CANADIAN BEEF CATTLE CHECK - OFF EVALUATION

FINAL REPORT

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Executive Summary

Canadian beef cattle producers pay a mandatory "check-off" for each animal marketed. A beef import levy is also applied to all beef cattle, beef and beef products imported into Canada. Check-off levies vary across Canadian provinces and are paid to their provincial association with a portion paid to the Canadian Beef Check-off Agency. Each province provides direction on how their national levy dollars are allocated. Through the collected levies, the Canadian Beef Cattle Research, Market Development and Promotion agency operating as the Canadian Beef Check-off Agency, provides funding for national research, marketing, and promotion through their partners the Beef Cattle Research Council, Canada Beef, and the Public Stakeholder Engagement program.

Two studies (Cranfield 2010 and Rude and Goddard 2016) were previously tasked with evaluating the investments in marketing and research from the mandatory national check-off dollars. These studies were based on developing an economic model of the beef industry and then solving for producer surplus with and without the expenditures in marketing and research. The driving force behind their Benefit Cost Ratios (BCRs) is the estimated expenditure elasticities. An elasticity estimate is simply an estimate of the percentage change in one variable caused by a percentage 1% change in another variable. That is, for example, how much did per capita disappearance change for a 1% change in marketing expenditures. While estimated elasticities are the driving force behind our method, we use a direct accounting approach rather than integrating under an estimated supply curve. This was chosen for a number of reasons. First and foremost, the various disaggregated Benefit-Cost Ratios (BCRs) required by this study cannot be recovered using the previous approach. Additional benefits of using a more direct accounting approach is transparency and avoiding misleading year-to-year variations. Moreover, the two approaches yield almost identical results given that the change in domestic price is constant in our approach and essentially constant in the previous approach. Another notable difference in our methodology is that Bayesian econometric methods were used which allows for the use of prior information to enter the estimation process. This was deemed necessary as the amount of data in many of the estimations was fairly limited.

With respect to domestic marketing expenditures -- *including the import levy* -- we found a BCR of 15.4:1. In comparison, Rude and Cranfield found BCRs of 17:1 and 8:1, respectively. With respect to Public and Stakeholder Engagement expenditures, we found a BCR of 16.0:1. Neither the Rude nor the Cranfield study reported BCRs for Public and Stakeholder Engagement.

We also estimated BCRs for export promotion expenditures by country for which the necessary data was available. We find the BCR for China expenditures is 5.3:1, Hong Kong expenditures is 4.3:1, Mexico expenditures is 5.3:1, Japan expenditures is 5.6:1, and the EU expenditures is 0.1:1. While the EU shows a very poor BCR, our understanding is that the expenditures in the EU involve global rather than EU trade. In this respect, the result is not very surprising or informative. Neither the Rude nor the Cranfield studies estimated BCRs by country.

We also estimated BCRs by specific export promotion activities; marketing expenditures were disaggregated into market development, consumer marketing, industry education, market intelligence, and stakeholder communication. We estimated a BCR of 5.6:1 for market development expenditures; a BCR of 9.2:1 for consumer marketing expenditures; a BCR of 7.3:1 for industry education expenditures; a BCR of 6.9:1 for market intelligence expenditures; and a BCR of 7.0:1 for stakeholder engagement expenditures. Again, neither the Rude nor Cranfield studies estimated BCRs by marketing activity.

With respect to research expenditures, Rude estimated a BCR of 35:1 whereas Cranfield estimated a BCR of 46:1. Both studies focused *only* on the carcass weight effect. In this sense, the results are under-estimated as they do not consider the gains with respect to other metrics such as survival rate, feed efficiency, beef quality, reproductive efficiency, and tame hay yields. With respect to carcass weight *only*, we estimate a BCR of 16.4:1, lower than both Cranfield and Rude. However, when we consider additional metrics at the feedlot level, we recover a BCR of 63.2:1, an estimate higher than past studies. We estimate a BCR of 21.0:1 with respect to survival rate at the feedlot level, a BCR of 7.2:1 with respect to feed conversion, and finally 18.7:1 BCR with respect to beef quality. Our results in comparison to past studies show an increase in BCRs. This is not surprising given that the benefits are measured across more metrics than in past studies. With respect to research BCRs relative to cow/calf operations, we estimate an overall BCR of 58.7:1. The overall research BCR is an aggregation of component BCRs given research expenditures cover multiple areas such as tame hay yields, reproductive efficiency, and survival rate. We estimate a BCR of 6.9:1 for reproductive efficiency; a BCR of 11.7:1 for survival rate; and a BCR of 40.1:1 for tame hay yields. Similar measures were not part of the Rude or Cranfield studies.

Aggregating across marketing and research categories, the overall BCR is 33:1. This compares to 9:1 found by Cranfield and 14:1 found by Rude. The large increase is caused by the inclusion of benefits (i.e., survival rate, reproductive efficiency, and tame hay yields) from research expenditures that were excluded in the previous studies. Note, if these benefits were also excluded in the current study, we would find an overall BCR of 13:1.

In conclusion, our results yield very similar BCRs to previous studies where they are comparable. Moreover, our results, like the Cranfield and Rude studies, suggest the BCRs are two to three times greater for research expenditures versus marketing expenditures. However, the very large confidence intervals for our estimated BCRs indicates that the benefits from research expenditures are not statistically higher than benefits from marketing expenditures. As a result, we refrain, unlike past studies, in suggesting that money be moved from marketing activities to research activities. The estimation uncertainty around the BCR estimates is sufficiently large such that statistically conclusive statements about the relative effectiveness between research and marketing activities cannot be made. Note, previous studies did not recover confidence intervals around their estimated elasticities or BCRs.

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1. Introduction

Canada produces roughly 1.55 million tonnes of beef annually and exports roughly half of all beef and cattle production. Canadian beef is shipped to several countries including the United States, Hong Kong, Japan, Mexico, and China. In 2020, Canada was ranked in the top 11 beef producing countries. Canadian beef consumption is roughly 18 kilograms per person per year. In 2019 the cattle industry had farm cash receipts over $9 billion, the second largest single source of farm cash receipts. There are 60,000 farms in Canada (2016 census) that derive much of their income from beef production.

Canadian beef producers are levied a mandatory check-off on each animal marketed. The Canadian Beef Check-Off Agency manages and administers the Canadian Beef Cattle Check-Off and a beef import levy that is applied to all beef cattle, beef and beef products imported into Canada. By the end of 2018, cattle producers in all provinces except Ontario saw an increase in the mandatory levy collected on cattle sales paid to the national beef programs, from $1.00 to $2.50 per head on live animals sold in the country. Provinces committed to the increase of funding for investment in market development, beef promotion and research with the aim of improving market competitiveness. The Canadian Beef Check-Off Agency reportedly collected $17.2 million in check-off and $1.2 million in import levy in 2020-2021. (https://www.cdnbeefcheckoff.ca/reports/your-beef-check-off-working-for-you/)

The Canadian Beef Check off Agency works with key stakeholders and partners, notably, Canada Beef, the Beef Cattle Research Council, the Public and Stakeholder Engagement team, and provincial and national partners to ensure that check-off dollars are invested into research, market development and promotion programs that deliver measurable value to the Canadian beef industry.

Two studies (Cranfield 2010, Rude and Goddard 2016) were previously tasked with evaluating the investments in marketing and research from the mandatory check-off. The Cranfield study showed that Canadian cattle producers gained significant benefits from investments in marketing and research. Cranfield recommended that monies be directed from marketing to research activities based on their results. In comparison to Cranfield, the Rude study found lower BCRs for research expenditures but higher BCRs for domestic marketing activities. Perhaps not surprising given that more money was directed to research activities in the time between the two studies. Unfortunately, neither study reported the uncertainty around their estimates nor incorporated that uncertainty into their recommendations.

