FED AND NON-FED CATTLE PRODUCTION

RETURNS IN RELATION TO TRADE FLOW

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. Introduction

The impact of importing beef into the United States has become a major topic of discussion between producers and policy makers. From the producers' standpoint, the National Cattleman's Beef Association has concerns in regards to the quantity of beef that the United States imports. The discussion pertains to imports of low-value, lean trim, non-fed beef negatively impacting the price of slaughter cows and in turn depressing the price of fed slaughter cattle.

From a value standpoint, the majority of revenue received by a producer is not from the salvage value of cull cows, but from the sale of calves, stockers, feeders, and through retained ownership of fed slaughter cattle. The over-all value of non-fed beef products is less than that of fed, or grain finished beef. Demand for both beef products exists in the United States market. However, quantities of domestically produced non-fed beef appear insufficient to meet domestic demand, making imports necessary to meet the demand for non-fed beef. These imports are thought to displace domestic production and thus have an adverse impact on price. The economic question is whether United States resources should be allocated for the domestic production of non-fed beef, or if those of competitors should be utilized.

A competitive advantage exists when production costs alone, not considering benefits to specialization and trade, define an advantage to production. In a competitive market, with the introduction of trade and specialization, the allocation of resources is based on comparative rather than competitive advantage. The objective in trading is to increase the value of output to both trading partners. The low cost producer may choose not to export if output and value can be increased through specialization and trade.

Exports of fed beef products, in value, outweigh non-fed imports. A comparative advantage exists when advantages not only in the costs of production are present, but also opportunity costs and benefits to specialization contribute to a region's advantage. Advantages based on specialization in production and a utilization of resources creates decreased costs and increased output. Debates over imports and what should and should not be done have been increasing in Washington, D.C. (Green). Producer groups are in favor of limiting beef imports to minimize their impact on domestic prices. Consumers prefer the importing of low-grade beef products to reduce prices of processed beef. The negative impacts on producers from increased imports, versus the positive impacts to consumers are at stake. A debate can ensue as to which party retains a greater loss or gain from such trade policy.

The purpose of this research is to determine whether beef trade is indicative of production returns, or if there are theoretic external variables impacting perfectly competitive trade flow. Beef production budgets will be developed, evaluating the returns to production for both fed and non-fed beef in the United States, Canada, Mexico, Argentina, Australia, and New Zealand. These countries were chosen because they represent 98% of the beef imported by the United States. Countries, such as the United States, appear to have greater returns to operating costs for grain-finished beef fueled by exports of the product, and the perception of an advantage. Likewise, non-fed beef producing countries appear to have a greater percentage return for grass-fattened beef due to their export market and perceived production and input advantages. A linear programming model maximizing returns to operating capital, calculated from the budgets, will illustrate optimal trade flow.

The countries, in which the United States primarily exports beef (e.g. the Pacific Rim) were not included in this analysis. The hypothesis of this research stemmed from the depression effects that non-fed beef imports have on domestic fed beef production and the question of efficiency. The assumption justifying the lack of considering the Pacific Rim is that an increase in exports would support the fed beef market in the United States expanding exports, thus further increasing the need for non-fed beef, lean trim, imports. This intervention would be extraneous to the initial question asked.

In a perfectly competitive marketplace returns to capital should be indicative of where a product is produced. With the intervention of government, trade flows may not accurately represent production returns due to producer and consumer subsidies, import quotas, tariffs, and other price and non-price trade barriers. If the optimal trade flows that reflect current returns to capital do not adequately represent the current trade flows between producing and consuming regions, it can be theorized that either production capacity is exhausted or government policies may be in play.

In countries that consume and produce the same product, quotas are often used as a policy tool to protect domestic producers. Whether or not protection benefits the economy as a whole is then debatable. In the case of an exporting region, governments can use producer subsidies, tariffs, and trade negotiations to protect producer interests. True returns are skewed by government intervention, not necessarily representative of the trade that would take place in the presence of perfect competition.

Throughout this manuscript, the implied meaning of competitive advantage will be the calculation of actual costs, i.e. costs that include inputs but may have government subsidies deeply imbedded in input prices (e.g. tariffs or subsidies of inputs, in addition to inports of inputs, tariffs or subsidies on competing inputs or end products, etc.). An absolute comparison is one based on actual costs, those without government intervention, which may be impossible to calculate accurately in this analysis due to the complexity of such interactions. Comparative comparisons or advantages are the actual costs including government intervention, in addition to opportunity costs. Opportunity costs considered highly subjective because of resource allocation, specialization opportunities through production, and the availability of variable inputs.

The United States is thought to have a comparative advantage in the production of grain-finished cattle for a variety of reasons, the utmost reason being the availability of grain. Additional reasons include market structure, breeding programs, large areas well suited to continual animal feeding, technology, and capital. Through the evaluation of competitive advantage, the analysis of costs (not including opportunity costs, interchangeability of industry production, etc.) will establish the return structure that exists for the production of both fed and non-fed beef in the United States, and primary exporting countries of non-fed beef to the United States market.

A comparison will be made between the modeled economically optimal beef trade flow and the actual, current trade flows. A primary assumption of this comparison is that the market currently operates under perfect competition. The lack of primary cost data, the lack of quantifiable inputs of an array of government policies and the interaction of those policies, and the inability to identify and measure other factors that may adversely affect competitive markets (e.g. product information, availability of contingency markets), are constraints to be developed in a model that accurately reflects optimum trade flows under competitive markets. The inability to separate the impacts of government intervention are primary assumptions surrounding data and model problems.

The specific objectives of this research are to determine returns to operating capital for the production of fed and non-fed beef in the United States, Canada, Mexico, Argentina, New Zealand, and Australia, establish current trade flows, and develop a linear programming model determining trade flows maximizing returns to capital, subject to available production capacity and current levels of consumption.

