and $6.97 (discounted); and
  - BCR to packers: $15.81 (non-discounted) and 10.14 (discounted).

These results lead to a number of implications for the management of the lamb checkoff program:

- *"Free rider" effects (checkoff benefits to Australia and New Zealand) are relatively small.*
  Although the lamb checkoff program has worked as designed to increase the demand for lamb and provide a positive return to stakeholders, the program has also positively impacted lamb imports and the sheep and lamb industries of Australia and New Zealand. Those "free rider effects" appear to be relatively small, however. When the "free rider effects" of imports on a checkoff program become large enough, checkoff organizations often begin to consider extending the checkoff assessment to imports because a non-trivial or sometimes substantial share of the benefits of the program may be being diverted away from the stakeholders who pay the program costs to the free riders who pay none of the costs. In the case of the lamb checkoff program, however, the free rider effects appear to be small. Consequently, little would likely be gained in terms of reduced leakage of returns to domestic stakeholders from requiring imports to pay a checkoff assessment. In fact, the benefits from assessing imports a checkoff could well be smaller than the cost of providing importers a seat(s) on the Board and a voice in strategic promotion decisions which would lead inevitably to pressure to shift the focus of the program away from promoting "American" lamb to lamb in general.

- *The lamb checkoff BCR is much higher than the BCRs calculated for larger and more mature programs like soybeans, cotton, beef, and pork but that does <u>not</u> necessarily indicate that the lamb checkoff program is much more effective than those other checkoff programs.*
  The higher BCR for lamb in part reflects the small size of the lamb checkoff program compared to those of other major commodities and the larger share of their industries' revenues spent on promotion. The $1.4 million spent by the lamb checkoff program in 2013 is meager in comparison to the $93 million spent by the soybean checkoff program, the $80 million spent by the cotton checkoff program, and the $41 million spent by the beef checkoff program. At the same time, the ratio of lamb checkoff expenditures to the value of lamb production was only 0.11% in 2013 compared to generally 0.5% to 1% or higher for other commodities. As the level of checkoff expenditures grows, the marginal impact of each additional dollar spent declines. So, for a huge checkoff program like soybeans, the marginal effectiveness of each dollar is much lower than for lamb which implies a lower average return to each dollar invested under the program. But with $93 million being spent, the absolute impact of their checkoff activities on their markets is much greater.

- *The lamb checkoff program continues to be vastly underfunded imposing a huge opportunity cost on industry stakeholders of potentially millions of dollars.*
  Despite the increase in the lamb checkoff assessment passed in 2013, the program continues to be underfunded. For every dollar in additional assessment NOT paid by stakeholders and

spent on lamb promotion, the estimated BCR indicates that industry stakeholders lose an average of $14.44 in additional industry revenue.

- *The higher BCR for the current checkoff program compared to the earlier program under the Wool Incentive Program may be the result of differences in funding strategies and the inclusion of packers as stakeholders.*
  Under the previous program, promotion funds were spread over a wide array of categories of promotion activities. The current program strategy has been to promote more directly to consumers and to the food service industry. To the extent that the current focus of promotion expenditures more effectively shifts out the demand curve, the BCR would also be expected to be higher. Also, under the previous lamb promotion program, packers were free riders so that any benefits they received as a result of promotion essentially represented a leakage of benefits away from stakeholders (producers and feeders at the time). The inclusion of packers as stakeholders not only increased checkoff funding levels from what they might otherwise have been but also helped limit the leakage of benefits to free riders.

- *The lamb checkoff program has worked well in its design to ensure that stakeholder groups realize roughly equivalent returns.*
  This result has not been generally true for checkoff programs with multiple stakeholder groups. If assessment rates are adjusted further in the future, care should be taken not to change the relative assessments of the stakeholders to maintain the current balanced return to those stakeholders.

- *The high lamb checkoff BCR is not indicative of the level of impact of the program on the U.S. and global sheep-lamb-wool supply chain.*
  The small amount of lamb checkoff funds expended in each year generated a positive but rather small lift for the industry. The small positive benefit divided by an even smaller checkoff expenditure resulted in some relatively large BCRs. With a low level of investment in lamb checkoff programs compared to the value of industry lamb sales, the overall impact of the program could hardly be expected to be significant in a practical sense in its effects on sheep and lamb production, prices, consumption, imports, and other market activities even though the impact could be said to be statistically significant.

- *The lamb checkoff BCRs for each stakeholder group measures the average returns to those stakeholders and <u>not</u> the return realized by individual stakeholders.*
  For example, not all sheep producers earned $13.84 or even $7.86 (discounted) for every dollar they have paid in assessments. Because the BCR is an average, some producers, some feeders, and some packers have realized higher returns while others have earned lower.

- *Care must be taken in communicating these results to stakeholders.*
  Past experience suggests that inevitably some stakeholders will ask something like this: "If the returns were $14.44 for every dollar invested in the lamb checkoff program, where are my $14.44 for every checkoff dollar I have been assessed?" The question conveys a common lack of understanding of not just the results of checkoff evaluation studies but how checkoff programs return value to them. The basic problem is that all stakeholders can easily identify the line on their balance sheets for the cost to them of the checkoff assessments. But there is no line on their balance sheets for what their contributions to the checkoff program have returned to them in additional revenues. Some part of each producer's revenue has come from the larger number of sheep and/or lamb they have been able to sell at a higher price as a direct result of the checkoff program. The problem is that they cannot tell how many more sheep or pounds of lamb they have been enabled to sell at how much of a higher price as a result of the checkoff program. That is what this study does – attempts to identify that part of stakeholders' revenue streams that are the result of the checkoff program rather than any other market event or force.

Table of Contents

Figures

Tables

RETURNS TO STAKEHOLDERS FROM THE AMERICAN LAMB CHECKOFF PROGRAM: A SUPPLY CHAIN ANALYSIS

The U.S. sheep industry is multifaceted, rooted in history and tradition, and one of the most complex industries in animal agriculture. Sheep provide lamb and mutton for consumption, wool and pelts for textiles, and milk by the dairy sheep industry. Despite the U.S. sheep industry's versatility, the dominant feature has been its steady decline since the mid-1940s. From a record high of 56.2 million head in 1942, inventories on January 1, 2014 slumped to 5.21 million head, the lowest level in recorded history (USDA 2014). The decline in U.S. sheep and lamb inventories has been a major cause of concern for sheep producers over the years. A confluence of various market factors, external forces, and government policies has been cited as the major cause of the industry's decline, including lower returns and higher risks relative to other livestock and crop enterprises, the discontinuation of the U.S. Wool Incentive payment program in the 1990s, a shift in consumer tastes and preferences toward other meats, and imports of lamb from Australia and New Zealand (Williams et al. 2008).

U.S. sheep producers have strived to revive their industry over the years through various means, including: (1) legal steps to remedy a perceived problem of oligopoly power by packers, breakers, and others in the marketing channel; (2) encouragement of producer cooperatives, and (3) promotion of the retail demand for lamb. The first two efforts have had little effect on trends in the industry. Industry efforts to enhance consumer demand for lamb, however, have met with some success over the years (see, for example, Williams, Capps, and, Dang, 2010). Demand-side efforts to deal with shrinking sheep and lamb markets began in the 1950s with a modest lamb promotion program operated by the American Lamb Council (ALC) of the American Sheep Industry Association, Inc. (ASIA) using funds made available under the Wool Incentive Program until the program and, hence, expenditures for lamb promotion were phased out in 1996/97. An unsuccessful effort was made that year to pass a mandatory checkoff program through a producer referendum. Six years later in 2002, a successful producer referendum allowed for the development of the Lamb Promotion, Research, and Information Order, better known as the American Lamb Checkoff Program, under the Commodity Promotion, Research and Information Act of 1996.

Like the advertising and promotion activities funded by most other U.S. commodity checkoff programs, lamb promotion efforts over the years have intended to enhance the profitability of the industry through retail-level promotion activities. Unlike those of most other commodity checkoff programs, however, the promotional activities of the American Lamb Board are dedicated to increasing not only the level of U.S. demand for lamb but also the U.S. industry's share of domestic consumption, an effort to "brand" the domestically produced product (lamb) in the face of rapidly growing imports from Australia and New Zealand. Retail promotion under

the current lamb checkoff program also differs from that of other checkoff programs in that producers are only one of several groups along the supply chain who are required to contribute to the funding of the program. Besides sheep producers, lamb feeders and lamb packers are also assessed checkoff fees under the current program. Producers are assessed a fee on each feeder lamb sold while feeders are assessed a fee on every slaughter sheep they sell to packers. In turn, packers are assessed a fee on each slaughter sheep they purchase. Lamb imports are not subject to the mandatory lamb checkoff.

Williams, Capps, and Dang (2010), the only previous published analysis of the effectiveness of the American Lamb Checkoff Program, focused on measuring just the retail-level revenue and returns generated by the checkoff promotion activities in their study. Their simple one-equation lamb demand model failed to account for potential price effects of the checkoff program, supply response by U.S. and foreign sheep, lamb, and wool producers and others along the global sheep-lamb-wool supply chain, the behavior of U.S. and foreign market agents at different points along the supply chain, or the free rider effects of lamb imports. Consequently, their study could not adequately consider the extent to which the retail-level benefits of lamb promotion have been transmitted up the domestic supply chain to U.S. industry stakeholders or the potential leakage of benefits along the global supply chain to foreign producers.

The primary goal of this study is to determine whether the retail-level lamb promotion efforts over the years have benefited industry stakeholders along the U.S. portion of the global sheep-lamb-wool supply chain. The study first considers whether the U.S. demand for lamb has increased as a result of lamb promotion efforts over the years, taking national and global price effects and U.S. and foreign supply response in account. The study also considers the effectiveness of the program in enhancing the demand for "American" as opposed to imported lamb. Finally, the study analyzes the U.S. and global market effects and U.S. sheep industry stakeholder returns from the lamb checkoff program in the context of the global sheep-lamb-wool supply chain within which it operates.

The analysis makes use of an extensive, 70-equation, non-spatial, price equilibrium, econometric simulation, global sheep-lamb-wool supply chain model referred to as LamMod. The analysis covers the period of 1987/88 through 2012/13 which allows for a comparison of returns to stakeholders under the current and previous lamb checkoff programs. LamMod includes econometric representations of the U.S., Australian, and New Zealand sheep, lamb, and wool industries and trade and includes endogenous variables representing supply, demand, prices, trade, and other market activities in all three countries and industries. After estimating the parameters, the model is simulated over the sample period as a means of model validation. LamMod is then used to simulate the impact of lamb promotion expenditures over the years on the global sheep-lamb-wool supply chain lamb and to calculate the returns to the U.S. sheep industry stakeholders who pay for the checkoff program.