2. Background Information

In Canada as in the US, any time a producer sells beef cattle, they pay a mandatory levy, either provincial or federal depending on whether the cattle are sold within the province or outside of provincial borders. A beef import levy is also applied to all beef cattle, beef and beef products imported into Canada. When a producer sells beef cattle in their province that levy is paid to their provincial association with the national portion paid to the Canadian Beef Cattle Check-off. Provincial check-off levies vary across provinces and the funds are allocated to support their respective association's activities. The federal check-off funds collected are used for research, promotion, and marketing and to increase the domestic and international demand for beef. Table 1 provides a summary of provincial and federal checkoffs. Table 2 provides a summary of how each province has requested their funds be allocated to national initiatives as of April 1, 2021.

Table 1: Provincial levy rates current as of January 1, 2022

Province	Canadian Beef Cattle Check-Off	Provincial Check-Off	Total Levy Deducted
British Colombia	2.50	2.50	5.00
Alberta	2.50	2.00	4.50
Saskatchewan	2.50	2.00	4.50
Manitoba	2.50	3.00	5.50
Ontario Beef & Veal	1.00	4.50	5.50
Quebec Cull Cows	2.50	14.40	16.90
Quebec Bob Calves	2.50	3.75	6.25
Quebec Fed Cattle	2.50	8.05	10.55
New Brunswick	2.50	3.50	6.00
Nova Scotia	2.50	3.50	6.00
Prince Edward Island	2.50	3.50	6.00

Source: Canadian Beef Check-off (https://www.cdnbeefcheckoff.ca/about-us/current-rates/)

Table 2: Percentages of provincial allocations to national initiatives as of April 1, 2021

Province	Canadian Beef Cattle Check-Off	Marketing	Research	Public and Stakeholder Engagement	Provincial Investment
British Columbia	$2.50	65%	25%	10%	0%
Alberta	$2.50	62%	31.4%	6.6%	0%
Saskatchewan	$2.50	65%	30%	5%	0%
Manitoba	$2.50	66.5%	23%	4%	6.5%
Ontario Beef	$1.00	22.6%	22.6%	5%	49.8%
Quebec	$2.50	0%	0%	0%	100%
New Brunswick	$2.50	25%	30%	5%	40%
Nova Scotia	$2.50	25%	30%	5%	40%
Prince Edward Island	$2.50	25%	30%	5%	40%
Import Levy	$1.00	100%	0%	0%	0%

Source: Canadian Beef Check-off (https://www.cdnbeefcheckoff.ca/about-us/current-rates/

3. Data

In this section we detail the data used in our analysis. We were fortunate to be given access to the dataset used in the Rude study. Moreover, the Rude data was updated from the Cranfield data. Our first step was to collect data so as to update the Rude data set. Some of that data was provided by Canfax while other data was updated through public collections (Statistics Canada, USDA, etc.). Additionally, it was necessary to collect data not collected in the previous studies.

For the domestic marketing BCRs, quarterly data was collected for per capita disappearance, real beef, chicken, and pork retail prices, and real per capita income. Marketing expenditures and import levy data were supplied by Canfax. For the export promotion BCRs, quarterly retail prices by country, exchange rates, and per capita GDP was collected. Marketing expenditures by country and by component was provided by Canfax. Cost of production for cow/calf operations was recovered from AgriProfit$2016-2020 (https://open.alberta.ca/dataset/781f2072-bdb5-40be-a7df-a0a44a760017/resource/81c299c5-4cd9-4f45-a71e-d89e36a54c92/download/afred-itrb-economic-productive-financial-performance-alberta-cow-beef-2016-2020.pdf). For the research BCRs, carcass weight, feed conversion ratios, feedlot survival rates, beef quality, feedlot margins, reproductive efficiency rates, cow/calf survival rates, and tame hay yields was provided by Canfax. All available historical data, either quarterly or annually, was used in the econometric estimations. However, given the estimated elasticities, the BCRs were calculated using the latest five-year average of benefits where possible.

We did run into issues of insufficient data for our veal analysis. Two problems were encountered. First, we necessarily used the beef retail price as a proxy for the veal price. This would be valid if in fact the veal and beef prices moved together (or were strongly correlated). However, during the project it was brought to our attention that this is not the case. Second, in order to convert the estimated veal elasticity into a BCR, a cost of production for veal producers is required. Unfortunately, this does not exist. What is required to undertake the veal analysis moving forward would be a veal retail price and a veal cost of production.

Similarly, we had lack of data problems for the verified beef expenditures, webinars, and webpage views. These programs have not been around sufficiently long to include them into the research metric base equations. What is required to undertake the analysis moving forward is just more time to pass to allow for more data collection. Moreover, for webinars and webpage views, constructing the costs associated with these activities may not be trivial.

4. Domestic Marketing Benefit-Cost Ratios

In this section we detail the domestic marketing BCRs analyses. We discuss this analysis in moderate technical depth for two reasons. First, it is comparable with the Cranfield and Rude studies whereas most of the estimated BCRs are being reported for the first time in this study. Second, it provides an overview of the analyses that was undertaken for each of the BCRs (technical results for other analyses are located in appendix 3). Note, all R code is included with this report (appendix 4) and thus any of the analyses can be replicated.

As with the Cranfield and Rude studies, domestic marketing expenditures are included in the domestic per capita disappearance equation. We have added the import levy revenue, which is used for domestic marketing and thus non-differentiable from the domestic marketing expenditures to the marketing expenditure data. This departs from the Rude 2018 study. However, our understanding is that the revenue from the import levy is used solely for domestic generic marketing. Given that, import levy revenue is necessarily modelled jointly with marketing expenditures.

The domestic per capita disappearance equation is of the same form as previous studies, in that it is a function of the beef retail price, pork retail price, chicken retail price, per capita income, quarterly dummies, BSE dummy, lagged disappearance, marketing expenditures, and public and stakeholder engagement (PSE) expenditures. Unlike previous studies, all variables entered linearly into the equation. Also, unlike previous studies, prior distributions were put on select parameters. With respect to the beef price, we assumed a uniform prior over the non-positive real line; that is, if beef price increases, everything else equal, per capita disappearance will not increase. With respect to per capita income, we assumed a uniform prior over the non-negative space; that is, if per capita income increases, per capita disappearance will not decrease. With respect to marketing expenditures, we assumed a uniform prior over the non-negative real line; that is, the marketing

expenditures may not have a negative effect on disappearance. Given that the PSE program is relatively new with very few data points we imposed a second prior. We first estimated the model without PSE and used the estimated posterior distribution on marketing expenditures as the prior for PSE expenditures. As a result, this also assumes that PSE expenditures may not have a negative effect on disappearance.

In Bayesian analysis, the posterior distribution of unknown coefficient θ is defined as $f(\theta|x) = f(x|\theta)*f(\theta)/f(x)$ where $f(\theta)$ is the prior, $f(x|\theta)$ is the likelihood as is commonly defined, and $f(x)$ is simply a normalizing constant. We use Markov Chain Monte Carlo (MCMC) sampling methods to estimate $f(\theta|x)$. This is common in Bayesian econometrics. Note that 6000 draws (4 chains by 1500 draws) are taken for each coefficient of which the first 500 draws are discarded (as is common). Intuitively, one can think of this method as an "educated" sampling approach.

In figure 1, we illustrate the trace plots, that is the sampling in the Markov Chain Monte Carlo, for the four relevant parameters (beef price, income, marketing expenditures, PSE expenditures) in the per capita disappearance equation. Note that b1 is the coefficient draws on beef price, b4 is the coefficient draws on income, b10 is the coefficient draws on marketing expenditures, and finally b11 is the coefficient draws on the PSE expenditures. Figure 2 illustrates the posterior distribution of these four variables with the shaded areas representing the 90% confidence interval. What is relevant and illustrated by these two figures is that the priors placed on the parameters are not intrusive; that is, the data -- not the prior -- is dictating the estimation results.

