Returns to Stakeholders from the American Lamb Checkoff Program: A Supply Chain Analysis

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Abstract

The United States sheep industry has suffered an almost constant decline in sheep and lamb inventories; a record of 56 million head in the early 1940s to only 5.33 million head in 2013. The steady decline of the industry can be attributed to a confluence of many factors, amongst which is the discontinuation of the U.S. Wool Incentive payment program. With the discontinuation of the program in 1996/97, an unsuccessful effort was made to pass a mandatory checkoff program through a producer referendum. Six years later, in 2002, to enhance the demand for lamb, the Lamb Promotion, Research, and Information Order, better known as the American Lamb Checkoff Program, was established under the Commodity Promotion, Research and Information Act of 1996. The main objective of this research was to measure the effectiveness of the Lamb Checkoff Program by determining the extent to which the program has been able to shift out the demand for U.S. lamb and how much of the promotion benefit, if any, has been transmitted back through the supply chain to the different stakeholders of the lamb industry. This research investigated questions dealing with the demand, supply and trade of sheep and lamb through the global supply chain.

This analysis used a seventy equation, non-spatial price equilibrium model (LamMod) to estimate the parameters of interest using the OLS method of estimation. After estimating the parameters of all seventy equations, the model was simulated over the sample period (1987 - 2013) as a means of model validation. The model was then used to simulate two expenditure scenarios, the “with” and “without” lamb checkoff expenditure to measure the effects and benefits of the program by calculating the Benefit-Cost-Ratio.

The results of this study clearly indicated that not only did the lamb checkoff program increase the demand for lamb, the program tended to lift the entire supply chain in the process

with every stakeholder group benefitting from it. 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.

Key Words: Lamb supply, Lamb demand, global supply chain, U.S., Rest of the world, Benefit cost ratio

JEL code: Q1 Q11 Q13 Q17 Q18

The United States sheep industry is multifaceted, rooted in history and tradition, and one of the most complex industries in animal agriculture. Despite the sheep industry's versatility, the dominant feature has been its steady decline since the mid-1940s. From a record high of 56 million head in 1942, inventories in January 1, 2013 slumped to 5.53 million head, the lowest level in recorded history (USDA 2013d). The decline in the number of sheep and lamb has been a major cause of concern for sheep producers and policy makers over the years.

One of the major steps taken by the industry to revive itself from the downfall is the lamb checkoff program under the Commodity Promotion, Research and Information Act of 1996. To enhance the demand for lamb , the Lamb Promotion, Research, and Information Order, better known as the American Lamb Checkoff Program, was established in July 2002. Since its inception through 2012/13, the American Lamb Board has spent a total of $13 million on lamb advertising and promotion.

The main goal of the current Lamb Checkoff Program is to increase the market share of "American" 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. It is an effort to "brand" U.S.-produced lamb as made in America and differentiate it from imported lamb as a higher quality and value product. The success of the program, and its predecessors can be measured by determining the extent to which the associated expenditures to promote lamb have been able to shift out the demand for U.S. lamb and how much of the promotion benefit, if any, has been transmitted back through the supply chain to stakeholders, primarily producers, feeders, and slaughterers. This research will investigate these questions taking into consideration the demand, supply and trade of sheep and lamb through the global supply chain.

The American Lamb Checkoff Program

A U.S. lamb promotion program has been in place in most years since the late 1970s. Beginning in 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 the1954 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. 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 about the 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 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. 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. 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. Administrative costs of the Lamb Board are kept low so that most of the collected checkoff funds are used for promotional purposes.

Methodology

A 70-equation, non-spatial, price equilibrium, simultaneous econometric model of the global sheep-lamb-wool supply chain was developed in a model called LamMod. 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 is simulated over the sample period (1987 through 2013) as a means of model validation. The model is then used to simulate two lamb checkoff expenditure scenarios. First, a "with expenditures" scenario simulation assumes that the checkoff expenditures to enhance U.S. lamb demand are made as actually occurred over time. Then, a second "without expenditures" scenario simulation assumes that the checkoff expenditures to enhance U.S. lamb demand are not made as actually occurred over time. In that second scenario simulation, lamb checkoff expenditures are 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. 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.

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 from 1987 through 2013. 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 R2 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. 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). 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.

The estimated long-run lamb promotion expenditure elasticity was 0.037 which is consistent with Williams, Capps, and Dang (2010) and in the range of those estimated for other checkoff commodities (Williams and Nichols 1998). The adjusted R2 and the Durbin Watson statistic indicate a good fit of the data and the absence of autocorrelation. 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).

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?