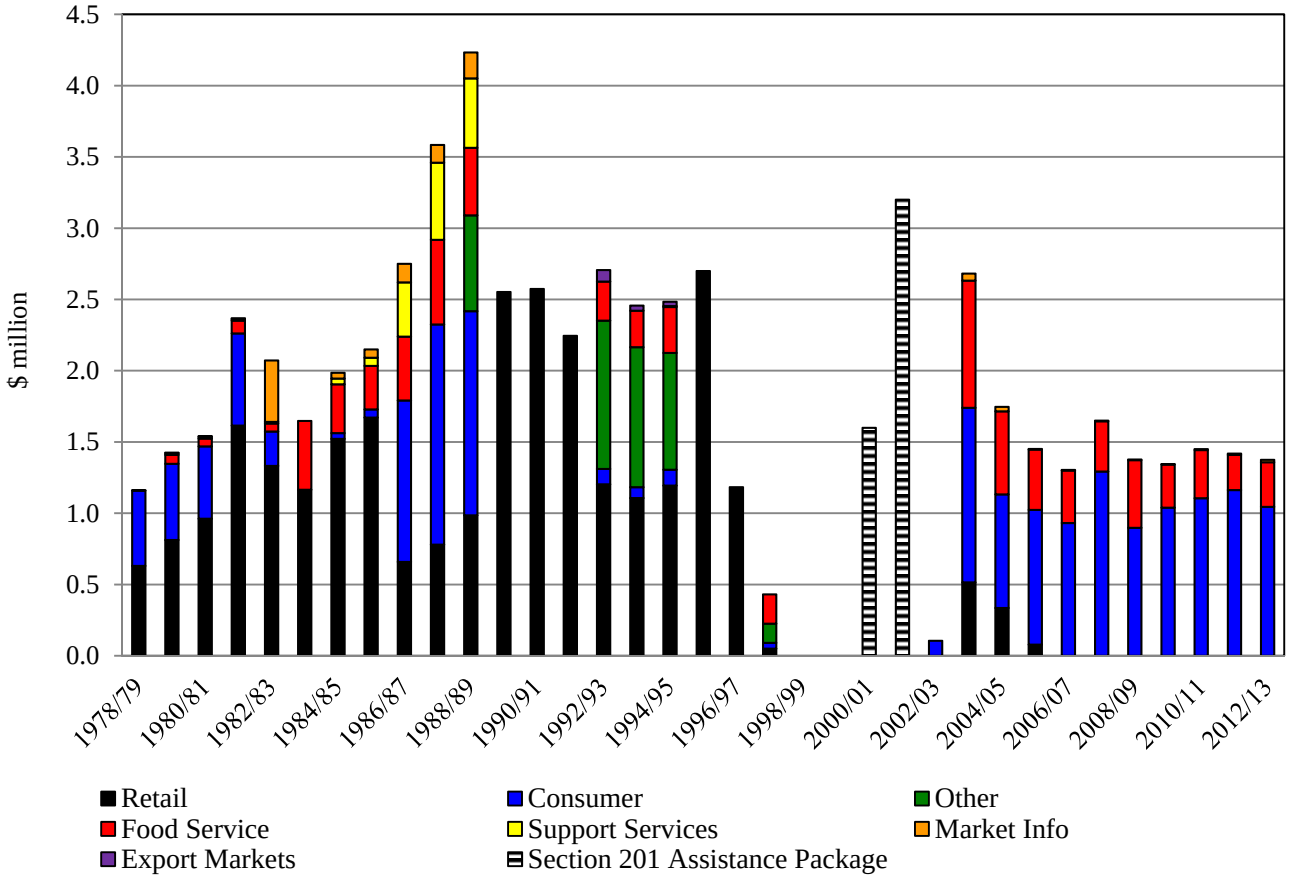
The report begins with some background on the U.S. lamb checkoff program. The structure of the global sheep-lamb-wool supply chain is then analyzed graphically and the expected effects of the lamb checkoff program are considered. The econometric model used in the analysis which replicates the graphical depiction of the global sheep-lamb-supply chain is then presented along with econometric results, related statistical measures, and model validation results. Finally, the results of simulating the econometric model to measure the effects of the lamb checkoff program on the global sheep-lamb-wool supply chain and the consequent measures of returns to the lamb checkoff program stakeholders are discussed. The report ends with concluding comments and implications for the management of the lamb checkoff program.

The American Lamb Checkoff Program

A U.S. lamb promotion program has been in place in most years since the late 1970s. Beginning in the about 1978/79, the American Sheep Producers Council, now known as the American Sheep Industry Association (ASIA), operated a lamb promotion program with voluntary deductions from government payments to lamb producers and feeders under the Wool Incentive Program. The deductions were authorized by a producer referendum under section 708 of the 1954 National Wool Act. The annual nominal expenditures on lamb promotion activities grew from $1.2 million in 1978/79 to a high of $3 million in 1993 before declining to $1.2 in 1996/97 as the phase-out of the Wool Incentive Program began to take effect (Figure 1). During those years, most of the funds dedicated to lamb promotion were allocated to promotional activities in four main areas: (1) retail marketing and promotion aimed primarily at the retail food store trade (theme promotions and contests, recipes, conventions, etc.); (2) consumer communications/relations including a wide variety of tasks and publicity efforts to promote directly to current and potential lamb consumers and users (newsletters, news releases, photography, and other media/promotional support, etc.); (3) food service promotion, including the development and placement of advertising with food service establishments, exhibits at culinary promotional events, etc.; and (4) support programs for buyers and merchandisers such as tours and staff training, technical and educational services, etc. (Capps and Williams 2011). During the 1990s, most of the available promotion funds were shifted to retail promotion activities with spending on little else except a few special projects in a few years (Figure 1).

With the termination of the Wool Incentive Program in 1996/97, an unsuccessful industry effort was made that year to pass a mandatory checkoff program through a producer referendum. At the about same time, the U.S. lamb industry filed a section 201 complaint against Australia and New Zealand lamb imports which resulted in the imposition of a three-year tariff-rate quota (TRQ) in 1999 on lamb imports from Australia and New Zealand. The inside tariff was set at 9% in the first year and reduced to 6% in the second year and 3% in the third year. Outside tariff rates were

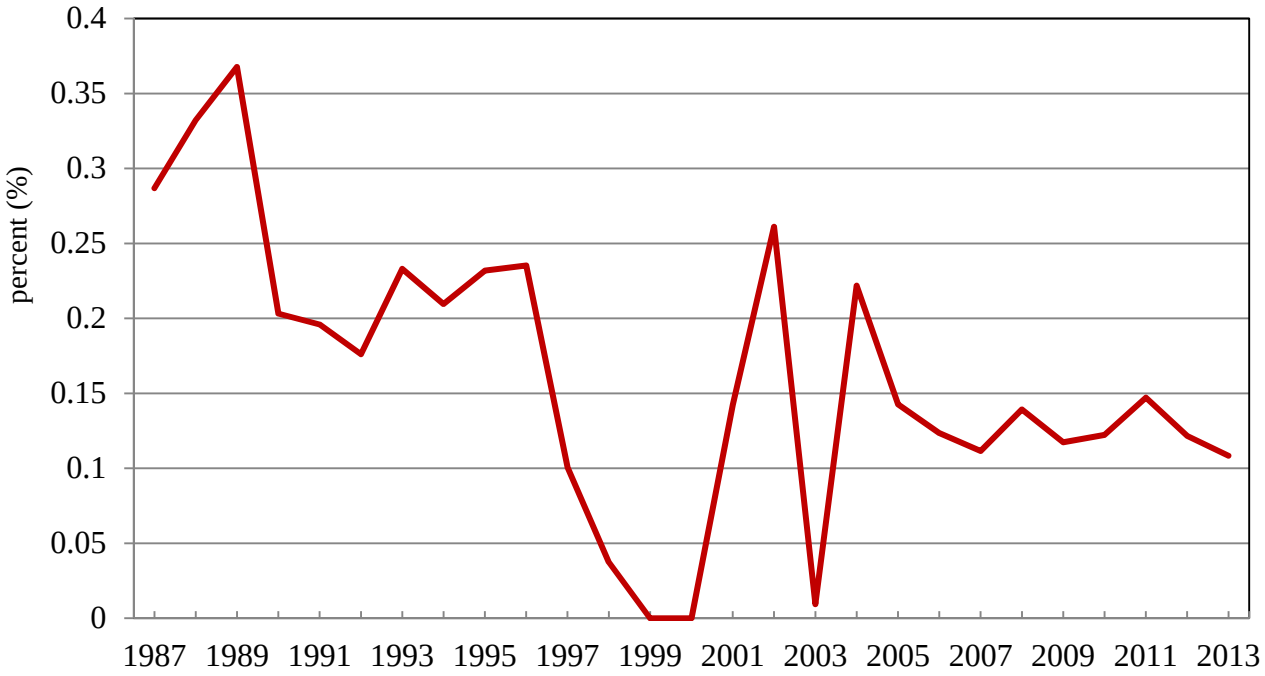
Figure 1: Lamb Promotion Expenditures by Category, 1978/79 – 2012/13



set at 40% in the first year declining to 32% in the second year, and 24% in the third year. The revenue collected from the tariff was given to the domestic lamb industry in an assistance package of $4.8 million which funded 23 lamb marketing and promotion projects in 2000/2001 and 2001/2002 (Figure 1). Most of the funds were allocated to ASIA for lamb identification and food service promotion and retail promotion. The rest of the funds were allocated to packers, breakers, and processors to promote lamb products to retailers and food service outlets.

The current lamb checkoff program was initiated in 2002 following another producer referendum. Since that time through 2012/13, the American Lamb Board (ALB), charged with the use and management of the lamb checkoff funds, has spent a total of just over $15.9 million on lamb advertising and promotion, about $1.45 million per year, lower than the $2 million to $3 million spent each year on lamb promotion during the 1990s by ASIA. The American Lamb Board is comprised of 13 individuals representing the U.S. lamb supply chain including producers, feeders, seed stock producers, and processors who are appointed to the Board by the U.S. Secretary of Agriculture. The work of the American Lamb Board is overseen by the U.S. Department of Agriculture. The Board's programs are supported and implemented by a small staff in Denver, Colorado.

Figure 2: Checkoff Investment Intensity Ratio, 1986/87 – 2012/13



The main objective of the current Lamb Checkoff Program is to increase demand for "American" lamb rather than lamb in general which includes imported lamb (American Lamb Board 2012). The program is funded by an assessment on all feeder and market lambs and all breeding stock and cull animals. In general, the purchaser collects the assessment with a deduction from the sales proceeds of the seller. The funds are then carried forward to the point of slaughter or export market and then collected and sent to the Board. Those who are assessed include producers (including seedstock producers), exporters, feeders and direct marketers, and slaughter plants (including ethnic and custom slaughter operations). The small number of imported sheep and lambs are also assessed on weight gain. U.S. lamb imports are not subject to the assessment. Since the beginning of the checkoff through May 2013, the assessment was $0.005 per pound of ovine animals (any age) sold by producers, exporters, and feeders and $0.30 per head of lambs purchased for slaughter by first handlers. Marketing agencies are not assessed a checkoff fee but they must collect assessments from the sellers and pass them on to the purchasers. Direct marketers who are both producers and first handlers were required to pay the $0.005 per pound assessment on the live weight at the time of slaughter and also the $0.30 per head assessment. In June 2013, the per pound assessment on live sheep and lambs sold increased to $0.007 while the per head assessment on lambs purchased for slaughter increased to $0.42.

Compared to the value of U.S. lamb consumed each year, the amount of funds that the lamb checkoff program collects and spends for the promotion of lamb is extremely small. The annual

lamb advertising-to-sales ratio (often referred to as the checkoff investment intensity ratio) over the 1987 to 2013 period ranged from a minimum of zero in 1999 and 2000 to a high of 0.37% in 1989, averaging 0.235% between 1987 and 1998 but only 0.140% since 2004 which was the first full year of operation of the current lamb checkoff program (Figure 2). The lamb advertising intensity has declined in recent years primarily because fewer promotion funds have been made available through the current program than what was formerly spent on lamb promotion by the ASIA under the Wool Incentive Program. Administrative costs are kept low so that most of the collected checkoff funds are used for promotional purposes.