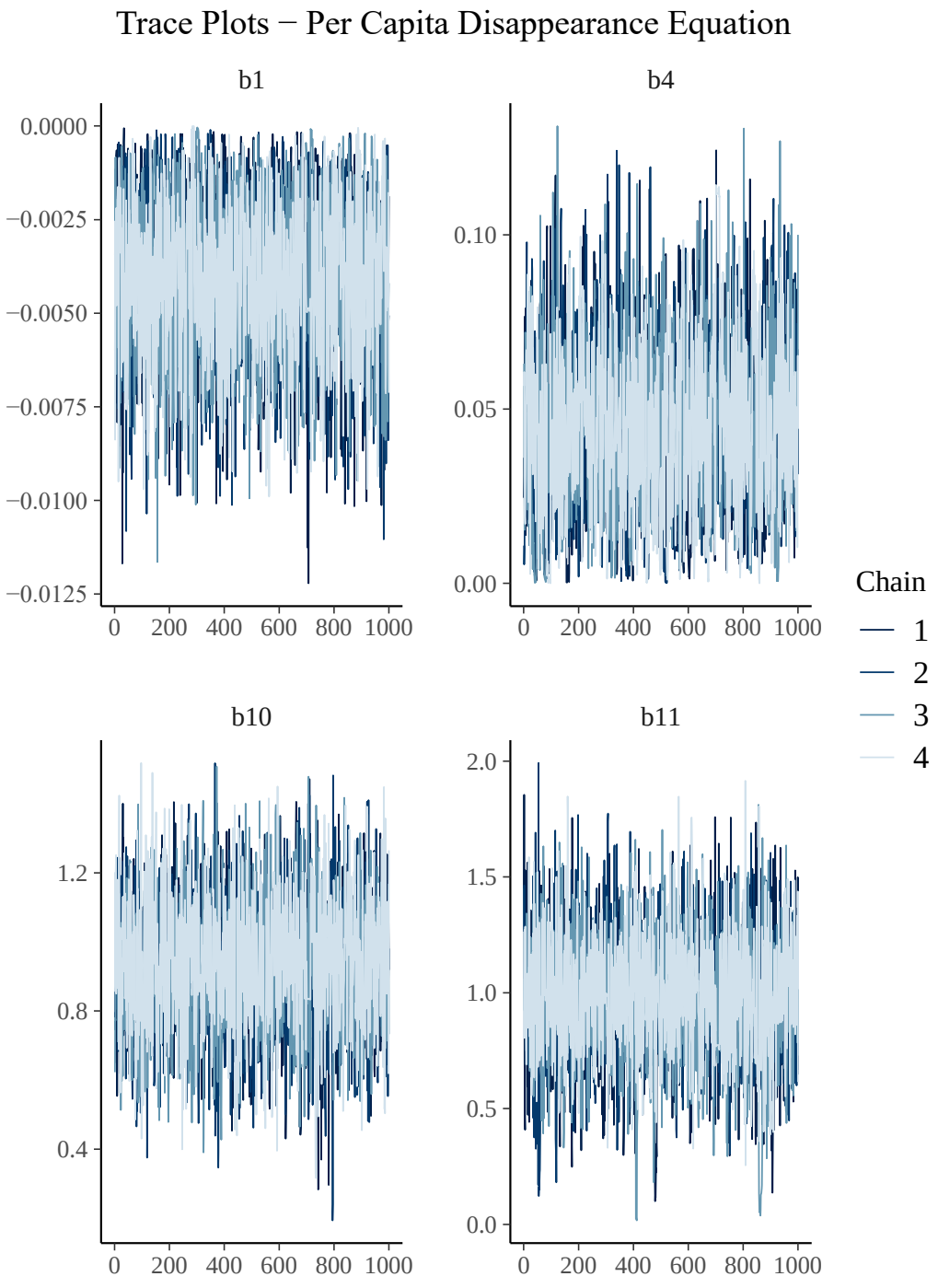


Figure 1: Trace Plots from Per Capita Disappearance Equation

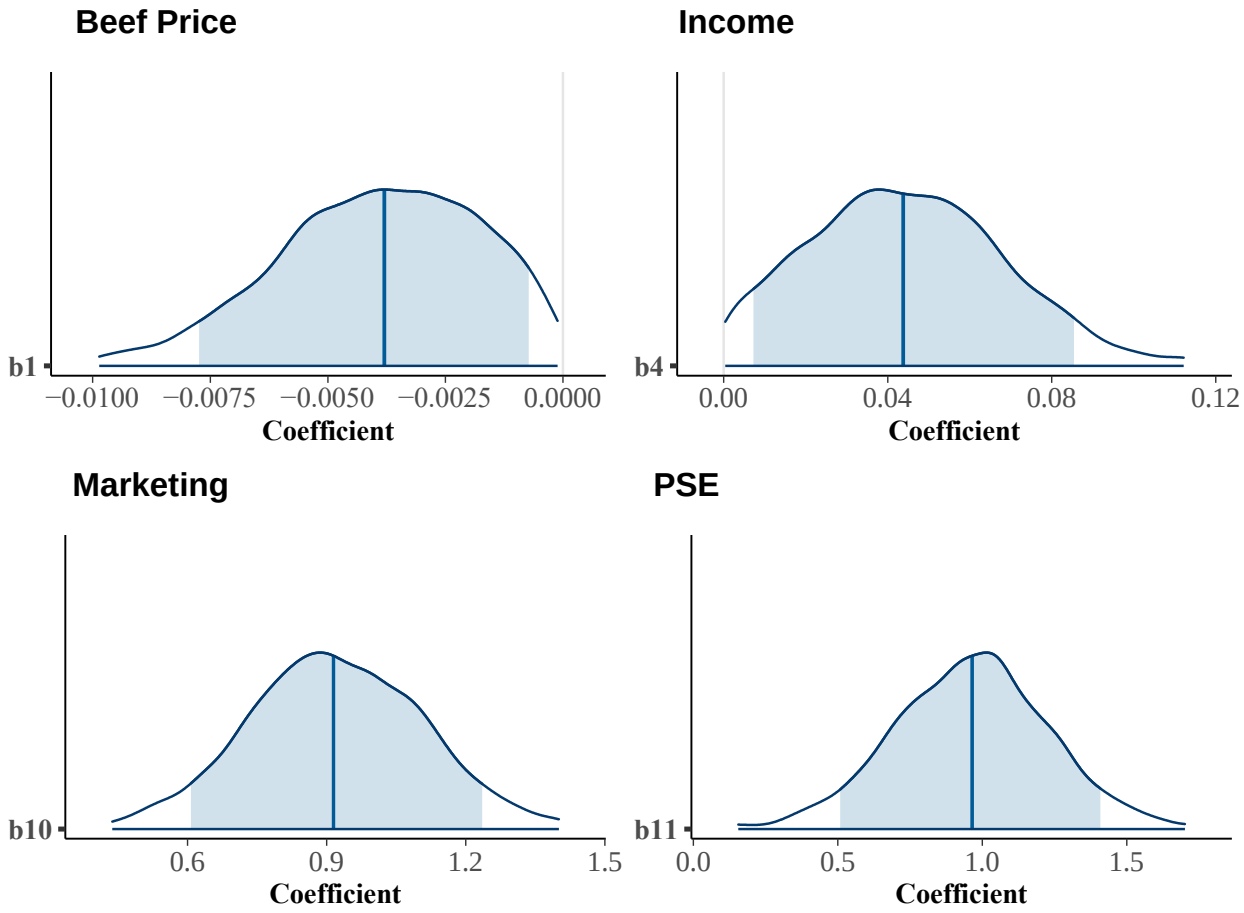


Figure 2: Posterior Distributions from Per Capita Disappearance Equation

Recall, an elasticity represents the percentage change in one variable for a 1% change in a second variable. These estimated elasticities, derived directly from the estimated coefficients, are the driving force of the BCRs in this study as well as both the Rude and Cranfield studies. In this case, they measure the change in disappearance for a change in marketing or PSE expenditures. As a result, we first present our estimated elasticities, their confidence intervals, and compare them to the Rude and Cranfield studies. We then present the BCRs and their corresponding confidence intervals and again compare to the Rude and Cranfield BCRs. Conversely, we do not present year-to-year BCRs which are highly variable, fairly uninformative, and easily misleading.

With respect to beef price, we find an elasticity of -0.071 whereas Rude finds -0.300 and Cranfield finds -0.289. The 90% confidence interval for our elasticity is (-0.014, -0.144). Neither Rude nor

Cranfield reported their confidence intervals. With respect to income, we find an elasticity of 0.210 whereas Rude finds 0.232 and Cranfield finds 0.0002. The 90% confidence interval for our elasticity is (0.035, 0.410). Again, neither Rude nor Cranfield reported their confidence intervals. Our results possibly indicate that beef consumption is less sensitive to price than it has been in the past which is not overly surprising given recent increases in per capita income.