II. Background

A country may be better off specializing in the production of goods and services for which its resources maintain the lowest opportunity cost, sharing surplus among other countries, than merely attempting to meet all production needs individually (Hahn et al, 1990). This condition exemplifies a comparative advantage, in comparison to a competitive advantage. Comparative advantage of a region is based upon opportunity costs, allocation of resources, and specialization in production, not only lowering costs but, more importantly, increasing production efficiency. Competitive advantage measures the production advantage attributable to costs of production. Competitive advantage in the production of fed and non-fed beef has been theorized between producing countries but not quantified. Studies have addressed the impacts of imports and exports in beef qualities, and estimated elasticities (Kalantar, Gum, and Menzie, 1975; Conner and Rogers, 1979; Brester and Marsh,1998, 1999; Brester and Wohlgenant, 1997), but none have cited comparisons between marginal returns on operating capital from differing production regions.

In today's open market world, capital will be attracted to opportunities that yield the highest return. Thus, marginal returns on operating capital may provide a good indication to compare opportunity cost. Cost of production estimates have been studied for corn, soybean, and hogs with the results indicating that the United States does exhibit an advantage in feed and labor productivity (Fang and Fabiosa, 2002). A study comparing China and the United States in numerous agricultural products (rice, wheat, other grains, oilseeds, cotton, cash crops, fruits and vegetables, swine and poultry, and other livestock) state that there is an advantage in the United States for available capital (Hayes and Fuller, 1999). Focusing on countries that primarily export non-fed beef to the United States, the literature implies that the United States maintains an advantage in the production of grain fattened beef (Brester and Marsh, 1999; Freebairn and Rausser, 1975). A comparison of competitive costs will quantify the competitiveness of the United States domestic market with respect to the major import contributors, Canada, Australia, Argentina, New Zealand, and Mexico, and establish whether there is a need for United States producers to compete with imports (Sharples, 1990). The U.S. beef industry is thought to have an advantage through industry structure, breeding programs, and availability of inputs in producing grain finished beef (Welsh and Llanes, 1996; Conner and Rogers, 1979). The availability of "cheap" grain as a feedstuff, and government subsidies are stated in most all published literature as being primary factors for the United States' lower cost of producing grain-finished animals.

Identifying the returns to operating capital for fed and non-fed beef in the United States and countries that primarily produce non-fed beef will aid in determining optimal trade flows. Lean trim imports from grass-fattened cattle produced in Australia, New Zealand, and Canada represent 80% of beef imported into the United States (Brester and Smith, 2000; Brester and Wohlgenant, 1997), in addition to Mexican and Argentinean imports. The impact of imports on United States producers has been controversial (Brester and Marsh, 1999; Peel, 1996). Controversy stems from the impact of imports on feeder and fed cattle prices on consumer prices, on consumer's tastes and preferences, consumer welfare, and the use of agriculture commodities as leverage tools through trade negotiations in the political arena.

Freebairn and Rausser (1975) state that the domestic supply of beef is self-adjusting over the long run and non-fed beef production varies inversely with imports. United States imports and exports have indirect impacts on the prices of fed cattle, non-fed cattle, and feeder cattle (Brester and Wohlgenant, 1997). An econometric model built by Brester and Marsh (1998, 1999) addresses the impacts of imports, exports, substitution effects, and consumer spending upon the domestic industry and likewise the prices of slaughter cattle. Brester and Marsh (1999) estimated that the lack of both importing and exporting beef would result in negative impacts on U.S. beef and cattle prices. A decrease of United States exports would decrease the price of fed and feeder cattle, while a decrease in imports would cause fed production to be shifted towards non-fed production, decreasing producer revenue in fed and feeder cattle. An increase in the price of domestic cull cattle may result from a decrease in imports, but the over-all impact on revenue would be negative given the shift in resource allocation. More resources would be allocated to non-fed beef production than to fed animal production. A greater revenue stream is earned from the sale of calves or feeder cattle for the grain fattening market. An increase in the price of cull cows or grass-fattened animals would not offset the decrease in revenue resulting from a decrease in the production of feeder cattle and calves. Through academic research, the increase in non-fed beef product prices resulting from a decrease in lean-trim imports was seen to be greater than the congruent decrease in fed cattle price (Conner and Rogers, 1979).

Brester and Wohlgenant (1997) built a linear elasticity model that found an increase in the price of fed cattle due to expanded export markets offset any losses to the producer from the decreases in the price of non-fed cattle, the decrease a result of imports. A general equilibrium model by Gaitan and Pavel (2000) established that a decrease in food prices would cause exports to expand, this then increases demand and prices. Increasing fed and feeder cattle production, decreasing non-fed cattle production and the domestic price of non-fed beef, would cause a decline in beef price even without a depression effect from imports (Brester and Wohlgenant, 1997; Hahn et al, 1990). A larger impact on producer prices would be seen from exports of high-value meats than imports of low-value meats (Parcell, Schroeder, and Kastens, 1998). The United States exports higher valued meat products, and is a net exporter of meat products by value. Most exporting countries have excess capacity in the production of red meat (Koo, Karemera, and Taylor, 1994), leaving room for expanded fed beef marketing and export.