Structure of the Global Sheep-Lamb-Wool Supply Chain and the Expected Effects of the American Lamb Checkoff Program

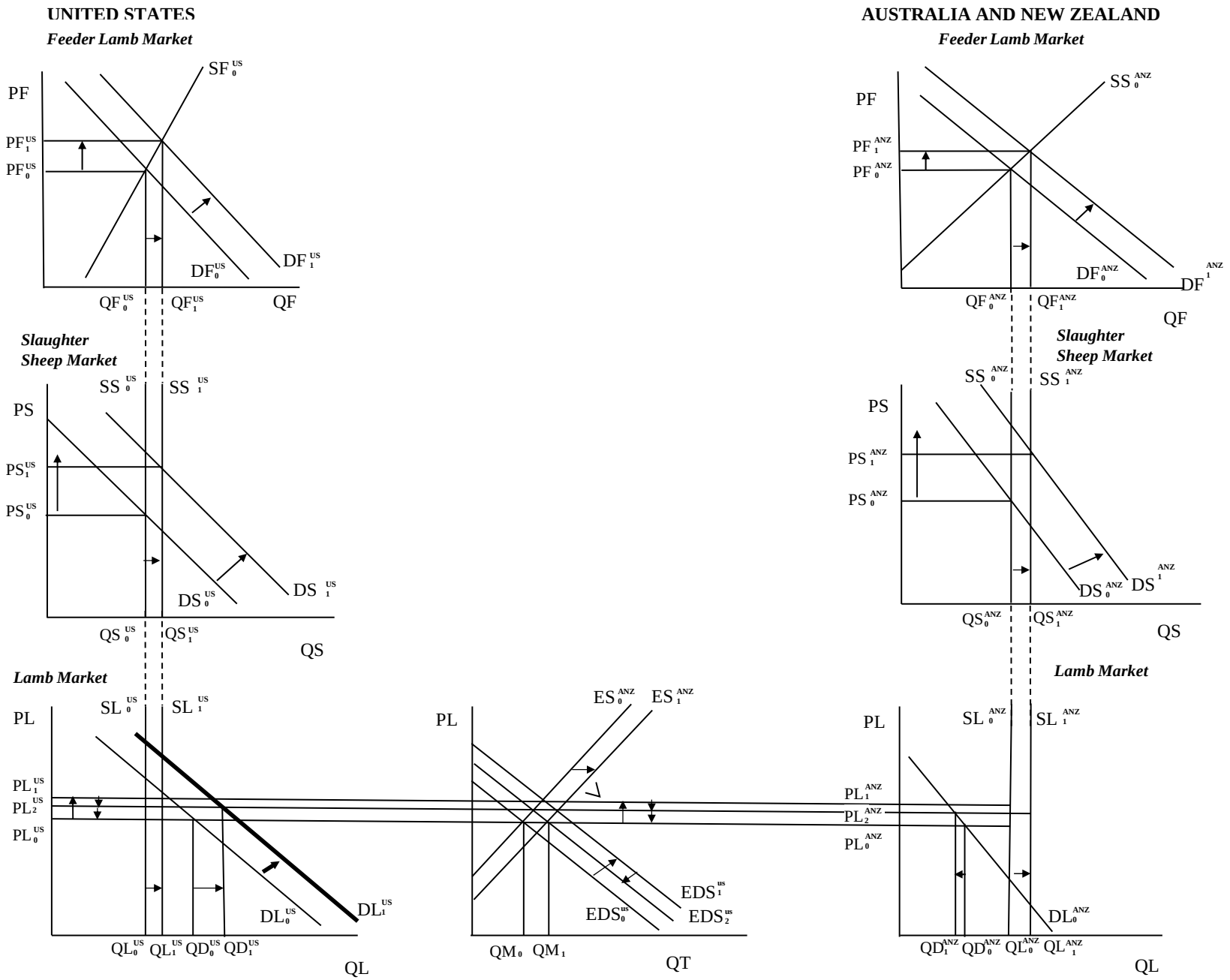
The graphical representation in Figure 3 is a simplification of global sheep and lamb markets. To keep the graphical analysis tractable for expositional purposes, the graphical representation of these markets focuses only on the key relationships in the supply chain. The econometric model used for the analysis provides a much more robust representation of world sheep, lamb, and wool markets. After using Figure 3 to describe the economic structure of the global sheep-lamb- wool supply chain, Figure 3 is then also used to explore the impacts of the lamb checkoff program on the supply chain and the transmission of benefits to U.S. stakeholders.

Economic Structure of the Global Sheep-Lamb-Wool Supply Chain

The left column of graphs in Figure 3 represents the U.S domestic sheep and lamb supply chain while the right column represents the supply chain in the rest of the world in which Australia and New Zealand are treated as one aggregate country (ANZ) for expositional purposes only. The econometric model used in the analysis later treats them as separate countries.

The middle column of Figure 3 has only one graph representing the world market for lamb which is the only point of global intersection between the U.S. sheep and lamb supply chain and those of Australia and New Zealand. In that graph, the intersection of the excess demand for lamb by the United States and the excess supply of lamb from Australia and New Zealand (represented jointly as ANZ in Figure 3) determine the equilibrium international prices of lamb and the trade quantity ($PL_0^{US} = PL_0^{ANZ}$ and QM_0, respectively). The top-left graph of Figure 3 represents the activities of U.S. sheep producers in supplying feeder lambs to the market represented by the feeder lamb supply curve (SF_0^{US}) and the demand for feeder lambs by feedlots and for direct sale (DF_0^{US}). The interaction of the supply and demand for feeder lambs determines the market price for feeder lambs (PF_0^{US}). The largest portion of feeder lambs enter feedlots and are transformed by feeding into slaughter lambs (represented by the dotted line between the two graphs in the top left of Figure 3).

Figure 3: Structure of the Global Sheep-Lamb Supply Chain and Expected Effects of U.S. Lamb Promotion



The supply of slaughter lambs is the number of lambs placed on feed (minus death loss) and is represented by a perfectly vertical supply curve (SS_0^{US}) in the middle-left graph of Figure 3. The vertical nature of the slaughter sheep supply curve in this figure is a graphical device to depict the fact that the quantity supplied of slaughter sheep can increase when the price of slaughter sheep increases only if: (1) feedlot operators first respond to the higher slaughter sheep price by demanding more feeder lambs from producers to be able to produce additional slaughter lambs (rightward shift of the demand for feeder lambs in the top-left graph of Figure 3) which drives up the price of feeder lambs and (2) producers then respond by retaining more ewes and supplying more feeder lambs to the market which takes time. Once more feeder lambs become available and are fed, the vertical slaughter sheep supply curve would then shift to the right. The intersection of the demand by lamb packers for slaughter sheep (DS_0^{US}) and the supply of slaughter sheep (SS_0^{US}) determines the market price for slaughter sheep (PS_0^{US}). Slaughter sheep are then transformed by packers into lamb (represented by the dotted line between the middle-left and bottom-left graphs in Figure 3).

The lamb supplied by packers, breakers, and others to the market is represented by the vertical lamb supply curve (SL_0^{US}) in the bottom-left graph of Figure 3. Again, the vertical nature of the lamb supply curve in the bottom-left graph of Figure 3 is a graphical device to depict the fact that packers can supply more lamb to the market in response to an increase in the price of lamb only if they first demand more slaughter sheep from feeders which drives up the slaughter price of sheep. Feeders, however, cannot supply additional slaughter sheep to packers without first feeding more lambs. Their demand for more feeder lambs from producers drives up the price of feeder lambs, sending a signal to producers to retain more ewes and produce more feeder lambs which takes time. Only when additional feeder lambs are available, fed, and then slaughtered, can packers supply more lamb to the market. The result would be a rightward shift in the vertical lamb supply curve in the bottom-left graph of Figure 3. Thus, in the domestic sheep and lamb supply chain, an increase in the demand for more lamb at the retail level requires that the resulting increase in the lamb price be transmitted along the supply chain all the way back to producers. Otherwise, retail price increases will have no effect on the domestic supply of lamb available in the market. In other words, the short-run supply curve for lamb is perfectly inelastic.

Note that in the domestic U.S. lamb market (bottom-left graph of Figure 3) the domestic demand for lamb (DL_0^{US}) is greater than the domestic quantity supplied at most prices resulting in a demand for foreign lamb represented by the excess demand for lamb (ED_0^{US}) in the middle-bottom graph of Figure 3. The interaction of the U.S. excess demand for lamb and the foreign supply of lamb represented by the excess supply of lamb from Australia and New Zealand (ES_0^{ANZ}) in the bottom-middle graph of Figure 3 determines the retail price of lamb (PL_0^{US}) in the U.S. market as shown in the bottom-left graph of Figure 3.

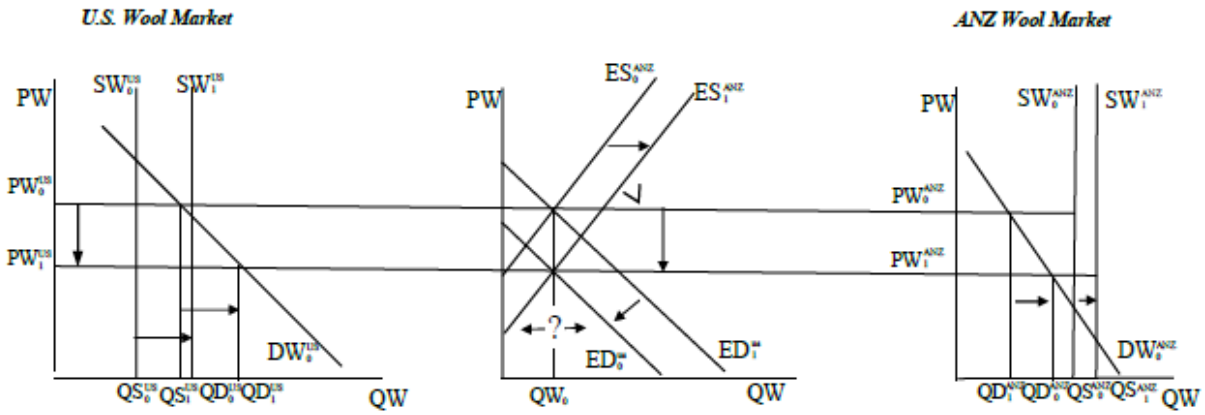
The sheep and lamb supply chains in Australia and New Zealand function in the same way. The main difference is that in those markets, more lamb is produced than can be consumed by their own consumers leading to an excess supply of lamb available for export represented by the upward sloping export supply curve ES_0^{ANZ} in the bottom-middle graph of Figure 3 which is the difference between the domestic Australia-New Zealand supply of lamb (SL_0^{ANZ}) and their domestic demand for lamb (DL_0^{ANZ}) at every price. The actual volume of lamb exported by Australia-New Zealand to the U.S. and imported by the U.S from Australia-New Zealand (QM_0) is determined by the interaction of the excess supply and excess demand for lamb in the world market as depicted in the bottom-middle graph of Figure 3.

Note that in Australia and New Zealand, as in the U.S., the supply of lamb is depicted as perfectly vertical (SL_0^{ANZ}) because the quantity supplied of lamb cannot change when retail price changes without an increase in lamb slaughtering. Additional lambs cannot be slaughtered, however, without an increase in the supply of fed lambs which cannot increase without an increase in feeder lambs. The quantity of feeder lambs, however, cannot increase without an increase in the lamb crop which takes time. Thus, for an increase in the retail price of lamb to increase the supply of lamb in Australia and New Zealand, just as in the U.S., the retail price increase must transmit all the way up the supply chain to producers who eventually can respond by producing more feeder lambs.

Figure 4 depicts the world wool market. The domestic U.S. demand for wool (left graph of Figure 4) is represented by DW_0^{US} which is greater than the domestic quantity supplied (SW_0^{US}) at most prices, resulting in a demand for foreign wool represented by the excess demand for wool (ED_0^{US}) in the middle graph of Figure 4. The main economic difference between the wool markets in the United States and in Australia and New Zealand is that in the latter countries more wool is produced than can be consumed by their own mills such that the supply of wool in those countries (SW_0^{ANZ}) is greater than the domestic demand for wool (DW_0^{ANZ}) at most prices in those countries (right graph of Figure 4). The difference between the supply and demand for wool in Australia and New Zealand is the Australia/New Zealand excess supply of wool (ES_0^{ANZ} in the middle graph of Figure 4).

The interaction of the U.S. excess demand for wool (ED_0^{US}) and excess supply of wool from Australia and New Zealand (ES_0^{ANZ}) in the middle graph of Figure 4 determines the price of wool in the U.S. (PW_0^{US}) and in Australia and New Zealand (PW_0^{ANZ}) and the volume of wool traded (Qw_0). The global wool market as depicted in Figure 4 links to the global sheep-lamb supply chain through the production of sheep and lambs. An increase in U.S. sheep and lamb inventories shifts the U.S. supply of wool (SW_0^{US}) to the right in Figure 4. An analogous rightward shift in the Australian/New Zealand wool supply (SW_0^{ANZ}) occurs when their sheep and lamb inventories increase as well.