With respect to marketing expenditures including levy revenue, we find an elasticity of 0.051 whereas Rude finds 0.053 and Cranfield finds 0.023. The 90% confidence interval for our elasticity is (0.034, 0.068). Neither Rude nor Cranfield reported their confidence intervals. Based on these elasticities and the direct accounting approach to calculating benefits (from 2016-2020 cow/calf cost of production by AgriProfit$), we find the BCR for marketing expenditures including levy revenue is 15.4:1. The 90% confidence interval for this is (10.4:1, 20.2.:1). In comparison, Cranfield found an average BCR of 8:1 whereas Rude found an average BCR of 17:1.

With respect to PSE expenditures, we find an elasticity of 0.00045 and a BCR of 16.0:1. Neither the Cranfield nor Rude studies considered PSE expenditures as this is a relatively new program. The 90% confidence interval for the PSE BCR is (9.0:1, 23.1:1). The larger confidence interval as compared to the BCR for marketing expenditures reflects that there is significantly less data with the PSE program: both are in the same neighborhood.

Any BCR above one (1:1) indicates that an additional dollar in expenditures will increase benefits above a dollar and thus suggests increasing expenditures. It is clear with respect to both marketing and PSE expenditures, far greater benefits have accrued than costs thereby suggesting increases in marketing and PSE expenditures.

R code for this analysis is located in appendix 4 and labelled “beef_market_levy_pse_final.R”, “regression_bayes_advert_inital.stan”, and “regression_bayes_advert_final.stan”. As mentioned earlier, the data used for this analysis is per capita disappearance, beef retail price, pork retail price, chicken retail price, per capita income, quarterly dummies, BSE dummy, lagged disappearance, marketing expenditures, and public and stakeholder engagement (PSE).

A similar analysis as the above was conducted for veal per capita disappearance. Two problems were encountered. First, we used the beef retail price as a proxy for the veal price. This would be valid if in fact the veal and beef prices moved together (or were strongly correlated). However, during the project it was brought to our attention that this is not the case. Second, in order to convert the veal elasticity into a BCR, a cost of production for veal producers is required. Unfortunately, this does not exist. Results and code for the veal analysis is in appendix 2.

5 Export Promotion Benefit-Cost Ratios by Country

In this section we detail the export promotion BCR analyses. Unlike previous studies, it was desired to recover BCRs by country. This significantly altered the way in which the analyses could be undertaken. The detailed econometric results (trace and posterior plots) are in appendix 3. Code is in appendix 4.

Based on data supplied by Canfax, we were only able to estimate models for five countries: Japan, China, Hong Kong, Mexico, and the EU. While the US would be an obvious country to include there are implicit agreements that prevent direct marketing activities. The priors for these coefficients assume that export promotion expenditures do not decrease consumption of Canadian beef. Also, an initial regression estimate was taken with respect to total exports versus total expenditures. The posterior distribution of this coefficient was used as the prior for both the component and country specific coefficient estimates. The elasticities with respect to the five countries are in Table 3 below.

	Lower CI	Median	Upper CI
Japan	0.097	**0.197**	0.299
Mexico	0.184	**0.268**	0.356
EU	0.005	**0.042**	0.115
Hong Kong	0.055	**0.164**	0.279
China	0.163	**0.397**	0.614

Table 3: Export Promotion Estimated Elasticities by Country

Using the average cost of production from AgriProfit$ 2016-2020 we recover estimated BCRs. These are located below in Table 4.

	Lower CI	Median	Upper CI
Japan	2.7:1	**5.6:1**	8.5:1
Mexico	3.8:1	**5.5:1**	7.4:1
EU	0.02:1	**0.1:1**	0.4:1
Hong Kong	1.4:1	**4.3:1**	7.3:1
China	2.2:1	**5.3:1**	8.2:1

Table 4: Export Promotion Estimated BCRs by Country

The results clearly suggest that the export promotion expenditures, with the exception of the EU, have had far greater benefits than costs. The confidence intervals are somewhat tighter than expected. With the exception of the EU, all estimated BCRs are in the same neighborhood of roughly 5:1. These results are smaller than Cranfield who estimated a BCR of 16.5:1. The EU results are concerning in that they suggest that the EU expenditures had almost no effect on EU consumption of Canadian beef. Discussion with personnel indicate that export promotion

expenditures in EU, during the time frame examined were aimed at global trade such as trade shows that happen to take place in the EU as opposed to specific expenditures meant to promote consumption of Canadian beef in the EU. Given this, the results are expected because the EU expenditures are not necessarily tied to increasing Canadian beef consumption in the EU. If specific consumption activities are undertaken, a targeted case study would be appropriate.

R code for this analysis is located in appendix 4 and labelled "country_final.R" and "bayes_country2_notpp.stan". Plots of the posterior distributions and trace plots are located in appendix 3.

6 Export Promotion Benefit-Cost Ratios by Component

Market expenditures were allocated into five categories: market development; consumer marketing; industry education; market intelligence; and stakeholder communication. Similar to above, the priors for these coefficients assume that export promotion expenditures do not decrease consumption of Canadian beef. As with the country specific regressions, an initial regression estimate was taken with respect to total exports versus total expenditures. The posterior distribution of this coefficient was used as the prior for the component specific coefficient estimates. This has the effect of decreasing estimation error through shrinkage – a common practice in statistics. The elasticities with respect to the five component areas are in table 5.

	Lower CI	Median	Upper CI
Market Development	0.025	**0.072**	0.121
Consumer Marketing	0.036	**0.062**	0.086
Industry Education	0.006	**0.014**	0.021
Market Intelligence	0.002	**0.004**	0.006
Stakeholder Communication	0.002	**0.004**	0.006

Table 5: Export Promotion Estimated Elasticities by Component

Using the average cost of production from AgriProfit$ 2016-2020 we recovered estimated BCRs (see table 6).

	Lower CI	Median	Upper CI
Market Development	1.9:1	**5.6:1**	9.4:1
Consumer Marketing	5.4:1	**9.2:1**	13.0:1
Industry Education	3.5:1	**7.3:1**	11.2:1
Market Intelligence	3.2:1	**6.9:1**	10.6:1
Stakeholder Communication	3.2:1	**7.0:1**	10.9:1

Table 4: Export Promotion Estimated BCRs by Component Expenditures

The results clearly suggest that the export promotion expenditures across all categories of marketing have had far greater benefits than costs. No one category stands out as significantly better than the others nor does one category stand out as significantly worse than the others. To some extent, this is affected by the priors, however such was not the case in the country analysis (EU results were far worse than any other country) using the same priors.

R code for this analysis is located in appendix 4 and labelled "country_final.R" and "bayes_country2_notpp.stan". Plots of the posterior distributions and trace plots are located in appendix 3.

7 Research Benefit-Cost Ratios

In this section we detail the research BCRs analysis and results. Unlike previous studies, it was desired to recover BCRs for a variety of research metrics not just carcass weight. This significantly altered the way in which the analyses could be undertaken. We first present the results of the analyses for feedlot operations and then for cow/calf operations as the research metrics for each are different.

7.1 Research Benefit Cost-Ratios – Feedlot operations.

In this section we detail the BCRs with respect to research expenditures as measured by productivity metrics at the feedlot level. Past studies considered BCRs with respect to research by measuring carcass weight. We measure not only productivity gains by carcass weight but also by survival rate, feed conversion, and beef quality. Given we are considering more metrics we do expect to find an aggregate BCR that is higher, and perhaps much higher, than past studies. Note that the feed efficiency metric is negative because it is measured as the feed conversion ratio. That is, a decrease in the feed conversion ratio represents an increase in feed efficiency. The estimated elasticities are in Table 7.