In regards to trade flows and policy implications, an econometric model of beef imports by Roberts and Martin (1984) emphasized the need to examine the implications of governmental policy as a result of an increase in import quantities. A quadratic programming model estimating consumer surplus, producer profits, and government revenue changes concluded that there are various benefits on the side of both the producing and consuming regions when trade takes place in a competitive market (Asuming-Brempong and Staatz, 2000). Koo, Karemera and Taylor (1994) cite exporting countries as primarily promoting exports through trade agreements and domestic producer subsidy programs while importing countries protect their interests through quotas, trade restrictions, and in some instances subsidies to consumers in an effort to promote consumption of domestically produced products. In some instances there is a refusal to purchase imported commodities regardless of price due to consumer perception (Goto, 1997). With trade agreements, the less differentiated the commodity the less of an impact trade agreements have on its price (Goto, 1997). Non-fed beef is a less differentiated product than fed beef, thus increased trade in non-fed beef would have a smaller effect on price than increases in trade from grain-fattened beef. Arguments and models can be cited supporting the reduction of tariffs and quotas, allowing the market to act in accordance with comparative or competitive advantage, allocating available resources to the best uses, and including transportation costs (Casario, 1996; Koo, Karemera, and Taylor, 1994; Landstra; Melton and Huffman, 1990; Rogowsky, Linkins, and Tsuji, 2001). The benefit from specialization and utilization of available resources is diminished when barriers to trade and excessive transaction costs are present (Barrett, 2001). On the note of transportation costs, complete data of all costs incurred is sketchy at best and all possible transaction costs can never be observed (Barrett, 2001). The observations of trade flows should reflect production costs, given rational decisions in regards to profit maximization. Bond found through analysis of transportation liberalization analysis that transportation infrastructure and thus transportation costs were lessened by tariff restrictions because of government intervention, thus choosing transportation costs and levels that maximized social welfare, not market competition. This is obviously an impediment to free trade.

Research on fed and non-fed beef, up to this point, is predominantly theory based. There have been no quantitative evaluations of competitive advantage in beef production. No research has addressed the comparative returns to capital for countries in which the

United States imports non-fed beef products. The research that stems from past literature will quantify the returns associated with fed and non-fed beef cattle to determine if there exists economic rationale for the United States imports of non-fed beef.

III. Data

The production of beef slaughter cattle follows two production practices, grass fattening, or non-fed beef, and grain fattening, or fed beef. Due to the availability of resources and cattle breeds, producing countries generally follow one production practice or another. The United States mainly produces fed beef while importing mostly non-fed beef products. Do to the lack of dis-aggregation of the data currently collected by statistical resources; this percentage of production can solely be an assumption at best.

Returns to operating capital for the production of fed beef will be evaluated via budget analysis. The revenue received by the production of the animal, less the cost to produce the animal, will then be divided by the total cost, giving a comparable percentage of returns. Only variable costs will be considered do to the availability and integrity of the fixed values that were found through research. The production countries included in this analysis are the United States, Canada, Mexico, Argentina, New Zealand, and Australia. Though perfect data and previously compiled budgets will not be available, interpretations of the data and resources that are available will be utilized. Assumptions and averages will be made and addressed where applicable. Budgets for the countries that import large quantities of fed beef from the United States were not calculated simply because the price depressing impact of imports into the United States was the sole focus in the manuscript. It is hypothesized that Pacific Rim countries would have exhibited a loss in returns to production for the beef that they raise and consume, requiring a greater amount of imports in comparison to production capacity.

Fed and Non-fed Budgets

The cost of purchasing a feeder steer, feed costs, marketing, minerals, protein supplement, veterinary care, death loss, and the sale price of the animal will comprise the expense items included in the budgets. Each budget will be calculated in the respective country's currency**.** The percentage returns, dividing the revenue received less costs incurred by the total costs from producing the slaughter animal, will make values comparable across countries. Revenue is defined as the slaughter price of the animal multiplied by the slaughter weight of the animal, less the percentage of death loss experienced through the feeding process. The costs incurred are a total cost of purchasing the initial animal, feed costs, marketing, minerals, supplement, and veterinary care. In the financial world where capital is injected into investments based solely on the potential return to the investment, it is logical to calculate investment viability from the percentage return from initial investment. The analysis from the budgets is based wholly on economic return and thus the most logical evaluation would be borrowed from the financial industry. The comparability of these budgets is time and production related. The time frame in which the data were collected spans 2000 to 2002. The production assumptions in each case have not been altered from that of their respective country, but are represented by the production assumptions referenced in Appendix A. All budgets are representative of the expenses required to produce one animal. The production practices may not be exactly comparable across countries but they are a representative of a "fed" practice, and a "non-fed" practice for the specific country. Production practices were not forced to converge, fearing that altering the assumptions under which the data were compiled would jeopardize the integrity of the data itself. Cull cows are considered non-fed beef in all evaluations.

Budget numbers for the United States will be a production weighted average of high production regions. Iowa State University, Penn State University, South Dakota State University, and Kansas State University have the most complete budgets for fed cattle and a compilation of the most accurate numbers will be used. As noted in Appendix B, the United States budgets themselves include calculations that were taken from each source referenced. Some values were found from numerous sources and averaged based on the density of the production region in which the data collection took place, and the appearance of outliers. Extremely high values or extremely low values of any variable were not considered, as they would represent extremes in United States input prices and quantities. In the budget, the calculations for slaughter weight and yearling steer weight were obtained from Iowa State University livestock budgets. The amount of feed was also gathered from budgets accessed through Iowa State University. The costs of both the slaughter animal and the yearling were provided through the Animal Marketing Service – USDA. Death loss percentage was provided by Kansas State University budgets compiled by Rodney Jones. The values of minerals and supplements were found from South Dakota State University budgets, compared against that of the Iowa State University budgets. The value of hay was obtained from Iowa State, the value of silage from Penn State, and the value of pasture a compiled average of Penn State, Iowa State, South Dakota State, and Kansas State budgets.

The British Columbia Ministry of Forestry and Agriculture, and the Ontario Ministry of Forestry and Agriculture have the most complete records for fed cattle budgets within Canada. The price of both the slaughter animal and the yearling steer were obtained through Agriculture and Agri-Food Canada. The weights of the animals, and the quantities and values of minerals, supplement, and feed were all found through the Ontario Feedlot Cost of Production Calculator. The value of barley was obtained through the British Columbia Ministry of Forestry and Agriculture, Planning for Profit budget. Orient Overseas Container Limited provided the cost of transportation. The weight of the carcass for transport was an average of the percent carcass body weight at slaughter, 65.2%.