Figure 4: Structure of Global Wool Markets and Effects of U.S. Lamb Promotion



The Expected Effects of Lamb Promotion on the Global Sheep-Lamb-Wool Supply Chain

Assuming that lamb promotion operates as intended, the programmatic activities of the American Lamb Board under the current lamb checkoff program (or those that were funded earlier through the Wool Incentive Program) can be represented as a rightward shift of the U.S. domestic demand for lamb (shown as a shift of DL_0^{US} to DL_1^{US} in the bottom-left graph of Figure 3). As a result, the U.S. excess demand for lamb shifts from ED_0^{US} to ED_1^{US} in the bottom-middle graph of Figure 3.

Initially, the U.S. price of lamb increases to PL_1^{US} sending the signal to U.S. packers to supply more lamb. As a result, the demand for slaughter lambs increases (DS_0^{US} to DS_1^{US} in the middle-left graph in Figure 3) which increases the price of slaughter sheep (PS_0^{US} to PS_1^{US} in that same graph of Figure 3). Feeders respond to the higher price of slaughter sheep by demanding more feeder lambs (a shift of the feeder lamb demand from DF_0^{US} to DF_1^{US} in the top-left graph in Figure 3). The consequence is an increase in the price of feeder lambs (PF_0^{US} to PF_1^{US} in the same top-left graph of Figure 3) and an increase in replacement ewes and in the subsequent lamb crop.

The eventual increase in feeder lambs (QF_0^{US} to QF_1^{US} in the top-left graph of Figure 3) allows an increase in supply of slaughter sheep (SS_0^{US} to SS_1^{US} in the middle-left graph of Figure 3) along with some downward adjustment in the slaughter price (PS_1^{US} to PS_2^{US} in that same middle-left graph of Figure 3) and eventually an increase in the supply of domestically produced lamb in the market (SL_0^{US} to SL_1^{US} in the bottom-left graph of Figure 3). The increase in the domestic supply of lamb shifts the U.S. excess demand for lamb back to the left to some extent (ED_1^{US} to ED_2^{US} in the bottom-middle graph of Figure 3) and softens the lamb price increase (decline in the price from PL_1^{US} to PL_2^{US} in the bottom row of graphs in Figure 3).

Just as the checkoff-induced increase in the price of lamb sets off a chain of events resulting in additional domestically produced lamb, that same price increase from the increased U.S. import demand for lamb sets off a similar chain of events in Australia and New Zealand resulting in additional production of lamb in those countries, making additional lamb available for export in an effort to benefit from the increased import demand for lamb by the United States. The result is a rightward shift in the excess supply of lamb from Australia and New Zealand (ES_0^{ANZ} to ES_1^{ANZ} in the bottom-middle graph of Figure 3), further expanding the inflow of lamb into the U.S. and further dampening the price of lamb (PL_2^{US} to PL_0^{US} in the bottom row of graphs in Figure 3).

The graphical analysis shows that a checkoff-induced increase in the U.S. demand for lamb will unambiguously increase U.S. imports of lamb (QM_0 to QM_1 in the middle-bottom graph of Figure 3). Whether or not the price of lamb will be higher as a result, however, is not clear and depends on the magnitude of the supply responses in both the U.S. and foreign countries to the checkoff-induced increase in the U.S. demand for lamb. In other words, the lamb checkoff could theoretically result in a higher, lower, or unchanged price of lamb in the U.S. and foreign markets. The middle-bottom graph in Figure 3 shows the case of no net effect on the price of lamb following the check-off induced increase in lamb demand as a result of the lamb supply response in both the U.S. and foreign markets. A smaller supply response would allow some net increase in the lamb price and a larger supply response would result in a net decline in the lamb price.

The checkoff-induced increase in the U.S. demand for lamb meat which increases the number of sheep produced leads not only to an increase in the U.S. production of meat as depicted in Figure 3 but also to an increased supply of wool shown in the left-hand graph of Figure 4 as a rightward shift of wool supply from SW_0^{us} to SW_1^{us}. The consequence is a leftward shift of the U.S. excess demand for wool from ED_0^{us} to ED_1^{us} in the middle graph of Figure 4.

As shown in Figure 3, the U.S. lamb promotion program has a tendency to increase the number of sheep produced in both Australia and New Zealand as well as in the United States leading to additional lamb meat production and, consequently, additional wool production by those two countries. The additional wool produced in those countries as a result of the lamb checkoff program is shown in Figure 4 as a rightward shift in their domestic wool supply curve from SW_0^{ANZ} to SW_1^{ANZ} in the right-hand graph in that figure. As a consequence, the excess supply of wool from those two countries shifts to the right from ES_0^{ANZ} to ES_1^{ANZ} in the middle graph of Figure 4. As a result, the price of wool in all markets unambiguously declines. The decline in the price of wool will have a moderating effect on the increase in sheep and lamb production as a result of the increase in demand for lamb from the checkoff promotion.

The impact of the checkoff promotion on world wool trade, however, is ambiguous and depends on not only the elasticities of the supply and demand for wool in all countries but also the elasticity of sheep production in all countries to changes in sheep and wool prices. Thus, if the excess supply of wool from Australia and New Zealand increases by more than the U.S. excess demand for wool declines, then wool trade will increase. Conversely, if the excess supply of wool from Australia and New Zealand increases by less than the U.S. excess demand for wool declines, then wool trade will decrease. Figure 4 shows the case of no change in wool trade as a result of the U.S. lamb checkoff program.

Methodology

The preceding graphical analysis provides an explanation of the potential effects of the lamb checkoff program on the domestic and foreign markets for lamb and wool. Although helpful for analyzing the expected direction of the effects of the checkoff-financed promotion and advertising in both the domestic and foreign markets, the graphical representation cannot capture the likely magnitude of the effects. A more in-depth analysis of the effects of a checkoff-induced increase in the U.S. demand for lamb and a check of the hypotheses of the direction of the effects presented in Figures 3 and 4 require a quantitative analysis of the checkoff program. To that end, a 70-equation, non-spatial, price equilibrium, simultaneous econometric model of the global sheep-lamb-wool supply chain was developed. The model, referred to as LamMod, essentially replicates the structure of the global sheep-lamb-wool supply chain as illustrated in Figures 3 and 4 with more detail on sheep production.

LamMod includes five groups of simultaneously linked mathematical equations: (1) the domestic U.S., Australia, and New Zealand live sheep supplies and demands (from breeding inventories through slaughter in each country); (2) the domestic U.S., Australia, and New Zealand production and consumer demand for lamb; (3) world lamb trade and price linkages; (4) domestic wool supplies and demands in the U.S., Australia, New Zealand, Argentina, and Uruguay; and (5) world wool trade and price linkages. LamMod is structurally similar to the models used by Williams, Shumway, and Love (2002) and Williams and Capps (2009) to analyze the U.S. soybean checkoff program, Davis et al. (2001) to analyze the pork checkoff program, Capps and Williams (2011) to analyze the cotton checkoff program, and Williams, Capps, and Bessler (2004) to analyze the effects of the Florida orange juice checkoff program.

After estimating the model parameters, the model was simulated over the sample period (1987 through 2013) as a means of model validation. Then the validated LamMod was used to simulate the values of the various endogenous variables in the model, such as sheep, lamb, and wool production, consumption, trade, and prices, over the sample data period. The results of this simulation are referred to as the "*with expenditures*" scenario or the baseline scenario because the simulation assumes that the checkoff expenditures to enhance U.S. lamb demand were made

as actually occurred over time. The second step was to set lamb checkoff expenditures in LamMod to zero in every year and then simulate the model over time again to see how the endogenous variables in the model change as a result of the removal of the checkoff expenditures. The results of this simulation are referred to as the "*without expenditures"* scenario because the simulation assumes that the checkoff expenditures to enhance U.S. lamb demand were not made as actually occurred over time. In other words, this simulation assumed that the lamb checkoff program did not exist over the sample period (1987-2013). The differences between the simulated values of the corresponding endogenous variables in the two simulations provide a measure of the change not only in U.S. lamb demand but also in all other model variables that have occurred over time as a direct result of the lamb checkoff program.

In effect, the simulation analysis allows a measurement of the extent of the impact of the checkoff program on U.S. lamb demand, imports, and other activities along the global sheep-lamb-wool supply chain. However, a critical question to be answered to determine the successfulness of the lamb checkoff program is whether any gains in profits realized by industry stakeholders as a result of the program have been sufficient to more than pay for their costs in financing the program. That is, has the program run at a loss or a profit over time from the perspective of those who have paid for the program? Have the market effects induced by the checkoff program been substantial enough to generate sufficient additional profits to stakeholders over time to more than cover their cost in financing the checkoff program? If not, then the conclusion would be that the program should be discontinued because the program costs stakeholders more than it returns to them. On the other hand, if the profits generated more than cover the costs, the program would be deemed a successful investment opportunity for stakeholders in the sheep and lamb industry.

To determine the profitability or return from the lamb checkoff program to the program stakeholders (producers, feeders, and packers), the results of the two simulation scenarios are used to calculate benefit-cost ratios (BCRs) to the U.S. sheep and lamb industry as a whole and to each program stakeholder group. The BCRs are calculated as the increase in revenues accruing to the U.S. sheep and lamb industry (net of additional costs of production) per dollar of expenditure as well as to each stakeholder group per dollar of expenditure attributable to the corresponding stakeholder group.

Model Parameter Estimation, Validation, and Data

The parameters of the LamMod are estimated using the Ordinary Least Squares estimator with annual data for 1987 through 2013. Two- or Three-Stage Least Squares estimators are sometimes used to estimate the parameters of simultaneous equations models. In this case, however, the large number of equations in the model and the availability of limited data points resulted in a greater number of predetermined variables than the number of observations. Also, the

consistency and efficiency gained in parameter estimation with the use of such system estimators are large sample properties. Consequently, OLS was the estimator of choice. The SAS statistical software was used for this analysis. The signs of all parameter estimates of the model are consistent with expectations and conform to economic theory. Also, all Durbin Watson (DW) and Durbin-h statistics indicate the absence of autocorrelation in all behavioral equations. The adjusted R^2 for the estimated model equations suggest that most equations provide an excellent fit of the associated data. The parameter estimates and regression statistics for all LamMod equations, along with a detailed discussion of the full model parameter estimation, are available from the authors upon request.

Key LamMod Equations

A key equation in LamMod is the U.S. per capita demand for lamb. In this equation, following Williams, Capps and Dang (2010), per capita lamb demand is specified to be a function of the real retail price of lamb meat, the real retail price of beef, the retail price of pork, real per capita income, and a lamb checkoff expenditure stock variable. To account for the time lag in the impact of checkoff expenditures on the demand, researchers have used a variety of lag processes. Previous research has long established that advertising has carryover or lagged effects (e.g., Nerlove and Waugh 1961; Waugh 1959; Ward and Lambert 1993; Ward and Dixon 1989; Wohlgenant and Clary 1992). However, neither theory nor previous research provides much guidance as to the appropriate structure and length of the dynamic processes involved. Conventionally, researchers have allowed the data to choose the optimal number of lags to include in the specification of a particular advertising stock variable through the use of statistical criteria like the Akaike Information Criterion (AIC), the Schwarz Information Criterion (SIC), or the Hannan-Quinn Criterion (HQC). The coefficients associated with the contemporaneous and lagged advertising expenditures also are commonly assumed to be a free-form lag or to follow some type of distribution, e.g., a geometric or trapezoidal decay or a polynomial (or Almon) distributed lag. Piggott et al. (1996) considered the advertising process to follow a free-form lag of four quarters. Cox (1992), as well as Brester and Schroeder (1995), used a second-order exponential lag distribution while Baye, Jansen, and Lee (1992) employed a geometric lag. Williams, Shumway, and Love (2002) employed a polynomial inverse lag. Kaiser (2006) in investigating the demand for eggs, Williams, Capps, and Dang (2010) in investigating the demand for lamb, Williams and Capps (2011) in investigating the demand for cotton, and Capps et al. (2013) in investigating the demand for fluid milk, cheese, and butter, used polynomial distributed lags with endpoint restrictions.