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- the with

expenditure period. The second scenario was the without expenditure scenario where the lamb checkoff program is assumed to have never existed. The LamMod was then 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 over time in the absence of any checkoff expenditures. 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 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. 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. 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. However the critical question that must be answered about the U.S. lamb checkoff program, 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?

Benefit-Cost Analysis Formulas

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. 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:

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

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:

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

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

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), PfQf + PwQh is the sum of the revenue earned by producers from the sale of feeder lambs and the sale of wool while CfQf + CwQh 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 (Cf) 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 (Cw) 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) $RF = \left(P_g^b Q_g^b - P_f^b Q_f^b - C_f Q_g^b\right) - (P_g^s Q_g^s - P_f^s Q_f^s - C_f Q_g^s)$

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), PgQg is the revenue earned by feeders from the sale of slaughter

sheep to packers while PfQf + CfQg 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 (Cf) 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) $RS = \left(P_m^b Q_m^b - P_g^b Q_g^b - C_g Q_g^b\right) - \left(P_m^s Q_m^s - P_g^s Q_g^s - C_g Q_g^s\right)$

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), PmQm is the revenue earned by packers from the sale of lamb meat while PgQg + CgQg 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 (Cg) 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) 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) 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) $E_{it} = \frac{Q_{it}}{\sum_{t=1}^{T} Q_{it}}$

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 (Qf 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) 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).

The slaughterers however 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 nondiscounted 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.

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

This research focused on the effectiveness of the American Lamb Checkoff Program by looking into the (1) 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) whether the checkoff program effectively increased U.S. consumption of "American" lamb as opposed to imported lamb and (3) the returns to U.S. sheep and lamb industry stakeholders from their investment in the checkoff program.

The results from the research as mentioned in the previous sections clearly indicated that not only the lamb checkoff program had positive impacts on U.S. and foreign sheep and lamb supply chain but as expected the effect of the program is more in U.S. compared to that of the rest of the world.

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, this research finds that the program has returned to stakeholders a profit much in excess of the cost.

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. 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. In the same way the stakeholder groups were also benifitted from the current checkoff program. The BCRs of the producers, feeders, and packers were $13.84,$14.88, and $15.81 respectively.

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Appendix

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

Table 2. Price Elasticities in Global Live 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 inventory	0.11*				1.37*		0.01	
Replacement inventory				0.89***				
Lamb crop inventory		0.15						
Feeder demand	-0.15*	0.15*			-0.65*	0.65*		
Slaughter demand		-0.2**		0.77***		-0.36**		1.42***
Australia								
Breedingewe inventory	0.05*		0.03		0.11*		0.06	
Othersheep inventory	0.04*		0.05		0.09*		0.11	
Slaughter demand	-0.2***			0.68***	-0.49***			1.65***
New Zealand								
Breedingewe inventory	0.03**		0.14		0.11**		0.52	
Othersheep inventory	0.04		0.17		0.09		0.31	
Slaughter demand	-0.18***			0.56***	-0.23***			0.72***
Argentina								
TotalSheep inventory			0.03**				0.06**	
Uruguay								
TotalSheep inventory			0.04**				0.33**	

* fifteen percent significance level
** ten percent significance level
*** one percent significance level

Table 3. U.S. Sheep and Lamb Market Lift from the Lamb Checkoff Program

	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	**49,773**	**2.9**
Lamb Crop	160,265	3	182,945	4.4	**170,142**	**3.7**
Sheep/Lamb Slaughter	203,555	4	209,591	5	**205,926**	**4.5**
	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	0.18	1.37	0.16	**1.38**	**0.17**
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**
	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	4.1	3.3	**3.3**	**3.2**
Lamb Meat ($/lb)	0.05	1	0.03	0.9	**0.4**	**0.9**

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**	**0.5**
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**
	tonnes	**%**	**tonnes**	**%**	**tonnes**	**%**
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	**-70**	**-0.02**
N Z Lamb Consumption	-106	0	-77	-0.04	**-95**	**-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	**tonnes**	**%**	**tonnes**	**%**	**tonnes**	**%**
Australia Lamb Exports	320	0.1	318	0.1	**319**	**0.1**
New Zealand Lamb Exports	363	1	344	0.9	**355**	**0.9**
U.S. Lamb imp	630	1.8	623	1.6	**627**	**1.7**

Table 5: Lamb Checkoff Program Benefit-Cost Ratios

	1987-2002	2003-2011	1987-2011
	$ net return/$spent	$ net return/$spent	$ net return/$spent
Benefit-Cost Ratios			
Total (BCR)	3.03	14.44	7.1
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	2.6
Feeders (FDBCR)	2	6.97	3.56
Slaughters (SDBCR)	a	10.14	a

[a] slaughterers did not participate in the checkoff prior to the program