Mexican budget calculations have been drawn from data put together by Peel (2001). The fed budget, in its entirety, was taken from a fed heifer budget compiled by Dr. Peel during a sabbatical. Orient Overseas Container Limited provided transportation costs, and as with the Canadian transport, the carcass body weight shipped was assumed to be the industry average carcass weight percent of live weight, 65.2%.

Argentina fed cattle budget data are compiled and published by the Instituto Nacional de Tecnologia Agropecuaria, or INTA. The INTA data are calculated on a per hectare basis and from stocking rates converted into per animal values for comparability. The INTA budgets were used in their entirety. The closest representation in the INTA budgets for the fed animal production was that of feeding silage on pasture with the removal of ‘Rollo’, or round bales from the pasture being credited as additional revenue. The non-fed production practice included the feeding of ‘Rollo’, and thus was included as a cost of production. Orient Overseas Container Limited was the source of the transportation cost as noted previously.

New Zealand's Ministry of Forestry and Agriculture and Beef New Zealand maintain data on non-fed cattle, or dairy steers that are fattened on grass rather than grain. The values provided by both entities are comparable to one another. Where applicable, an exact average of the two values was made. The New Zealand production budgets that were available through Beef New Zealand and the Ministry of Forestry and Agriculture assume that beef production is complimentary to that of sheep production. The separation of the two industries in the available budgets without additional data was thought to have jeopardized the data. For the fed calculations in New Zealand, assumptions have been made based upon the similarities between the New Zealand market and that of the Mexican market since New Zealand is void of any form of fed cattle production. Values were interpolated from the Holstein feeding budgets (Peel, 2001). All figures were converted to New Zealand dollars, the slaughter price of the animal being a representative price of a New Zealand slaughter animal. The prices of both the slaughter animal and the steer were taken from New Zealand Agri-fax, transportation costs provided by Orient Overseas Container Limited. All other variable quantities and prices were taken from a Holstein finishing budget compiled in 2001, by Dr. Peel.

Australian fed cattle budgets were available through the Australian Government Department of Agriculture, Fisheries, and Forestry. An analyst with the National Livestock Reporting Service, Meat and Livestock Australia provided the value of all livestock in the budget. Costs of veterinary, marketing, fodder crops and pasture were found in budgets provided by the New South Whales Agriculture Farm Enterprise Budget. Orient Overseas Container Limited provided transportation costs.

Returns to operating capital for non-fed beef production will also be evaluated via budget analysis based upon a single animal production practice. Data were gathered times over the span of 2000 to 2002. The non-fed budgets were comprised of the same inputs as the fed budgets, except feed used and costs will differ. The producing countries will be the same as those evaluated for fed cattle. Mexico, Argentina, New Zealand, and Australia are predominantly non-fed beef producing countries and should evaluate the level of advantage or disadvantage that the United States has with respect to non-fed beef production. Percentage returns, revenue less costs divided by cost, can be used to evaluate the competitive advantage in the production of non-fed beef, given a perfectly competitive, efficient market.

In the United States, the only true source of non-fed beef on any large scale is that of cull cows. If non-fed beef were to be produced on a large scale in the United States in addition to the hypothetical industry, it would likely feed yearlings on pasture. Thus, non-fed beef budgets were developed using a feeding program for grass-fattened steers in Kansas. This budget was developed from the grass fattening budgets of Kansas State University, Penn State University, and South Dakota State University. In the United States cattle industry, cattle buyers commonly discount an animal that is thought to have been fed on grass, therefore the slaughter price for the grass fed animal is a discounted price of a fed animal based on a grade and yield discount, taken from a simulation model built by Dr. Clem Ward and Dr. Darrell Peel; the Packer-Feeder Simulation Model. The weights of the yearling and slaughter steers were found in a Kansas State University budget for Summer Grazing of Steers. The Animal Marketing Service division of the USDA provided the values associated with the animals. Values of grain feed were found with South Dakota State University. The cost and quantity of both hay and pasture is a compilation of values found with Iowa State University, Penn State University, Kansas State University, and South Dakota State University. The value of silage was found through Penn State budget material. The carcass body weight is an industry average.

Canadian budgets were available for yearlings on dry land, the closest enterprise to a true grass fattening operation. Budget values were available from the British Columbia Ministry of Forestry and Agriculture, along with the Ontario Ministry of Forestry and Agriculture. The value of the slaughter animal and the yearling were found through Agriculture and Agri-Food Canada, the amounts and weights of the animals were found in Ontario Feedlot Cost of Production calculations. The amount and value of minerals and supplement are taken also from the Ontario Feedlot Cost of Production Calculator. The amount of pasture is contained in a budget from Yearling on Dry-land, British Columbia Ministry of Agriculture, Fisheries and Food, and the value of that pasture represented in and budget of Planning for Profit, published by the British Columbia Ministry of Agriculture, Fisheries, and Food. The transportation cost is provided by Orient Overseas Container Limited.

Mexican data were obtained from Peel (2001). In its entirety, the budget numbers are drawn from a budget for grass finishing bulls. Orient Overseas Container Limited provided the transportation cost.

Argentina data are from the INTA, grass fattened production termed medium complete cycle production. The entire budget was drawn from a budget published by the INTA. Orient Overseas Container Limited provided transportation costs.

Beef New Zealand and the New Zealand Ministry of Forestry and Agriculture have numerous data banks for use in developing budgets. Beef production, though all grass fed, is regarded as a complimentary production practice to sheep production and budgets independent of those including sheep production were not available. Grazed forage comprises 95% of all beef diets in New Zealand. Weights of the animals were found through Massey University and the values were provided by Agri-fax New Zealand. Aggregated values of inputs were drawn from a Sheep and Beef Monitoring Report put out by the New Zealand Ministry of Forestry and Agriculture. Carcass body weight conversions were obtained through Agri-fax New Zealand, and transportation costs provided by Orient Overseas Container Limited.