	Lower CI	Median	Upper CI
Carcass weight	0.0070	0.01678	0.02610
Survival Rate	0.0056	0.02524	0.05679
Feed Conversion	-0.02031	-0.00571	-0.00046
Beef Quality	0.03042	0.05935	0.09720

Table 7: Estimated Research Elasticities by Feedlot Metric

Given these metrics are at the feedlot level, cost of production for cow/calf could not be used to recover benefits. Therefore, feedlot margins from the Canfax TRENDS model were used. The estimated BCRs are in Table 8.

	Lower CI	Median	Upper CI
Carcass weight	8.5:1	**16.4:1**	24.1:1
Survival Rate	4.6:1	**21.0:1**	47.2:1
Feed Efficiency	0.6:1	**7.2:1**	25.6:1
Beef Quality	9.6:1	**18.7:1**	30.6:1
Total	**23.3:1**	**63.2:1**	**127.4:1**

Table 8: Estimated Research BCRs by Feedlot Metric

The results indicate that BCRs for research expenditures are 63:1. This is higher, as expected, than past studies which only considered benefits accrued through carcass weight gains. Conversely, our estimated BCR with respect to carcass weight is 16:1 which is lower than both Cranfield and Rude. Similar to past studies we find that the BCRs with respect to research expenditures are roughly double to triple that of marketing BCRs. Within the research metrics, none stand out as either performing significantly better or worse than other metrics.

R code for this analysis is located in appendix 4 and labelled "research_feedlot_final.R", "regression_bayes_research_component_annual.stan" and "regression_bayes_research_component_annual_fe.stan". Plots of the posterior distributions and trace plots for each coefficient corresponding to each metric are in appendix 3.

7.2 Research Benefit Cost-Ratios – Cow/Calf operations.

In this section we detail the estimated BCRs with respect to research expenditures as measured by productivity metrics at the cow/calf level. We measure productivity gains by reproductive efficiency, survival rate, and tame hay yields. The estimated elasticities are reported in Table 9.

	Lower CI	Median	Upper CI
Reproductive Efficiency	0.0039	0.0132	0.0262
Survival Rate	0.0028	0.0225	0.0654
Tame Hay Yields	0.0190	0.0755	0.1431

Table 9: Estimated Research Elasticities by Cow/Calf Metric

Given these metrics are at the cow/calf level, the cost of production estimates from AgriProfit$ 2016-2020 was used to recover benefits. The estimated BCRs are in Table 10.

	Lower CI	Median	Upper CI
Reproductive Efficiency	2.0:1	**6.9:1**	13.6:1
Survival Rate	1.5:1	**11.7:1**	34.1:1
Tame Hay Yields	10.1:1	**40.1:1**	76.0:1
Total	**13.7:1**	**58.7:1**	**123.8:1**

Table 10: Estimated Research BCRs by Cow/Calf Metric

The results indicate that BCRs for research expenditures as measured by benefits accruing to the cow/calf sector are 59:1. This is also higher, as expected, than past studies which only considered benefits accrued through carcass weight gains. Similar to past studies we find that the BCRs with respect to research expenditures are roughly double to triple that of marketing BCRs. In this situation, it does appear that gains in tame hay yields account for a significant amount of the benefits accruing to cow/calf operations.

R code for this analysis is located in appendix 4 and labelled "research_feedlot_final.R", "regression_bayes_research_component_annual.stan" and "regression_bayes_research_component_annual_fe.stan". Plots of the posterior distributions and trace plots for each coefficient are located in appendix 3.

8 Summary and Conclusions.

Canadian beef cattle producers currently pay a mandatory levy, called check-off for each animal marketed. A beef import levy is also applied to all beef cattle, beef and beef products imported into Canada. Provincial check-offs vary across provinces and are paid to their provincial association with a portion paid to the Canadian Beef Cattle Check-off. Through collected levies, the Canadian Beef Cattle Research, Market Development and Promotion agency operating as the Canadian Beef Check-off Agency, provides funding for research, marketing and promotion programs on a national basis.

Two previous studies (Cranfield 2010 and Rude and Goddard 2016) were tasked with evaluating the investments in marketing and research. The driving force behind their results, and ours, were the expenditure elasticities. An elasticity is simply a percentage change in one variable caused by a percentage change in another variable. That is, for example, how much did per capita disappearance change for a 1% change in marketing expenditures. Given the disaggregated measures required for this study such as Benefit-Cost Ratios (BCRs) by country of export, by

type of marketing activity, by various research metrics, a direct accounting approach was necessary to recover BCRs from estimated elasticities. This also allowed benefits to be estimated based on five-year averages rather than very erratic and completely misleading year-to-year data. Moreover, this approach is more transparent. Another notable difference in our analyses is that Bayesian econometric methods were used which allows the incorporation of prior information into the estimation process.

Overall, the results are very reasonable and show BCRs above one in all cases except for the EU market. Specifically, with respect to domestic marketing expenditures -- *including the import levy* -- we found a BCR of 15.4:1. In comparison, Rude and Cranfield found BCRs of 17:1 and 8:1, respectively. With respect to public and stakeholder engagement expenditures, we found a BCR of 16.0:1. Neither the Rude nor the Cranfield study reported BCRs for public and stakeholder engagement. We also estimated BCRs for export promotion expenditures by country. Here we find China at 5.3:1, Hong Kong 4.3:1, Mexico 5.3:1, Japan 5.6:1, and the EU 0.1:1. While the EU shows a very poor BCR, our understanding is that the expenditures in the EU at the time period of the data examined, involve global trade and are not focused on EU trade. In this respect, the result is not very surprising or informative with respect to the EU. Neither the Rude nor the Cranfield studies estimated BCRs by country.

Similarly, we considered BCRs by export promotion activities. Specifically, marketing expenditures were disaggregated into market development, consumer marketing, industry education, market intelligence, and stakeholder communication. We find a BCR of 5.6:1 for market development; a BCR of 9.2:1 for consumer marketing; a BCR of 7.3:1 for industry education; a BCR of 6.9:1 for market intelligence; and finally, a BCR of 7.0:1 for stakeholder engagement. Again, neither the Rude nor Cranfield studies estimated BCRs by marketing activity.

With respect to research expenditures, Rude found a BCR 35:1 whereas Cranfield found a BCR of 46:1. Both focused *only* on gains in carcass weight. In this sense, the results are under-estimated as they do not consider the gains with respect to other metrics such as survival rate, feed efficiency, beef quality, reproductive efficiency, and tame hay yields. Because of the more direct accounting approach, we could recover BCRs for these measures as well. With respect to carcass weight *only*, we find a BCR of 16.4:1, lower than both Cranfield and Rude. However, when we consider additional metrics at the feedlot level, we recover a BCR of 63.2:1, an estimate much higher than past studies. We find a BCR of 21.0:1 with respect to survival rate at the feedlot level, a BCR of 7.2:1 with respect to feed efficiency at the feedlot level, and finally 18.7:1 BCR with respect to beef quality at the feedlot level.

With respect to research BCRs relative to cow/calf operations, we find an overall BCR of 58.7:1. Specifically, we find a BCR of 6.9:1 for reproductive efficiency; a BCR of 11.7:1 for survival rate; and a BCR of 40.1:1 for tame hay yields. Similar measures were not part of the Rude or Cranfield studies.

In conclusion, our results yield very similar BCRs to previous studies where they are comparable. Moreover, our results, like the Cranfield and Rude studies, suggest the BCRs are two to three times greater for research expenditures versus marketing expenditures. However, the very large confidence intervals for our estimated BCRs indicates that the benefits from research expenditures are not statistically higher than benefits from marketing expenditures. Note, previous studies did not recover confidence intervals around their estimated elasticities and thus BCRs.

Appendix 1: Verified Beef and BCRC website Analysis

As stated above, we had problems for the verified beef, BCRC webinars, and BCRC webpage views (at beefresearch.ca). These programs have not been around sufficiently long to include them into the research metric base equations. Moreover, verified beef metrics had missing data in the middle of the time series. What is required to undertake the analysis moving forward is just more time to pass to allow for more data collection. Furthermore, for webinars and webpage views constructing the costs associated with these activities may not be trivial.