To characterize the carryover effects of lamb checkoff advertising on lamb demand in this analysis, the Almon polynomial distributed lag (PDL) with head and tail restrictions was used following Williams Capps, and Dang (2010). The search for the degree of polynomial and the lag length in the PDL process involved a series of nested OLS regressions. Ultimately, a one

degree polynomial with lag length two and endpoint restrictions was selected based on the Akaike Information Criteria (AIC) and Schwarz Information Criteria (SIC). To account for inflation, diminishing marginal returns, and zero expenditures in some years, a square root transformation of the inflation-adjusted expenditure variable was used as the lamb checkoff expenditure stock variable in the demand model, again following Capps, Williams, and Dang (2010).

The real retail prices of lamb, beef, pork, and chicken were all originally included as regressors in the U.S. lamb demand equation. All except the price of chicken were found to be statistically significant with the expected signs. The estimated own-price elasticity of lamb demand was found to be -0.62 while the cross price elasticities of beef and pork were estimated to be somewhat lower at 0.46 and 0.47, respectively (Table 1). These demand elasticities indicate the percentage change in lamb demand from a one percent change in the prices of lamb, beef, and pork. Thus, the results indicate that a 10% increase in the price of lamb reduces the demand for lamb by 6.2% whereas a 10% increase in the prices of beef and pork increase the demand for lamb by 4.6% and 4.7%, respectively. The estimated own-price elasticities of per capita lamb demand across most recent studies are similar, ranging from -0.4 to -0.7 except for Schroeder et al. (2001) who report a relatively (and implausibly) high price elasticity of -1.1 (Williams, Capps, and Dang, 2010). By way of comparison, the own-price elasticities of lamb demand in Australia and New Zealand were estimated in this study to be somewhat higher at -0.89 and -0.79, respectively (Table 1).

Previous estimates of the beef cross-price elasticities of lamb demand have ranged from about 0.50 to 0.60 (see Williams, Capps and Dang 2010). Schroeder et al. (2001) found pork price to be marginally statistically different from zero with an elasticity of 0.17. Byrne, Capps, and Williams (1993) found similar results indicating pork to be a weak substitute for lamb. Williams, Capps, and Dang (2010) found statistically significant cross-price elasticities between lamb and beef (0.63) and lamb and pork (0.34). At the same time, RTI (2007) and Williams, Capps, and Dang (2010) concluded that lamb and chicken are independent commodities in consumption.

The results for the income elasticity of lamb demand are mixed. Both Purcell (1989) and Schroeder (2001) found an inverse relationship between income and lamb consumption. Byrne (1993) and Williams, Capps, and Dang (2010), however, found the income coefficient to have a positive sign but to be statistically insignificant. In this study, the estimated coefficient of the per capita income variable had a positive sign although the p-value was a little high indicating that income is not a highly significant driver of per capita lamb consumption.

Table 1: Estimated LamMod Lamb Demand Elasticities

	Own-price	Cross-price			Income	Checkoff expenditures
		Beef	Pork	Chicken		
U.S	-0.62**	0.46**	0.47***	-	0.25*	0.037*
Australia	-0.89***	0.40***	-	0.43**	0.62***	
New Zealand	-0.79[c]	0.47***	-	-	0.80***	

* fifteen percent significance level
** ten percent significance level
*** one percent significance level
c = constrained

The estimated long-run lamb promotion expenditure elasticity was 0.037 which is consistent with Williams, Capps, and Dang (2020) and in the range of those estimated for other checkoff commodities (Williams and Nichols 1998). The adjusted R^2 and the Durbin Watson statistic indicate a good fit of the data and the absence of autocorrelation. The expenditure elasticity p value can be said to be significant even at the fifteen percent (15%) level because of the low number of observations for expenditures in the dataset and the use of polynomial distributed lags which further reduced the degrees of freedom. Also, the significance test is a one-tailed test implying significance of the expenditure coefficient at the 10% level in a two-tailed test.

The estimated price elasticities of other key equations in LamMod are provided in Table 2. Some of the major implications regarding the global sheep-lamb-wool supply chain flowing from these estimated price elasticities include the following:

- The short-run elasticity of the U.S. sheep breeding (mature ewe) inventory with respect to the live sheep price was estimated to be quite low (0.11) but more than double that of Australia (0.05) and New Zealand (0.03) and more than 5 times that of Argentina (0.02) and Uruguay (0.02). Over the long run, U.S. sheep inventories are highly responsive to the live sheep price with a price elasticity of 1.37 compared to 0.11 in both Australia and New Zealand;
- The wool price elasticity of the U.S. sheep breeding (mature ewe) inventory is also low (0.01) but comparable to that of Australia (0.03) but much lower than that of New Zealand (0.14);
- The elasticity of U.S. sheep slaughter demand to the price of live (slaughter) sheep (-0.20) and to the retail price of lamb (0.77) were highly similar to those same slaughter demand price elasticities in both Australia (-0.2 and 0.68) and New Zealand (-0.18 and 0.56); and
- The estimated own-price elasticity of the U.S. mill demand for wool is quite low (-0.02) compared to those estimated for in Australia (-0.55) and New Zealand (-0.60).

Table 2: Estimated Price Elasticities in U.S., Australia, and New Zealand Sheep Markets

	Short-run Price Elasticities				Long-run Price Elasticities			
Equations	**Farm Price**	**Slaughter Price**	**Wool Mill Price**	**Lamb Retail Price**	**Farm Price**	**Slaughter Price**	**Wool Mill Price**	**Lamb Retail Price**
U.S.								
Mature ewe inventories	0.11*				1.37*		0.01	
Replacement inventories				0.89***				
Lamb crop inventories		0.15						
Feeder demand	-0.15*	0.15*			-0.65*	0.65*		
Slaughter demand		-0.2**		0.77***		-0.36**		1.42***
Australia								
Breeding ewe inventories	0.05*		0.03		0.11*		0.06	
Other sheep inventories	0.04*		0.05		0.09*		0.11	
Slaughter demand	-0.2***			0.68***	-0.49***			1.65***
New Zealand								
Breeding ewe inventories	0.03**		0.14		0.11**		0.52	
Other sheep inventories	0.04		0.17		0.09		0.31	
Slaughter demand	-0.18***			0.56***	-0.23***			0.72***
Argentina								
Total Sheep Inventories			0.03**				0.06**	
Uruguay								
Total Sheep Inventories			0.04**				0.33**	

* fifteen percent significance level
** ten percent significance level
*** one percent significance level
c = constrained

Model Validation

Validation of the structural model involved a check of the dynamic, within-sample (ex-post) simulation statistics for the fully simultaneous structural model. Dynamic simulation statistics (e.g., the root mean squared error, Theil inequality coefficients, and the Theil error decomposition proportions) were calculated from simulating the full model over the 1987 to 2013 sample period. Taken together, the simulation validation statistics suggested that the ability of the LamMod to replicate the observed values of the endogenous variables over time is highly satisfactory. As a consequence, the model can be used with a high degree of confidence for simulation analyses, such as the effects of a change in the level of lamb checkoff funding on the global sheep-lamb-wool supply chain.

Data

Two general types of data were required for this analysis: (1) data for sheep, lamb, and wool supplies, demand, trade, prices, etc. to support the estimation of the parameters of the equations in LamMod and (2) the promotion expenditures of the American Lamb Board over time. The first set of data is available from numerous public sources. The main U.S. data sources for sheep and lamb are databases of various USDA agencies, including the National Agricultural Statistics Service (USDA 2014a and 2014d), the Economic Research Service (USDA 2014b), and the Grains Inspection Packers and Stockyards Administration (USDA 2014c). The main source of data for U.S. wool market prices and quantities is the Cotton and Wool Yearbook of the Economic Research Service (USDA 2013).

Data for Australia and New Zealand were taken from databases available from their respective statistical services. Australian data for slaughter sheep numbers, lamb meat production, and lamb meat consumption were collected from the Australian Bureau of Statistics (ABS 2013) and the Australian retail prices of meat products from the Australian Department of Agriculture, Fisheries, and Forestry year book publication (DAFF 2013). New Zealand data for breeding ewes, sheep slaughtered, and lamb meat production data were taken from Statistics New Zealand (2013). Due to the lack of data for domestic prices in New Zealand, the per unit export prices of lamb and substitute meats are used as price proxies in the model.

The total stock of live sheep, per unit export prices, total sheep exported and total sheep imported for consumption of both meat and wool for Australia, New Zealand, Argentina and Uruguay were collected from FAOSTAT (FAO 2014). Many exogenous variables like gross domestic product, exchange rates, price indices (such as producer price indices and consumer price indices) were taken from the International Financial Statistics (IFS) of the International Monetary Fund (IMF 2014).

Global Sheep-Lamb-Wool Supply Chain Simulation Analysis of the Lamb Checkoff Program

Using the econometric model developed for this study (LamMod), a simulation analysis was conducted to answer three related questions: (1) What have been the effects of the American lamb checkoff program on the global sheep-lamb-wool supply chain? (2) Has the checkoff program effectively increased the consumption of “American” lamb as opposed to imported lamb? (3) What have been the returns to U.S. sheep and lamb industry stakeholders from their investment in the checkoff program?

What Have Been the Effects of the American Lamb Checkoff Program on the Global Sheep-Lamb-Wool Supply Chain?

To answer this first question, two scenarios were simulated with LamMod and the results compared. In the first scenario simulation, the lamb checkoff program is assumed to have operated over time exactly as has been the case over the 1987 to 2013 sample period. This scenario is referred to as the baseline or the "with checkoff expenditures" scenario. In the second scenario simulation, the lamb checkoff program is assumed to have never existed. In this scenario, the level of lamb checkoff expenditures in the model were set to zero in each year from 1987 through 2013 and LamMod was again simulated over the sample period to generate changes in the levels of U.S. and world sheep, lamb, and wool production, consumption, trade, and prices that would have existed over time in the absence of any checkoff expenditures. This scenario is referred to as the "without checkoff expenditures" scenario. Because no exogenous variable in LamMod other than lamb checkoff promotion expenditures was allowed to change as the two simulation scenarios were conducted, this process effectively isolates the impacts of lamb promotion expenditures on the many endogenous variables in the model. Consequently, the simulated differences between the values of the endogenous variables in the baseline scenario ("with checkoff" expenditures) and in the zero checkoff expenditure scenario ("without checkoff" expenditures) provide direct measures of the historical effects of the lamb checkoff program on the U.S. and world sheep, lamb, and wool markets.

A comparison of the changes in the endogenous variables in LamMod under the *with checkoff expenditures* and *without checkoff expenditures* scenarios indicates clearly that the lamb checkoff program has been effective in increasing the U.S. supply of live sheep, the U.S. lamb crop, the number of U.S. feeder lambs and slaughter sheep, U.S. lamb production, U.S. lamb consumption, and U.S. sheep and lamb prices over what would have been the case in the absence of the program. For example, the lamb checkoff program provides a 2.1% "lift" to U.S. breeding sheep inventories over the 1987-2013 period (Table 3). The "lift" is the average annual increase in some variable like production, demand, trade, or prices over the period of analysis (1987-2013). Thus, the 2.1% "lift" in U.S. breeding inventories achieved as a result of the checkoff program means that U.S. sheep breeding inventories averaged about 2.1% higher annually over the 1987-2013 period (about 125,707 head) as a result of the checkoff program than they would have without the checkoff program. The U.S. lamb crop lift from the checkoff program over that same period was 3.7%, U.S. lambs on feed 2.9%, U.S. lambs slaughtered 4.5%, U.S. lamb production 4.7%, U.S. lamb imports 1.2%, U.S. lamb consumption 3.6%, the producer price of live sheep 3.2%, and the retail price of lamb 0.9%.