The Australian non-fed beef budget data were found through the Australian Government Department of Agriculture, Fisheries, and Forestry. Weight and amounts of animals in the estimated production were found in a New South Whales Agriculture Farm Enterprise Budget. The values of the animals were acquired from an analyst with the National Livestock Reporting Service, Meat and Livestock Australia. The values of veterinary costs, selling costs, and feed were taken from New South Whales Agriculture Farm Enterprise Budget. Orient Overseas Container Limited provided the transportation cost.

Assumptions and conditions for each country and the production practices of each can be found in the non-fed table located in Appendix A.

The linear programming model will allocate resources based upon the percentage returns in each country evaluated and for each production practice. Also included in the linear programming model will be the transportation costs between each country, represented in United States dollars in all scenarios.

Transportation Costs

Cost of transportation for beef products were acquired through a representative of Orient Overseas Container Line Limited (OOCL). The ability to find data pin-pointing the costs of transportation finitely is apparently of no concern to firms shipping product. The most accurate and justifiable value for transportation was that of $0.06 per pound to the west coast of North America, and $0.07 to the east coast, origins being from either the Pacific Rim or the Southern Hemisphere. Ground shipment charges for trade between Canada and the United States at $0.0489 per pound, and Mexico and the United States at $0.044 per pound. Due to the lack of availability or qualified sources, the average shipment rate of $0.065 per pound was used as the transportation cost between countries of similar distances as the United States and any of the Southern Hemisphere countries; Australia, New Zealand, and Argentina. For transportation between Australia and New Zealand, the two countries closest to one another, were estimated to be one-sixth the cost to ship a ton of meat from either country to the United States. For all other like distanced origins and destinations, Argentina to New Zealand, Argentina to Australia, Canada to Mexico, Canada to Argentina and Mexico to Argentina, the similar distances were calculated as costing the same as shipments into the United States, $0.065 per pound.

Percent return is a measure for comparison between countries; those with the highest returns to operating capital and management, given resource constraints, will be represented as having a competitive advantage in the production of fed beef. Tables of the assumptions pertaining to production practices are found in Appendix A.

The resulting percentage returns from the data collected should give a clear indication as to which country has a competitive advantage in the production of fed and non-fed beef, given the assumptions noted. The returns included in the linear programming model will determine the most appropriate allocation of resources given the maximization of returns. The return maximization approach will define a competitive advantage but will not include a consideration of alternative production opportunities necessary to determine a comparative advantage. Even if the returns are the greatest, alternative production opportunities in consideration with trade enable greater levels of consumption, a country may or may not produce the product that has the highest returns, rather the most efficient or advantageous, given the ability to acquire other products through trade. However, the assessment of competitive advantage can be made between fed and non-fed beef production and this assessment may provide a starting point for analyzing current trade flows.

The production practices from each of the selected countries differ in structure and practice. Since the production of beef stems from market structure and input availability, some markets are more adept at producing one type of beef than another, in addition to the sociological aspect of what has been produced historically.

Beef production and consumption data for the selected countries is available through the United States Department of Agriculture Foreign Agriculture Service, in thousands of metric tons. The amounts of beef products that are imported and exported from each country were available through the United Nation's Comstat database.   The

United Nation's quantity data is published in kilograms, and values in United States dollars. Kilograms were converted to metric tons to enable comparison of production and consumption data in the analysis. If current trade flows are not representative of the trade flows simulated based upon returns to capital it may be concluded that other factors may exist that affect the current flow of trade. The assumption that returns to capital will be representative of trade flows establishes that the market should be perfectly competitive.

Through a conceptual understanding of each respective market, acquired through extensive reading of ever facet of the beef industry, in all applicable regions, assumptions were made to compile the data needed for evaluation. These assumptions are listed in the tables contained in Appendix A. A discussion of each is appropriate.

In the United States, fed cattle are predominately produced as opposed to grass fattened, or non-fed cattle. The market structure, breeds, and pricing structure are all tailored for the fed beef industry. It is relatively unheard of to grass fatten beef on a large scale. Calves are started on grain rations at 500 to 600 pounds in weight and fattened until they reach 1050 to 1200 pounds. The feed can range from corn and hay, to silage of various composites, supplemental nutrients, and milled feed. Feeding regimens are designed to be from 150 to 230 days in duration, dependent upon the amount of protein in the feed and the desired quality of the weight gained. The United States' method of finishing an animal is highly intensive and thus death loss, on average around 1%, is less than might be expected in harsher conditions or on open pasture. As mentioned previously, the only large quantity of non-fed beef that is produced in the United States is a result of the cow/calf industry in that after the cows, which have been living on pasture, have outlived their usefulness in the herd they are culled and slaughtered. Obviously this action is not the focus of the beef industry, but rather a by-product. 50-50 trimmings, or 50% lean, grass fed meat that is mixed with 50% of the meat from a fed animal are the basis for the lean, or non-fed beef category. 50-50 beef is used to make 90-10, 80-20, and 70-30 ground meat products. In the United States and Canada these products are mostly the result of cow slaughter, differing from that of the other countries in that the non-fed beef is derived from slaughter cattle that have been fattened solely on grass pasture. The non-fed assumptions that were made for the budget are an adaptation of feeding steers on pasture, and a slaughter price that is a discounted fed steer price, calculated at a discount due to the lower grade of animal from grass fattening. The discount rate used was taken from a pricing model built by Dr. Clem Ward and Dr. Darrell Peel for a Packer-Feeder simulation model. The discount rate is applied to the grade and yield of the animal. The grass fattened carcasses were assumed to be select with a yield grade of 4-5, 3 at best. The production practice of fattening cattle on grass, would likely produce a greater death loss. These losses were conservatively calculated at 1%. The term of feeding on pasture is estimated at 150 days. This is the most accurate and longest period budget that could be found in the literature. This budget provided for 200 pounds of gain but was well represented in the data and few assumptions had to be made. There are no available budgets for feeding cows on grass solely for the purpose of slaughter. The inclusion of the value of the calves produced from such was included in all.