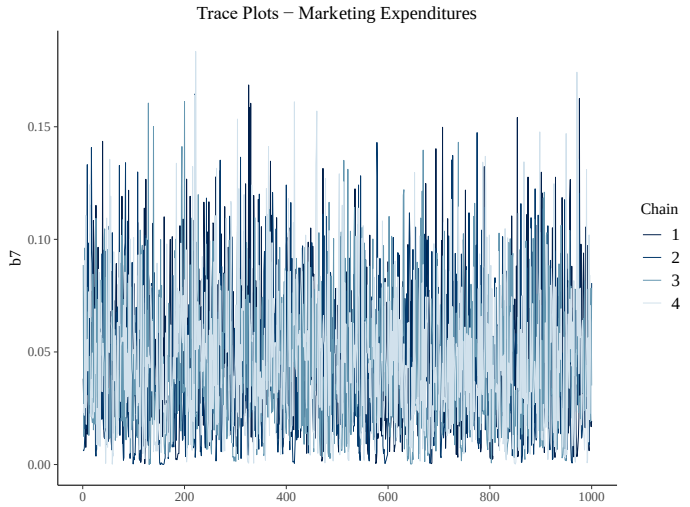
We re-did analyses while including these measures (verified beef, BCRC webinars, BCRC webpage views) into the research metric equations. The results in the main text are **not** based on these subsequent regressions because including these measures significantly limits the data available for the regressions. The elasticities are provided below so that they may be compared to future work. Verified Beef elasticity is per 1,000. Webinar elasticity is per person attended. Webpage is per 1,000 views.

Elasticities	Verified Beef Training	BCRC Webinar Attended	BCRC Webpage Views
Reproductive Efficiency	0.0082	0.0015	0.0023
Survival Rate - Cow/Calf	0.0145	0.0190	0.0118
Tame Hay Yields	0.0398	0.0169	0.0255
Carcass Weight	0.0050	0.0008	0.0010
Feed Efficiency	-0.0098	-0.0051	-0.0054
Survival Rate – Feedlot	0.0136	0.0080	0.0063
Beef Quality	0.0273	0.0011	0.0065

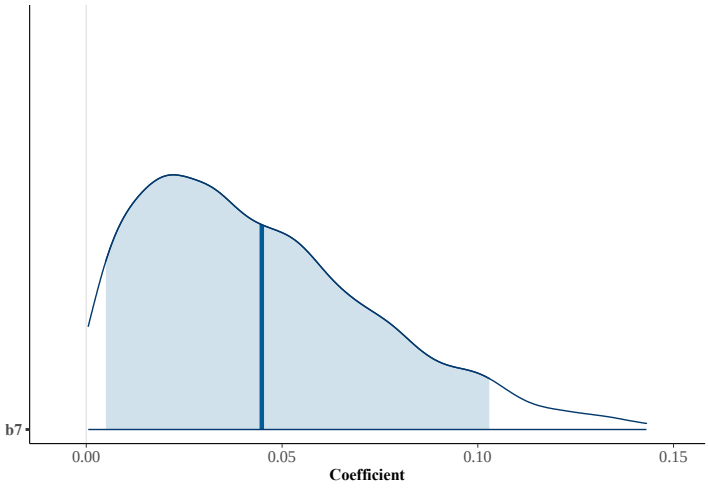
It is difficult to compare the elasticities across different categories because the percentage changes in the denominator are different measures. Nonetheless, the above elasticities suggest that all forms of communication have built awareness and provided support to producers.

Appendix 2: Veal Analysis

An analysis was conducted for veal per capita disappearance and marketing expenditures. Two problems were encountered. First, we used the beef retail price as a proxy for the veal price. This would be valid if in fact the veal and beef prices moved together (or were strongly correlated). However, during the project it was brought to our attention that this is not the case. Second, in order to convert the veal elasticity into a BCR, a cost of production for veal producers is required. Unfortunately, this does not exist either. Results (trace plots and posterior distribution) and code for the Veal analysis are located below. The elasticity of marketing expenditures with respect to Veal per capita disappearance is 0.035 with a confidence interval of (0.004, 0.092).



Posterior Distribution of Marketing Coefficient − Veal

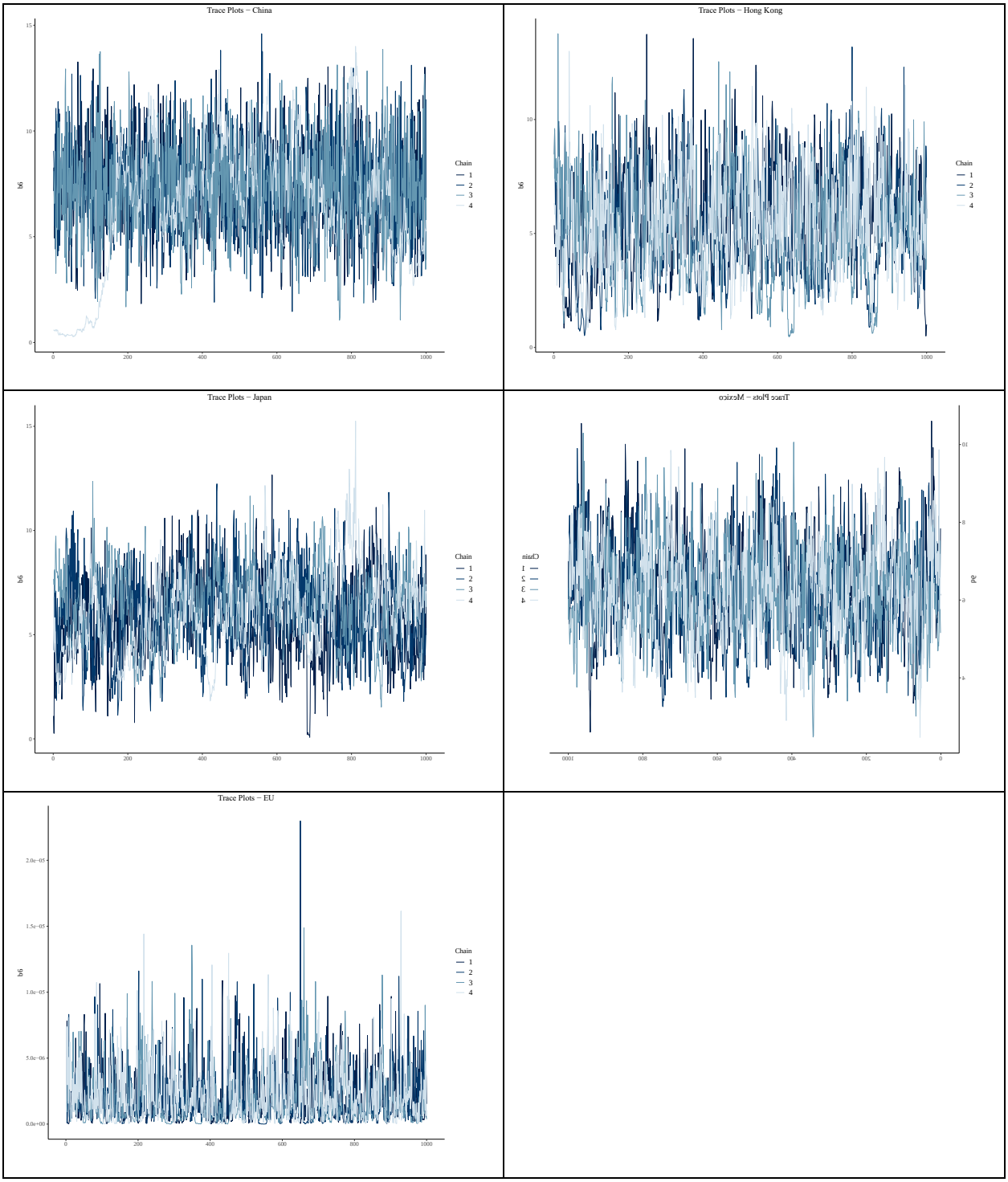


Veal Code (veal.r, regression_bayes_veal_initial.stan)