Through its effect on U.S. lamb and wool prices and imports, the lamb checkoff program also impacted the sheep industries of Australia and New Zealand. The U.S. lamb import lift of 1.2% about 1.38 million pounds) and the U.S. lamb retail price lift of about 1% (about $0.40/lb) from

Table 3: U.S. Sheep and Lamb Market Lift from the Lamb Checkoff Program, 1987-2013

	1987-2002		2003-2013		1987-2013	
Average Annual Change in:	**head**	**%**	**head**	**%**	**head**	**%**
Breeding Sheep Inventories	120,571	1.7	133,357	3.2	**125,707**	**2.1**
Mature Ewe Inventories	61,020	1.1	82,674	2.4	**69,335**	**1.8**
Replacement Ewe Numbers	27,684	2.5	29,368	4.3	**28,704**	**3.4**
Feeder Lamb Numbers	44,946	2.8	52,789	3.0	**49,773**	**2.9**
Lamb Crop	160,265	3.0	182,945	4.4	**170,142**	**3.7**
Sheep/Lamb Slaughter	203,555	4.0	209,591	5.0	**205,926**	**4.5**
Average Annual Change in:	**mil.lbs**	%	**mil.lbs**	%	**mil.lbs**	%
Lamb Production	10.1	4.1	10.9	5.4	**10.4**	**4.7**
Lamb Consumption	11.5	3.5	11.9	3.7	**11.5**	**3.6**
Lamb Imports	1.39	1.8	1.37	0.8	**1.38**	**1.2**
Wool Production	0.93	1.7	1.01	3.1	**0.96**	**2.1**
Wool Consumption	1.25	0.01	1.29	0.01	**1.27**	**0.01**
Wool Imports	0.32	0.08	0.28	0.05	**0.3**	**0.06**
Average Annual Change in:	**lb/person**	%	**lb/person**	%	**lb/person**	%
Lamb Per Capita Consumption	0.38	3.4	0.4	3.6	**0.39**	**3.5**
Prices	**$/unit**	%	**$/unit**	%	**$/unit**	%
Live Sheep ($/head)	2.65	3.2	4.10	3.3	**3.30**	**3.2**
Lamb Meat ($/lb)	0.05	1.0	0.03	0.9	**0.4**	**0.9**

the U.S. lamb checkoff program induced larger sheep and lamb meat production and higher sheep and lamb prices in both Australia and New Zealand as well as lower lamb consumption in both countries from the higher prices (Table 4). The checkoff program lift for the Australian and New Zealand sheep and wool industries, however, is quite small compared to the lift in the U.S.

because the absolute changes generated by the U.S. checkoff program are small and the size of Australia's and New Zealand's industries are so much larger than that of the United States. The results demonstrate that the U.S. lamb checkoff program provides positive (but small) benefits to the Australian and New Zealand sheep industries in terms of larger live sheep inventories, slaughter, lamb exports, and sheep and lamb prices. The higher U.S. demand for lamb imports from Australia and New Zealand as a result of the U.S. lamb checkoff program stimulated an increase in sheep slaughter in each country of 11,984 head (0.04%) and 22,000 head (0.07%), respectively, on average in each year over the 1987-2013 period of analysis.

The consequent lamb production lift in Australia and New Zealand from the U.S. lamb checkoff program was 249 metric tons (mt) (0.04%) and 260 mt (0.07%), respectively, over the same period. The lift in the Australian slaughter demand led to a lift in Australian breeding sheep inventories and lamb crop of about 12,132 head (0.03%) and 17,897 head (0.02%), respectively. In New Zealand, the lamb checkoff program lift in sheep inventories and the lamb crop was 16,895 head (0.06%) and 19,460 head (0.06%), respectively. The higher demand for lamb for export to the U.S. also raised the Australian and New Zealand prices of live sheep by 0.25 Australian dollars/mt (2.7%) and 0.15 New Zealand dollars/mt (3.2%), respectively.

Table 3 and 4 also decompose the lift of the lamb checkoff program into two time periods: (1) 1987-2002 prior to the implementation of the current lamb checkoff program and (2) 2003-2013 since the current program was initiated. The results indicate that the current lamb checkoff program has had a somewhat more positive effect each year on U.S. sheep inventories and slaughter, lamb production and consumption, and wool production and consumption as well as on the live sheep and lamb prices than was the case for the checkoff program in previous years. The import-increasing effect of the current checkoff program was somewhat smaller, however, than during the earlier period when lamb promotion was funded from the Wool Incentive Program. Williams, Capps and Dang (2010) also found that the current checkoff program has had a somewhat larger effect on lamb consumption than was the case for the lamb promotion program in preceding years.

Has the Lamb Checkoff Program Effectively Increased the Consumption of "American" Lamb as Opposed to Imported Lamb?

A primary goal of the current lamb checkoff program is to increase the demand for "American" lamb rather than imported lamb. Over the last decade, the share of U.S. lamb demand accounted for by imports has increased dramatically, reaching to more than 50% of total U.S. lamb demand.

Table 4: World Sheep and Lamb Market Lift from the Lamb Checkoff Program, 1987-2013

	1987-2002		2003-2013		1987-2013	
Annual Average Change in:	**head**	**%**	**head**	**%**	**head**	**%**
Australia Breeding Sheep	11,009	0.02	13,967	0.04	**12,132**	**0.03**
New Zealand Breeding Sheep	16,553	0.05	17,292	0.07	**16,895**	**0.06**
Australia Lamb Crop	17,369	0.02	18,769	0.03	**17,897**	**0.02**
New Zealand Lamb Crop	18,714	0.05	20,670	0.07	**19,460**	**0.06**
Australian Slaughter	11,467	0.03	12,009	0.05	**11,984**	**0.04**
New Zealand Slaughter	20,918	0.06	23,642	0.08	**22,000**	**0.07**
Annual Average Change in:	**metric tons**	**%**	**metric tons**	**%**	**metric tons**	**%**
Australia Lamb Production	247	0.04	251	0.05	**249**	**0.04**
New Zealand Lamb Production	257	0.06	267	0.07	**260**	**0.07**
Australia Lamb Consumption	-73	-0.02	-67	-0.02	**-71**	**-0.02**
New Zealand Lamb Consumption	-106	0.0	-77	-0.04	**-93**	**-0.05**
Prices	**Local Currency /mt**	**%**	**Local Currency/mt**	**%**	**Local Currency /mt**	**%**
Australia Sheep Price	0.26	2.9	0.24	2.6	**0.25**	**2.7**
New Zealand Sheep Price	0.02	2.7	0.01	1.7	**0.15**	**3.2**
U.S. Lamb Import Price ($/mt)	0.28	2.4	0.26	2.3	**0.27**	**2.3**
Trade	**metric tons**	**%**	**metric tons**	**%**	**metric tons**	**%**
Australia Lamb Exports	320	1.0	318	1.0	**319**	**1.0**
New Zealand Lamb Exports	363	1.0	344	0.9	**355**	**0.9**
U.S. Lamb Imports	630	1.8	623	0.8	**627**	**1.2**

In managing the checkoff program, the strategy of the American Lamb Board has been to "brand" U.S.-produced lamb as made in America and differentiate it from imported lamb as a higher quality and value product. Consequently, another means of measuring the success of the current lamb checkoff program is to determine how the import share of domestic lamb demand has changed as a result of the program.

An examination of Table 3 reveals that the current lamb checkoff program has generated a positive lift for both domestic lamb consumption (domestic and imported) and lamb imports. However, the lift (i.e, the average annual increase) in imports over the 2002-2013 period has been much smaller (1.38 million lb) than for domestic lamb consumption (11.5 million lb). Consequently, the checkoff program has successfully reduced the lamb import share of domestic lamb, a result consistent with the findings of Williams, Capps and Dang (2010). In other words, for every pound of imported lamb that the checkoff program has added to U.S. lamb consumption each year, the program has added 7.3 lb of domestically produced lamb to domestic consumption. Clearly on this measure of success, the lamb checkoff program has been effective.

What Have Been the Returns to U.S. Sheep and Lamb Industry Stakeholders from their Investment in the U.S. Lamb Checkoff Program?

The preceding simulation analysis clearly demonstrates that the U.S. lamb checkoff program has had a significant and positive effect on the U.S. sheep, lamb, and wool industries. The more critical question that must be answered about the U.S. lamb checkoff program, however, is whether any gains in profit realized by industry stakeholders as a result of the program have been sufficient to more than pay for their costs in financing the program. That is, has the program run at a loss or a profit over time from the perspective of those who have paid for the program? Have the market effects induced by the checkoff program been substantial enough to generate sufficient additional profits to stakeholders over time to more than cover their cost in financing the checkoff program? If not, then the conclusion would be that the program should be discontinued because the program costs stakeholders more than it returns to them. On the other hand, if the profits generated more than cover the costs, the program would be deemed a successful investment opportunity for stakeholders in the sheep and lamb industry.

The standard method to address questions related to the stakeholder returns from a commodity checkoff program is to conduct a benefit-cost analysis of the program. Following a discussion of the formulas used to calculate the benefit-cost ratios (BCRs) (i.e., the *average* return per dollar spent on the checkoff program) for each of the three main stakeholder groups of the lamb checkoff program (producers, feeders, and packers), the resulting BCRs are presented and discussed.

Benefit-Cost Analysis Formulas

A checkoff benefit-cost ratio (BCR) generally is calculated as the additional industry profits (additional revenues net of additional production costs and checkoff assessments) earned by stakeholders as a consequence of the checkoff expenditures as measured through the scenario analysis divided by the historical level of checkoff expenditures made to generate those additional profits.

The general formula for a Benefit-Cost Ratio is:

$$(1)\quad \text{BCR} = \frac{\sum_{t=1}^{T}(R_t - C_t - E_t)}{\sum_{t=1}^{T} E_t}$$

where R is the additional revenues generated by the checkoff program, C is the additional costs required to generate the additional revenue (such as cost of production), and E is the checkoff program expenditures.

Simplifying equation (1) gives:

$$(2)\quad \text{BCR} = \frac{\sum_{t=1}^{T}(R_t - C_t)}{\sum_{t=1}^{T} E_t} - 1.$$

For the lamb checkoff program, there are three primary groups of stakeholders who pay the costs of the checkoff program through their checkoff assessments: (1) sheep producers, (2) lamb feeders, and (3) lamb packers. The checkoff-induced revenue that has accrued to each of the three groups of stakeholders over a given time period can be calculated from the scenario simulation results since those results provide a measure of the increase in price and output at each level along the U.S. sheep-lamb and wool supply chain generated by the checkoff program. From that revenue stream, the costs required to generate the additional revenue at each level of the supply chain must be netted out along with the checkoff assessments paid to obtain the *net* revenue to stakeholder groups generated by the checkoff program. The calculated additional net revenue to the entire industry generated by the checkoff program is then divided by the cost of the lamb promotion program (the sum of all checkoff expenditures) to obtain the industry-wide BCR.

The additional net revenue to sheep and lamb producers as a result of the lamb checkoff program in a given time period (RP) is the sum of the additional revenue they earn from additional sales of lambs and sheep and the additional sale of wool produced minus the additional costs of production related to additional inventories of sheep and lambs and the cost of shearing

additional sheep in a given time period. RP can be calculated as follows (assuming all variables are subscripted by t for a given time period):

$$(3)\quad RP = \left(P_f^b Q_f^b + P_w^b Q_h^b - C_f Q_f^b - C_w Q_h^b\right) - \left(P_f^s Q_f^s + P_w^s Q_h^s - C_f Q_f^s - C_w Q_h^s\right)$$

where P is price per unit or per head, Q is quantity sold or number of head, and C is cost of production per unit or per head; the subscripts f, w, and h refer to feeder lambs and sheep, wool, and sheep shorn, and the superscripts b and s refer to baseline simulation value (*"with expenditures"* scenario) and scenario simulation value *("without expenditures"* scenario), respectively.

The first parenthesis in equation (3) is calculated from the baseline simulation values (the *"with expenditure"* scenario) while the calculation in the second parenthesis uses the scenario simulation values (the *"without expenditures"* scenario). In both parenthesis in equation (1), $P_fQ_f + P_wQ_h$ is the sum of the revenue earned by producers from the sale of feeder lambs and the sale of wool while $C_fQ_f + C_wQ_h$ is sum of the cost of producing feeder lambs and shearing sheep for wool. Thus, the additional net returns to producers (RP) generated by the checkoff program over the period of analysis (1987-2011) is the difference between the net revenue earned by producers with and without the lamb checkoff program in place.