In Canada, the industry is run in largely the same manner. Fed beef production is the focus and only cull cows contribute to non-fed beef numbers with any magnitude. Finishing is conducted over an average of 300 days by the use of hay, corn, corn silage, and stimulants. The death loss in Canadian feedlots is a bit higher than that of United States feed lots at 2%. The estimates that were made for a non-fed industry are also taken from the modification of a fed steer production practice with a discounted slaughter price, again assuming a select 4-5 yield-grade animal, similar to the United States industry. Dry-land pasture over 120 days, though short, with a gain of 200 pounds is the closest assumptions that could be made to preserve the integrity of the data. Though non-fed, grass fattened meat, is produced in Canada, the production of beef itself is entirely different from those countries in the Southern Hemisphere.

Mexico has a larger demand for fed beef than it has grain to produce. Thus, Mexico is a net importer of grains. Feedlots, are not as plentiful as in the United States or Canada, and the Mexican feedlots feed cattle through the use of grains and silage over an average 112 day period. The death loss in the feedlots is calculated at 0.5%, less than that of either the United States or Canada. There is a grass fattening industry in Mexico, which utilizes approximately half of the cattle produced. These cattle remain on grass pastures for up to 428 days with supplements of minerals. Mexico has available land that is not competing with crop production, allowing for the use of pasture in fattening animals. This unused, non-competing pastureland alone establishes a difference in the market structure between that of Mexico and the United States or Canada where land for grazing is scarce.

For Australia, the industry has recognized the profitability of producing fed cattle and exporting to the Pacific Rim. Only a small portion of the cattle in Australia are currently fed grain due to the lack of grain availability. The industry can be judged based on the production practices that have emerged and are being refined. Baled silage, stored grain, and crop stubble are the most commonly used feeds for fed cattle rations and have the most accurate data available. Like Canada, the feeding process incurs a death loss of 2%. The infant fed cattle industry that currently exists is representative of United States and Canadian influences. Non-fed is the predominant beef production practice for reasons similar to those of Mexico. Large amounts of land not in competition with crop production are available for the production of grass-fattened cattle. Small amounts of grain may supplement forage during extremely dry falls. The age of cattle fattened on grass pasture at the time of slaughter is older than that of the cattle that are fed grain, and especially older than the animals in the Canadian and United States production practices.

In New Zealand fed cattle production does not occur commercially. All of the cattle produced in New Zealand are pastured on grass until appropriate slaughter weight, or their useful life in the dairy industry has expired. The assumptions that were made in order to develop a budget for fed beef in New Zealand were taken from the similarities between New Zealand and Mexico. The reason for the assumption in similarities is that Mexico has a large dairy industry using dairy-bred cattle, similar to those in New Zealand, thus producing a fed animal in New Zealand would hypothetically be similar to the grain fattening of a Holstein heifer in Mexico. The climates are similar as is the need to import grain for finishing due to the lack in both cases of adequate grain production. All denominations were converted to New Zealand dollars. The assumptions were for the grain fattening of a Holstein heifer from the weight of 100kg to 420kg over 240 days. The death rate is also the same as for the Mexican Holstein budget at 1%. The parallels in the Mexican budget are the closest representation of what a New Zealand fed cattle industry might look like. The dairy industry in New Zealand is the foundation of the market structure for cattle, and also the reason for the breeds produced.

The most effective representation of a beef industry in New Zealand is that of grass fattening bull and steer calves up to the age of two years. The weights are assumed to start at 300kg and be slaughtered at 400kg. The bulls fed on grass have a higher and faster gain than that of steers and produce leaner meat. This meat is less tender than that from a steer. An assumption in regards to the budgets is drawn from the lack of separation between sheep production and beef production in New Zealand. Feeding cattle for slaughter is not the focus of the cattle industry in New Zealand, milk production is. Slaughter cattle production is calculated as a by-product of sheep production, as the separation of the two practices in the budgets was not necessarily evident.

Argentina has a cattle industry similar to that of Mexico. Extensive land area for the pasture feeding of animals is available and the lack of sufficient grain to support a grain fed industry is apparent. Fed beef in Argentina is a smaller proportion of the cattle slaughtered than that of grass fattened beef. Feeding programs are comprised of pastured animals supplemented by silage, which does not define a textbook feeding program but is the most accurate industry to allow a comparison between Argentina and the other countries. The production of fed beef is based on feeding of steers or heifers from weights of 180 and 170kg to 370 and 290kg respectively. From the data compiled and published by the Instituto Nacional de Tecnologia Agropecuaria, the length of time for this production to occur was not cited. The production of non-fed beef or complete cycle production as referred to in the Argentinean data is simply of pasturing steers and heifers on grass pasture, starting them at 180 and 170kg respectively. Non-fed slaughter weights were not listed for steers or heifers, only the bulk value of the slaughter animal. The assumption will be made that the slaughter weight is similar to that of the fed beef production, approximately 370 and 290kg respectively.

In some cases assumptions and interpretations of the available data were necessary as the data may have been incomplete or the production practice simply does not currently exist. A “best effort” has been made in all cases to compile what is representative of the beef industry. These assumptions and interpretations are documented in Appendix A. Future research efforts may begin by revisiting the validity of these assumptions as the production practices in each country become more institutionalized. Mentioned in the case of Mexico and Argentina, and the assumed case in New Zealand, the existence of sufficient amounts of grain is the most limiting factor for the production of grain-finished beef. It may be cheaper to move the animal to the feed due to a seven or eight to one feed conversion ratio, than to ship or cultivate grain.

IV. Methods

The development of enterprise budgets for fed and non-fed beef for Canada, Mexico, the United States, Australia, New Zealand, and Argentina provide the means to determine trade flows assuming competitive markets based on competitive advantage. Trade flows exist between producing and consuming countries and are the result of many factors such as resource endowments, production costs, transportation costs, and government policies.