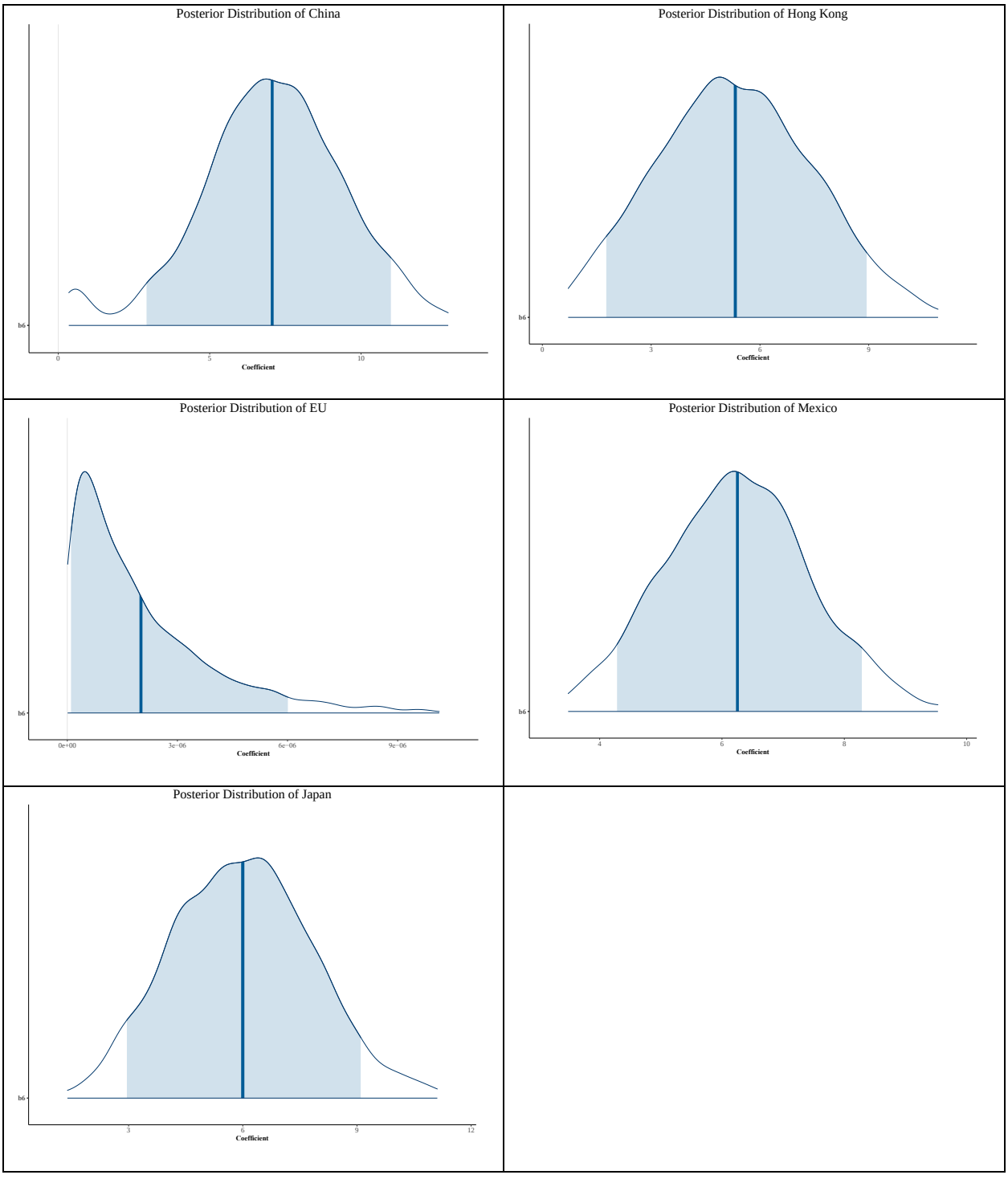
Appendix 3: Econometric Results

Trace and Posterior Plots

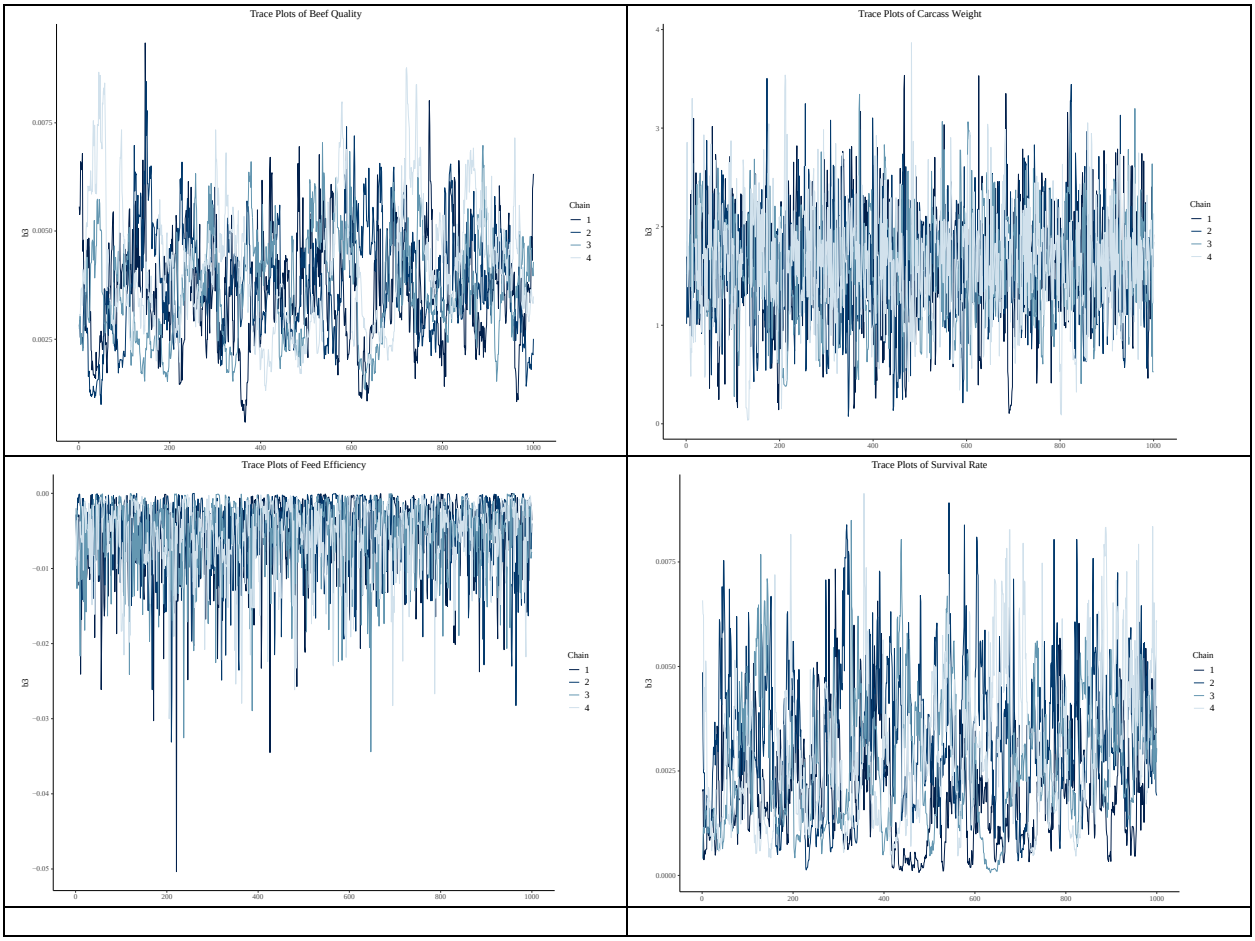
Trace Plots by Country



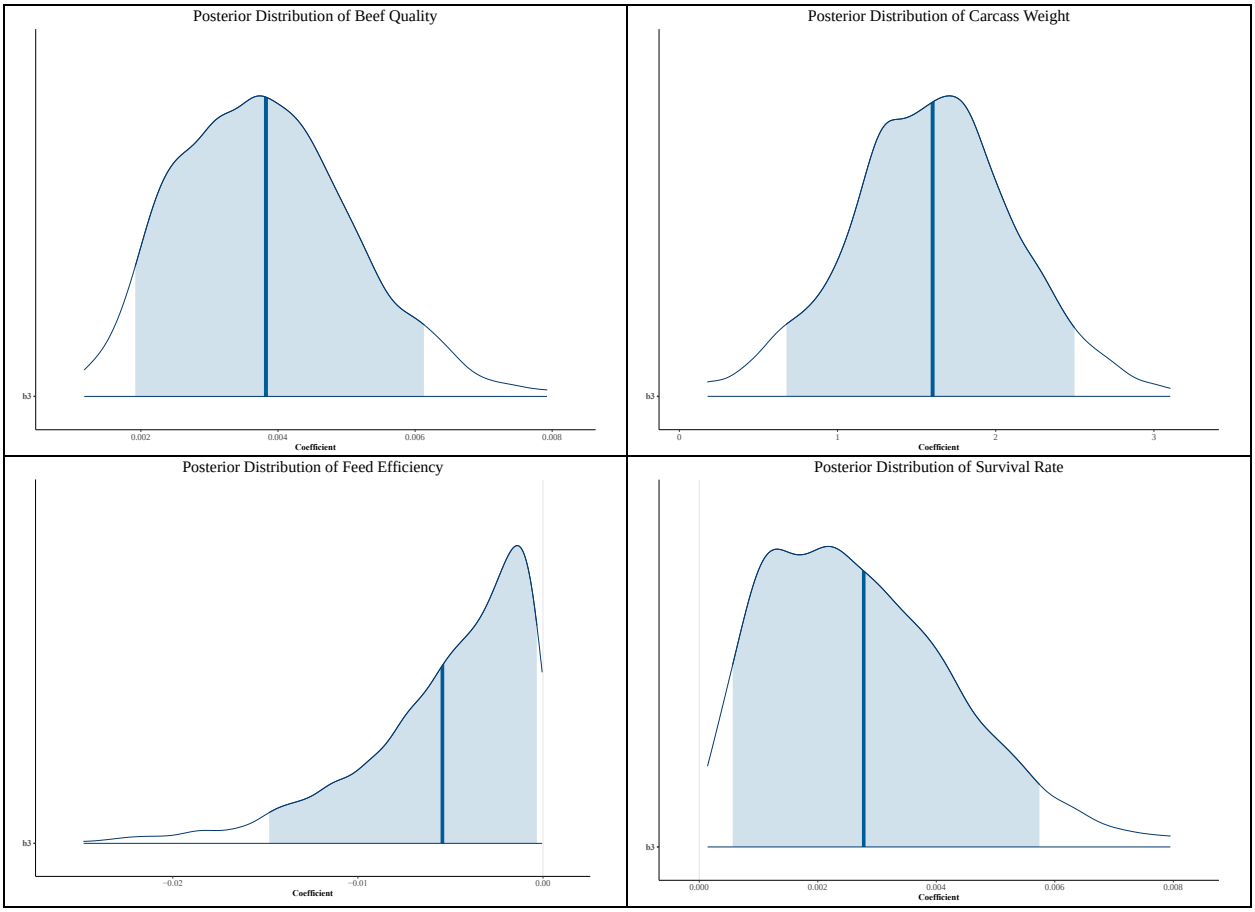
Posterior Distribution by Country



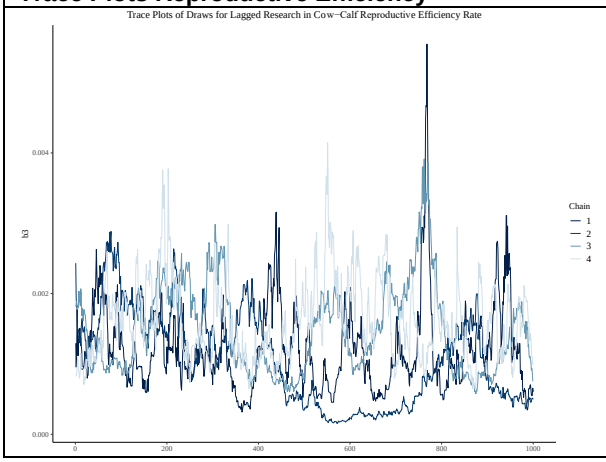
Trace Plots Beef Quality, Carcass Weight, Feed Efficiency and Survival Rates



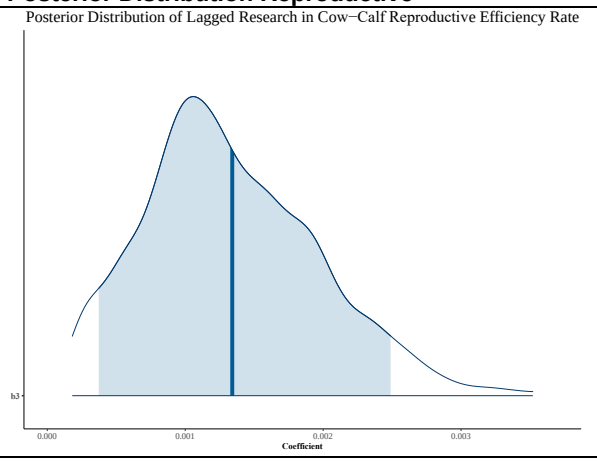