Unfortunately, a time series of U.S. sheep production costs (C_f) is not available. Production cost data across sheep producing states were gathered from available sheep enterprise budgets prepared primarily by the extension services at the respective land grant universities. The calculated costs of production vary widely across states not only because of differing cost conditions and production systems but also because of the many different methods used to calculate the costs. After eliminating unreasonably high and low estimates, the average of the total operating costs per head (variable plus fixed cost) of the remaining estimates for 2013 was $204.59 per head. To generate a sheep production cost time series over the 1987 to 2013 period of analysis to use in the calculation of producer net revenues (equation (3)), the average cost for 2013 was multiplied by the index of prices paid by producers published by NASS (2013). An average estimate of $5.00/head for the cost of shearing (C_w) in 2013 was also obtained from the state-level sheep enterprise budgets and likewise multiplied by the index of prices paid by producers to generate a time series representing the cost of shearing sheep per head over the simulation period.

The additional net revenue to lamb feeders in a given time period as a result of the lamb checkoff program (RF) in a given time period is the additional revenue they earn from additional sales of slaughter lambs to packers minus the additional costs they accrue from purchasing additional feeder lambs from producers and the additional costs of production associated with feeding

additional lambs to slaughter weights. RF can be calculated as follows (assuming all variables are subscripted by t for a given time period):

$$(4)\quad RF = \left(P_g^b Q_g^b - P_f^b Q_f^b - C_f Q_g^b\right) - \left(P_g^s Q_g^s - P_f^s Q_f^s - C_f Q_g^s\right)$$

where P is price per head, Q is number of head, and C is lamb feeding operation costs per head; the subscripts g and f refer to slaughter sheep and feeder lambs, respectively; and the superscripts b and s refer to baseline simulation value *("with expenditures"* scenario) and scenario simulation value *("without expenditures"* scenario), respectively.

As with equation (3), the first parenthesis in equation (4) is calculated from the baseline simulation values (the *"with expenditure"* scenario) while the calculation in the second parenthesis uses the scenario simulation values (the *"without expenditures"* scenario). In both parenthesis in equation (4), P_gQ_g is the revenue earned by feeders from the sale of slaughter sheep to packers while $P_fQ_f + C_fQ_g$ is sum of the cost of the feeder lambs to the feeder and the cost of feeding lambs to slaughter weights. The additional net returns to feeders (RF) generated by the checkoff program over the period of analysis (1987-2013) is the difference between the net revenue earned by feeders with and without the lamb checkoff program in place. The cost per head of feeding lambs (C_f) over the 1987 through 2013 obtained in the same manner from sheep enterprise budgets representing the costs of feeder lambs and used to calculate the net change in revenues to lamb feeders (equation (4)).

The additional net revenue to lamb slaughterers (or packers) a result of the lamb checkoff program (RS) in a given time period is the additional revenue they earn from additional sales of lamb meat minus the additional costs they accrue from purchasing additional slaughter sheep and the additional costs of production associated with slaughtering additional slaughter sheep. RS can be calculated as follows (assuming all variables are subscripted by t for a given time period):

$$(5)\quad RS = \left(P_m^b Q_m^b - P_g^b Q_g^b - C_g Q_g^b\right) - \left(P_m^s Q_m^s - P_g^s Q_g^s - C_g Q_g^s\right)$$

where P is price per lb or per head, Q is number of head or number of pounds, and C is cost per head to packers of slaughtering sheep; the subscripts m and g refer to lamb meat and slaughter sheep, respectively; and the superscripts b and s refer to baseline simulation value (*"with expenditures"* scenario) and scenario simulation value (*"without expenditures"* scenario).

As with equations (3) and (4), the first parenthesis in equation (5) is calculated from the baseline simulation values (the *"with expenditure"* scenario) while the calculation in the second parenthesis uses the scenario simulation values (the *"without expenditures"* scenario). In both parenthesis in equation (5), P_mQ_m is the revenue earned by packers from the sale of lamb meat while $P_gQ_g + C_gQ_g$ is the sum of the cost of the slaughter sheep to lamb packers and the cost of

processing the slaughter sheep to packers. The additional net returns to packers (RS) generated by the checkoff program over the period of analysis (1987-2013) is the difference between the net revenue earned by lamb packers with and without the lamb checkoff program.

A time series for lamb processing costs per head (C_g) is also unavailable. A lamb processing cost of $33.57/head is used by the USDA Agricultural Marketing Service (AMS) in its Weekly National Lamb Market Summary report (USDA 2014e). Assuming that the processing cost is correlated with the cost of labor, the employment cost index for all civilian workers for both farms and non-farms (employment cost index for total compensation, by ownership, occupational group, and industry) (USDL 2014) was multiplied by the USDA lamb processing cost estimate to generate a lamb processing cost/head series for the entire simulation period of 1987-2013.

Using these measures of the returns to stake holders, several Benefit-Cost Ratios (BCRs) were calculated. The Benefit-Cost Ratio that measures the return to the lamb checkoff program across all stake holders (producers, feeders, and packers), net of their contributions to the checkoff program expenditures, is referred to as the Total Benefit-Cost Ratio (TBCR) and is calculated as:

$$(6)\quad \text{TBCR} = \frac{\sum_{t=1}^{T}(RP_t + RF_t + RS_t)}{\sum_{t=1}^{T} ET_t} - 1$$

where ET is the sum of the checkoff expenditures from funds contributed by all three stakeholder groups.

In the same way, the BCR to each stakeholder group can be calculated as the sum of the returns to each group over the simulation period divided by the respective group's contribution to the checkoff expenditures. Thus, the producer BCR (PBCR) is calculated as:

$$(7)\quad \text{PBCR} = \frac{\sum_{t=1}^{T} RP_t}{\sum_{t=1}^{T} EP_t} - 1$$

where EP is the share of the checkoff expenditures funded by contributions from sheep producers.

The feeder BCR (FBCR) is calculated similarly as:

$$(8)\quad \text{FBCR} = \frac{\sum_{t=1}^{T} RF_t}{\sum_{t=1}^{T} EF_t} - 1$$

where EF is the share of the checkoff expenditures funded by contributions from lamb feeders.

Finally, the packer or slaughterer BCR is calculated as:

$$(9)\quad SBCR = \frac{\sum_{t=1}^{T} RS_t}{\sum_{t=1}^{T} ES_t} - 1$$

where ES is the share of the checkoff expenditures funded by contributions from lamb packers.

Data for lamb advertising and promotion expenditures since July 2002 when the national lamb checkoff program began operations were provided by ALB (2014). Lamb promotion expenditures in the years before the national lamb checkoff program were provided by ASIA (2013). The checkoff expenditures attributable to each stakeholder group in each time period were calculated from total expenditures assuming that those expenditures were proportional to the number of animals on which each group was assessed a checkoff fee:

$$(10)\quad E_{it} = \frac{Q_{it}}{\sum_{t=1}^{T} Q_{it}}$$

where E is checkoff expenditures, *i* = checkoff stakeholder (producers, feeders, and packers), and Q is the number of head on which a stakeholder group paid a checkoff assessment. As discussed earlier, producers are assessed a checkoff on feeder lambs (Q_f in equations (3) and (4) above), feeders are assessed a checkoff on slaughter lambs (Qg in equations (4) and (5) above), and packers also on slaughter lambs (also Qg in equations (4) and (5) above).

As has been done by various studies of the return to commodity checkoff programs (Williams and Nichols 1998; Williams et.al. 2010), the lamb checkoff BCR and the BCRs for each stakeholder group can be discounted to account for the time value of money. A discounted BCR (DBCR) is calculated by discounting the net returns generated over time to present value before dividing by total promotion expenditures:

$$(11)\quad DBCR = \frac{\sum_{t=1}^{T} (R_t - C_t - E_t)/(1+i)^t}{\sum_{t=1}^{T} E_t}$$

where *i* is the interest rate chosen to discount the net revenue to present value, R is the additional revenue generate by the checkoff program (total or for individual checkoff stakeholder groups). In this study, the 30-day Treasury bill interest rates over time were used to discount the net revenue. The Treasury Bill rate was used simply because it represents a realistic alternative investment rate for the period of analysis.

Benefit-Cost Analysis Results

The BCRs for the lamb checkoff program, calculated as discussed above, clearly indicate that the program has benefited the U.S. lamb industry as a whole as well as each stakeholder group (Table 5). Over the period of analysis (1987-2013), the lamb checkoff program (over both the current and preceding checkoff programs) returned $7.10 per checkoff dollar spent on promotion over all stakeholder groups. The results also indicate that returns per dollar spent on promotion were substantially higher during the more recent period of the national checkoff program ($14.44) than was the case under the previous program funded by the wool incentive program ($3.03).

Note that slaughterers did not participate in the previous checkoff program (years prior to 2003). Consequently any net revenue that accrued to slaughterers during the 1987-2002 period of analysis as a result of the checkoff program are not included in the total revenues earned by stakeholders during that period (producers and feeders only) which led to a lower overall return to the program. In other words, during that early period, slaughterers were free riders who benefitted from the program but did not pay into the program. Any increased revenues to packers during that period were leakages from the system that reduced the returns to producers and feeders from promotion expenditures. Over the period since the establishment of the current checkoff program (2003-2013), the return to the overall program has been much higher with the participation of slaughterers than in preceding years at $14.44 per dollar of lamb checkoff expenditures. The returns to individual stakeholder groups under the current program have been much higher and quite similar under the current program at $13.84 to producers, $14.88 to feeders, and $15.81 to slaughterers.

The Discounted BCRs (DBCR) across stakeholders are lower than the corresponding non-discounted BCRs because the revenue streams over the years generated by the checkoff program are discounted to present value. Present value, also called "discounted value", is the current worth of a stream of revenue (such as the cash flow generated by the lamb checkoff program) over time given a specified rate of return, referred to as the "discount rate". The higher the discount rate, the lower the present value of the cash flows. The present value of a cash flow, or stream of revenue in this case, is usually less than the actual or "future" value of those revenues because money has interest-earning potential, a characteristic referred to as the time value of money, described aptly by the well-known phrase that "a dollar today is worth more than a dollar tomorrow." Such is the case because each dollar could be invested and earn a day's worth of interest, making the total accumulate to a value more than a dollar by tomorrow.

Table 5: Lamb Checkoff Program Benefit-Cost Ratios

	1987-2002	2003-2013	1987-2013
	$net return/ $spent	$net return/ $spent	$net return/ $spent
Benefit-Cost Ratios			
Total (BCR)	3.03	**14.44**	7.10
Producers (PBCR)	1.93	**13.84**	4.73
Feeders (FBCR)	4.22	**14.88**	7.01
Slaughterers (SBCR)	[a]	**15.81**	[a]
Discounted BCRs			
Total (DCBR)	0.81	8.26	3.46
Producers (PDBCR)	0.98	7.86	2.60
Feeders (FDBCR)	2.00	6.97	3.56
Slaughters (SDBCR)	[a]	10.14	[a]

[a] Slaughterers did not participate in the checkoff prior to the current program.

To calculate present value, the accumulated interest that might have been earned if checkoff funds had been invested is first deducted from the revenue stream. The result is the return that was actually earned from the checkoff program since any income generated by the checkoff-earned revenue has been subtracted. In this sense the DBCR is actually a more realistic measure of the return generated by the checkoff program per dollar of checkoff funds spent. The calculated DBCR over the entire period since the current checkoff program was established is $6.97. For producers, feeders, and packers, the DBCR over that same period is $7.86, $6.97, and $10.14, respectively.