Competitive advantage can theoretically be analyzed by interpreting discrepancies in trade flow, what trade is conducted currently and what would be most profitable by evaluating returns to operating capital. A competitive advantage only exists in perfectly competitive, efficient markets (Sharples), and agricultural policy in the form of tariffs and quotas skew the market's efficiency. Due to agricultural policy and government involvement, trade flows may not be indicative of what would be theoretically most profitable for all trading countries. If trade flows are not representative of what would exist economically upon optimal allocation of resources within and between countries then exogenous variables must exist that affect trade. One of the inherently tangible theories is the constraint of trade distorting policies on production capacity.

The hypothesis is that the United States should demonstrate a competitive advantage in fed beef production due to market structure, breeding programs, and availability of feed. New Zealand, on the other hand (dairy industry, dairy breeds, pasture), should have a competitive advantage in the production of grass-fattened beef as a result of the abundance of pasture, lack of feed grains, and a well-established dairy industry. The availability of inputs is theorized to be the most important variable in establishing an advantage. Roberts and Martin emphasized the need to look further into the implications of governmental policy and its effect on trade, and agriculture policy may skew the market through tariffs, quotas, trade agreements, or agriculture subsidies (feedstuffs, land, capital). Trade flows may not be representative of returns to capital.

The variables to be included in the enterprise budgets:

Table 1, Enterprise Budget Variables

Gross Income
Slaughter steer
Death loss %
Operating Costs
yearling steer
minerals
supplement
veterinary
marketing
Feed
Fodder crops
corn
oats
barley
hay - Rollo (Argentinean budget variable)
silage
pasture
Transportation

From the comprised budgets, the objective function for a linear programming model is developed to maximize returns to capital, bounded by production and consumption constraints in each country. The maximization will be evaluated based on the rationale that capital will flow towards the industry with the highest return potential, in addition to advantages in interest rates, inflation rates, and respective exchange rates.

It is admitted that the prices of all products were acquired during a similar time period and the analysis was conducted as a single point interpretation. Interest, inflation, and exchange rates were not included in the model other than the inclusion of conversion values of transportation costs into U.S. dollars for all regions.

The linear programming model attempts to model the optimal trade flow that would occur under perfect competition given the production returns provided in the enterprise budgets. The maximization will be the returns produced from the number of head produced in each country, less the transportation required to satisfy all consumption requirements under the parameters of current production levels. The amount of production is constrained at less than or equal to current production, thus emulating full capacity. Even though full capacity is prescribed to the model, production efficiencies will be evident through the resulting modeled trade flow. The consumption constraints are to be satisfied through domestic production and trade flow, equally satisfying current consumption levels.

The linear programming model equations are as follows:

Objective Function:

$$MaxZ = \sum_i \sum_j K_{ij} X_{ij} - \sum_i \sum_j \sum_k R_{ijk} T_{ijk}$$

Subject to-

Consumption:

$$D_{ij} = \sum_j X_{ij} - \sum_k T_{ijk} \quad \text{, for all } ij$$

Production:

$$P_{ij} \leq a_{ij} X_{ij} \quad \text{, for all } ij$$

Balance:

$$0 \leq -a_{ij} X_{ij} - \sum_j T_{ijk} \quad \text{, for all } ij$$

Where:

$X_{ij} =$ The number of head produced in country j, with method i.

$K_{ij} =$ The returns to operating capital for one head in country j, with method i.

$T_{ijk} =$ Tons of method i transported from country j to country k.

Matrix j = Matrix k

$R_{ijk} =$ The cost to transport one ton of method i, from country j to country k.

$D_{ij} =$ The consumption in country j, of method i.

$P_{ij} =$ The production in country j, of method i.

$a_{ij} =$ Carcass yield of meat in tons, per head.

Production capacity is considered a limiting factor for trade flow. Currently there exists sufficient supplies of non-fed beef production but a limited supply of fed beef to satisfy world demand as a result of the limited grain and land availability. With an increase in production, the lower cost production countries imports and exports may adjust to new levels. Thus, the linear programming model constraint on production will be relaxed to determine the impact of product capacity on trade flows. Demand of fed and non-fed beef will be held constant at current levels. The production capacity will be increased in two separate scenarios, one for a 10% capacity increase and the other for a 20% increase. The increases will be implemented into the model for fed and non-fed beef. Those countries with the greatest percentage returns will increase beef production to their threshold and increase exports. Countries with low capital returns will import all the low cost beef available and produce the remainder of what is needed to meet demand quantities. The rationale is appropriate for both fed and non-fed beef production.

If complete data were available there would be production for fed steers and heifers, grass fattened steers and heifers, cow slaughter, and the consumption, export, and import of each respective product in each country. Unfortunately complete trade, production, and consumption data were not available. The available trade data on beef does not differentiate between grain and grass fattened cattle or fed and non-fed beef products. Thus, assumptions were made to disaggregate total production and consumption in each country into production and consumption of fed and non-fed beef. These assumptions were made after reading and researching the production practices and consumer's tastes in each of the countries analyzed. Knowing that the assumptions are subjective, an understanding of the beef industry was found through literature searches and the available explanations accompanying each of the data sources used, the assumptions are found in Tables 2 and 3.   While the accuracy of the assumptions are largely arguable; given the data restrictions they are necessary and provide a starting point for this analysis. Future analyses of trade flows may begin eliminating the need for these assumptions.