Posterior Distributions Beef Quality, Carcass Weight, Feed Efficiency and Survival Rates



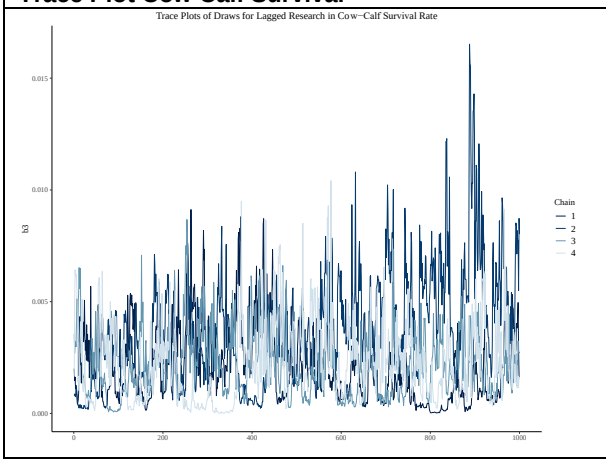
Trace Plots Reproductive Efficiency



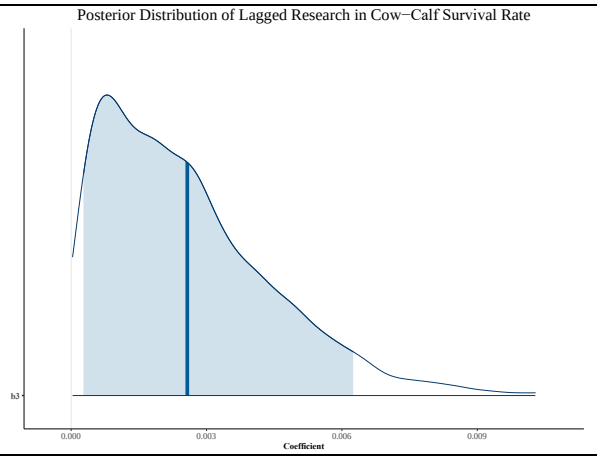
Posterior Distribution Reproductive



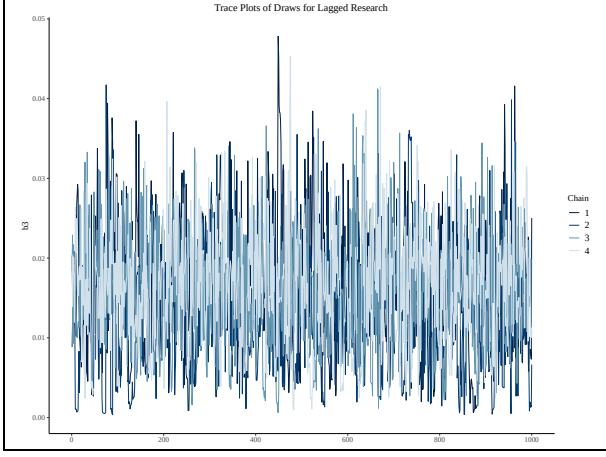
Trace Plot Cow Calf Survival



Posterior Distribution Cow Calf Survival



Trace Plot Tame Hay



Posterior Distribution Tame Hay