Conclusions and Implications

This study expanded previous research on the effectiveness of the American Lamb Checkoff Program beyond a simple analysis of the impact of the program at the retail level of the market to a consideration of the impacts of those expenditures along the full U.S. and global sheep-lamb-wool supply chain. In the process, this study focused on answering three interrelated questions within the context of that supply chain: (1) What have been the effects of the American lamb checkoff program on U.S. and foreign sheep and lamb prices, sheep inventories, feeding, and slaughter, and lamb production, consumption, and trade? (2) Has the checkoff program effectively increased U.S. consumption of "American" lamb as opposed to imported lamb? (3) What have been the returns to U.S. sheep and lamb industry stakeholders from their investment in the checkoff program?

To conduct the analysis, a 70-equation econometric simulation model of world sheep, lamb, and wool markets, referred to as LamMod, was constructed and validated over the 1987-2013 period. The model was then used to simulate two lamb checkoff expenditure scenarios. First, a "*with expenditures*" scenario simulation assumed that the checkoff expenditures to enhance U.S. lamb demand were made as actually occurred over time. Then, a second "*without expenditures*" scenario simulation assumed that the checkoff expenditures to enhance U.S. lamb demand were not made as actually occurred over time. In that second scenario simulation, lamb checkoff expenditures were set to zero in every year which impacted the levels of prices and quantities in the model over time. The differences between the simulated values of the corresponding model variables representing the U.S. and global sheep, wool, and lamb markets in the two scenarios provided a measure of the changes in the global sheep-lamb-and wool supply chain that have occurred over time as a direct result of the U.S. lamb checkoff program.

With respect to the first question, the simulation analysis demonstrates clearly that the U.S. lamb checkoff program has impacted U.S. and foreign sheep and lamb markets. Some of the salient results are the following:

- In the U.S., the average annual lift of the current checkoff program (how much higher production, price or other variables were in each year on average since 2003 than would have been the case in the absence of the program) was:
  - breeding sheep inventories: 3.2%;
  - lamb crop: 4.4%;
  - lambs on feed: 3.0%;
  - sheep slaughtered: 5.0%;
  - lamb production: 5.4%;
  - lamb imports: 0.8%;
  - lamb consumption: 3.7%;
  - price of live sheep: 3.3%; and
  - retail price of lamb: 0.9%.

- Checkoff expenditures under the current checkoff program (2003-2013) created somewhat more lift along the U.S. sheep-lamb-wool chain than was the case under the preceding lamb promotion program operated by the American Sheep Industry Association.
- The import-increasing effect of the current checkoff program has been somewhat smaller than was the case under the preceding lamb promotion program, a result consistent with Williams, Capps, and Dang (2010).
- The current lamb promotion program also has created some lift in Australia and New Zealand as well but to a much lesser extent than in the U.S. The average annual lift in Australia and New Zealand since 2003 was, respectively:
  - breeding sheep inventories: 0.04% and 0.03%;
  - lamb crop: 0.03% and 0.07%;
  - sheep slaughter: 0.05% and 0.08%;
  - lamb production: 0.04% and 0.07%;
  - lamb consumption: -0.02% and -0.04%;
  - live sheep price: 2.6% and 1.7%; and
  - price of lamb exported to the U.S.: 2.3% (both countries).

With respect to the question of whether the lamb checkoff program actually promoted consumption of American lamb as intended rather than imported lamb, the study finds that the lamb program increased total U.S. lamb consumption by more than lamb imports over the period of analysis implying that that the program has effectively worked to reduce the lamb import share of domestic consumption, a result consistent with the findings of Williams, Capps, and Dang (2010).

As to whether or not the lamb checkoff program returned more to those who paid for the lamb checkoff program (primarily sheep producers and feeders and lamb packers) than the program cost them in checkoff assessments, the study finds that the program has returned to stakeholders a profit much in excess of the cost. Specifically the study finds:

- The Benefit-Cost Ratio (the dollars of net returns per dollar of checkoff expenditure) to the lamb industry as a whole over the entire period of analysis (1987-2013) was $7.10, considerably lower than the $44.14 reported by Williams, Capps and Dang (2011) at the retail level. When discounted to present value, the BCR was still a healthy $3.46. In other words, for every dollar invested by industry stakeholders in lamb promotion through the checkoff program, they realized $7.10 in additional profit ($3.46 on a discounted basis).
- Under the current lamb checkoff program (2002-2013), the industry BCR was $14.40 compared to the BCR of $3.03 in preceding years when the promotion expenditures were funded by the now defunct Wool Incentive Program.

- Returns to stakeholder groups (BCRs) under the current checkoff program were quite similar:
  - BCR to producers: $13.84 (non-discounted) and $7.86 (discounted);
  - BCR to feeders: $14.88 (non-discounted) and $6.97 (discounted); and
  - BCR to packers: $15.81 (non-discounted) and 10.14 (discounted).

These results lead to a number of implications for the management of the lamb checkoff program. First, although the lamb checkoff program has worked as designed to increase the demand for lamb and provide a positive return to stakeholders, the program has also positively impacted lamb imports and the sheep and lamb industries of Australia and New Zealand. Those "free rider effects" appear to be relatively small, however. This study indicates that imports accounted for only about 13% of the lift (average annual increase) in U.S. lamb consumption induced by the checkoff program over the years. In other words, the lift in the consumption of domestically produced lamb from the lamb checkoff program was about 7.3 times that of lamb imports. When the "free rider effects" of imports on a checkoff program become large enough, checkoff organizations often begin to consider extending the checkoff assessment to imports because a non-trivial or sometimes substantial share of the benefits of the program may be being diverted away from the stakeholders who pay the program costs to the free riders who pay none of the costs. In the case of the lamb checkoff program, however, the free rider effects appear to be small. Consequently, little would likely be gained in terms of reduced leakage of returns to domestic stakeholders from requiring imports to pay a checkoff assessment. In fact, the benefits from assessing imports a checkoff could well be smaller than the cost of providing importers a seat(s) on the Board and a voice in strategic promotion decisions which would lead inevitably to pressure to shift the focus of the program away from promoting "American" lamb to lamb in general.

A second implication of this study is that the highly positive BCR calculated for the lamb checkoff program, which is actually much in excess of the BCRs calculated for larger and more mature programs like soybeans, cotton, beef, and pork, does not indicate that the lamb checkoff program is much more effective than those other checkoff programs. Rather, the higher BCR primarily reflects the extremely small size of the lamb checkoff program compared to those of other major commodities. For example, the soybean checkoff program spent nearly $93 million in 2012 on promotion, research, and related checkoff activities. Likewise, the cotton checkoff program spent in excess of $80 million in 2012 while the beef checkoff program spent nearly $41 million. Not only is the $1.4 million spent by the lamb checkoff program in 2013 meager by comparison, the lamb checkoff intensity, that is the ratio of checkoff expenditures to the value of production, was only 0.11% in 2013 compared to generally 1% to 2% for other commodities. In other words, stakeholders in other checkoff programs pay more and contribute a much higher share (up to 10 to 15 times higher) of their industry revenues to their respective checkoff programs than do lamb industry stakeholders. Research has shown that as the level of checkoff expenditures grows, the marginal impact of each additional dollar spent declines. Thus, for a huge checkoff program like soybeans, the marginal effectiveness of each dollar is much lower

than for lamb which implies a lower average return to each dollar invested under the program. But with $93 million being spent, the absolute impact of their checkoff activities on their markets is also much greater.

Third, an implication that follows from the previous implication is that despite the increase in the lamb checkoff assessment that was passed in 2013, the program continues to be vastly underfunded imposing a huge opportunity cost on industry stakeholders of potentially millions of dollars. The results indicate that for every dollar in additional assessment NOT paid by stakeholders and spent on lamb promotion, industry stakeholders lose an average of $14.44 in additional industry revenue. Of course, as indicated above, increases in checkoff assessment rates and total spending on promotion are usually accompanied by a reduction in the corresponding BCR. Thus, the increase in in the lamb checkoff assessment rate approved last year will be expected to result in a somewhat lower return to promotion over time. But with such a high estimated BCR, the industry could increase the assessment rate substantially beyond even the new levels and still expect to generate a quite reasonable rate of return comparable to the $2 to $8 per dollar of promotion earned by the beef, pork, cotton, soybeans, and other checkoff programs.

Fourth, the higher BCR to the current lamb checkoff program than for the previous lamb promotion program under the Wool Incentive program may relate to the somewhat higher annual expenditures under the previous program. However, marked differences in spending strategies could well have contributed to the higher BCR to the current promotion programs. Under the previous program, promotion funds were spread over a wide array of categories of promotion activities in the early years. Then, towards the end of the program, promotion funds were spent almost exclusively on retail marketing and promotion activities aimed primarily at the retail food store trade. The current program strategy has been to promote more directly to consumers and to the food service industry. To the extent that the current focus of promotion expenditures more effectively shifts out the demand curve, the BCR would also be expected to be higher. Another potential reason for the large difference in the BCRs between the two periods is the inclusion of slaughterers as stakeholders under the current checkoff program. Packers were free riders under the previous program and any benefits they received as a result of lamb promotion programs was essentially a leakage of benefits away from stakeholders (producers and feeders at the time). The inclusion of packers as stakeholders not only increased checkoff funding levels from what they might otherwise have been but also helped limit the leakage of benefits to free riders.

Fifth, the lamb checkoff program has worked well in its design not only to boost lamb demand but also to provide roughly equivalent returns to each stakeholder group. This result has not been generally true for other checkoff programs with multiple stakeholder groups. In the case of the cotton checkoff program, for example, Capps and Williams (2011) found that the annual average return to producers was $5.7 per dollar of promotion expenditure and $14.4 per dollar of expenditure to importers. Thus, if assessment rates are adjusted further in the future, care should

be taken not to change the relative assessments of the stakeholders to maintain the current balanced return to those stakeholders.

Sixth, the high BCRs calculated for the lamb checkoff program are not indicative of the level of impact of the program on the U.S. and global sheep-lamb-wool supply chain. The small amount of lamb checkoff funds expended in each year generated a positive but rather small lift for the industry. The small positive benefit divided by an even smaller checkoff expenditure resulted in some relatively large BCRs. Checkoff groups sometimes interpret estimated BCRs much in excess of 1:1 to imply large absolute impacts of their program on the market. Nothing could be further from the truth. A BCR of 25:1, for example, results by dividing a $25 billion industry profit benefit by a $1 billion checkoff investment or by dividing a $25 benefit by a $1 investment. With a low level of investment in checkoff programs compared to the value of sales as is the case for the lamb checkoff program, the overall impact of the program could hardly be expected to be significant in a practical sense in its effects on production, prices, consumption, imports, and other market activities even though we found the impact to be statistically significant.

Seventh, the stakeholder BCRs calculated in this study provide measures of the *average* returns to those stakeholders from lamb promotion and <u>not</u> the return realized by individual stakeholders. In other words, not all sheep producers, for example, earned $13.84 or even $7.86 (discounted) for every dollar they have paid in assessments. Because the BCR is an average, some producers, some feeders, and some packers have realized higher returns while others have earned lower. To suggest that all stakeholders benefit equally from the lamb checkoff program would be to commit the inferential error termed “the fallacy of division” where one reasons that something true for the whole must also be true of all or some of its parts.

Finally, care must be taken in communicating these results to stakeholders. Past experience suggests that inevitably some stakeholders will ask something like this: “If the returns were $14.44 for every dollar invested in the lamb checkoff program, where are my $14.44 for every checkoff dollar I have been assessed?” The question conveys a common lack of understanding of not just the results of checkoff evaluation studies but how checkoff programs return value to them. The basic problem is that all stakeholders can easily identify the line on their balance sheets for the cost to them of the checkoff assessments. But there is no line on their balance sheets for what their contributions to the checkoff program have returned to them in additional revenues. What they often fail to understand is that the benefits to them are included in the revenue line on their balance sheet. Some part of that revenue has come from the larger number of sheep and/or lamb they have been able to sell at a higher price as a direct result of the checkoff program. The problem is that they cannot tell how many more sheep or pounds of lamb they have been enabled to sell at how much of a higher price as a result of the checkoff program. In essence, that is what this study does – attempts to identify that part of stakeholders’ revenue streams that are the result of the checkoff program rather than any other market event or force.

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