Table 2 Consumption Assumptions

Consumption	Fed Beef	Non-fed Beef
United States	85%	15%
New Zealand	10%	90%
Canada	85%	15%
Australia	55%	45%
Mexico	40%	60%
Argentina	50%	50%

The consumption of non-fed beef in the United States is increasing through demand for "fast-food", while the production practices are largely that of fed beef through the finishing in feedlots. The assumptions were made that 85% of the United States beef consumption is fed, 15% non-fed. Likewise, 90% of production would be fed due to the highly developed finishing industry, 10% being non-fed from culled herd cows. In the case of New Zealand, there is a small quantity of imports and a non-existent fed beef industry. Since New Zealand imports very little beef, the assumptions were made that 10% of consumption would most likely be fed beef, 90 % non-fed. From the dairy industry and the lack of a grain-finishing industry, 100% of production was assumed to be non-fed. Canada's cattle industry is similar to the United States from a production standpoint, as well as consumer preferences. Consumption was assumed to be dominated by 85% fed beef, 15% non-fed. The production practice, as stated, mirrors that of the United States and is assumed to be 90% fed and 10% non-fed. Australia partakes in more trade between countries than it's neighbor, New Zealand. From the quantities imported the assumption was made that Australia could plausibly consume 55% fed beef products, and 45% non-fed. Since the fed production practice is just immerging in Australia, the assumption was made that 10% of production would be fed, and 90% non-fed, pasture fattened beef. Mexico has a large trade with both Canada and the United States, but also has production capacity in both practices. From the values and quantities exchanged the consumption of fed beef is interpreted as being 40%, non-fed 60%, likewise non-fed beef production is assumed to be a dominant 65% due to pasture availability, and fed beef 35%. Argentina also has the ability to produce both fed and non-fed beef, though currently only imports beef, and does not export. The lack of bilateral trade is due to health concerns. With the limitations of consuming what is produced and importing small quantities from the United States, Argentina's consumption was estimated as being 50% fed and 50% non-fed, while production was 40% fed, with 60% non-fed.

Table 3, Production Assumptions

Production	Fed Beef	Non-fed Beef
United States	90%	10%
New Zealand	0%	100%
Canada	90%	10%
Australia	10%	90%
Mexico	35%	65%
Argentina	40%	60%

The transportation between each country was estimated using industry-shipping rates, all in United States dollars. The shipment of meat by ocean median cost was $0.065 per pound of meat shipped, or $143.325 per metric ton. Because of the nature of these values, the transportation between any two countries that were equidistant as Australia, New Zealand, and Argentina are from the United States, the transportation cost will be calculated at $143.325 per metric ton. The distance between Australia and New Zealand is approximately one-sixth the distance as that from New Zealand to the United States and the transportation for ocean freight shipment is then estimated at one-sixth the cost. In the case of Mexico and Canada, and the United States, ground transport is used. The shipment rate from Mexico to Canada is the same as the longer distances for two reasons. Mexico stretches southward and shipments from the most southern regions to Canada would be of similar distance. Second, the full cost of shipment via ocean freighter is less than the calculated ground shipment charges, thus estimates of industry efficiency are assumed. It is inefficient to ship across the entire continent by ground transportation therefore ocean shipment is calculated. Activities in the model are the combinations of trade between the six countries examined, and the production of both fed and non-fed beef in each country.

The model places restrictions on consumption in each country to be equal to the current level of consumption. Production is constrained to be less than or equal to the current level of production. For analysis purposes, the production capacity or constraint was increased by 10%, and then again by 20% to examine the possible changes in production trends and trade flow given increased production in hypothetically cost-advantageous countries.

For this model, the assumption is made that the United States is operating at full capacity in feeder, cow/calf, and crop production. The argument that the United States should be producing more non-fed, grass fattened beef to compete with imports would require that additional land resources be available to produce such animals. Cows and calves are currently raised on permanent pasture in the United States. Once the calf is weaned it is then placed in a stocker/feeder type operation and conditioned for placement into the feedlot. This is the production practice for producing fed beef. If the calf was retained on grass pasture and fattened to an appropriate slaughter weight there would have to be additional grass pasture available for this feeding activity. The model assumes full capacity, in that the assumption is made that all available pastureland is currently allocated to the production of cows and calves. This may not be true due to weather constraints, government programs, and the like. Under the assumption of full capacity production, it is quite possible that additional land would only be found through the conversion of cropland to pasture land to produce grass fattened animals. Removing this land from crop production then decreases the amount of corn and grain that would be produced for the fed beef industry and export markets. A decrease in grain available would decrease the quantity of cattle that could be finished in the United States. In addition to the decrease in available feedstuffs for the finishing industry, there would be a decrease in the amount of corn available for export. Countries that wish to grain finish animals, but do not have the production resources available to produce enough grain, import large quantities of grain from the United States. The revenue received from the exports would be diminished in addition to the loss for the domestic industry.

For example, an acre of cropland in the mid-west could produce an average of 170 bushels of corn or one-eighth of a grass-finished animal, based on observed national average assumptions made by Colorado State University (http://www.colostate.edu/Depts/CoopExt/Adams/sa/grazing.htm#stocking). With the value of a bushel of corn being approximately $2.00, the production of one acre would be worth $340 net. For the production of a grass-fattened animal at a value of $86.50 per hundredweight and weighing 800 pounds, one-eighth of the animal's production would be worth $86.50. Even feeding the animal to a fed weight of 1150 pounds, which would take a considerable amount of additional pasture time; an eighth of the animal's value would be $124.34. Just from the example of production numbers, the land resource would be better suited to produce $340 through crop production, than $124.34 through livestock production. Restating the assumption that both crop and cow/calf productions are at maximum capacity, if additional land became available the same argument could be formulated to plant the land into crop production as opposed to feeding cattle on grass pasture up to slaughter weight. Simply stated, given input constraints and the assumption of maximum capacity, the United Stated still retains a competitive advantage in the production of grain finished beef as opposed to grass finished cattle.

For the purposes of examining shifts and changes to trade flow, these same assumptions of maximum capacity are assumed for the additional five countries. Not assuming that land is more profitable in the production of feed-grains, but that the maximum amount of usable land is in production of one commodity or another. These assumptions then lend themselves to the analysis of the trade flows through the linear programming model.

V. Results

Table 4, Limited Production v. Consumption of the Countries in Question

United States Production	59%	United States Consumption	66%	Net	-7%
Canadian Production	6%	Canadian Consumption	5%		+1%
Mexican Production	9%	Mexican Consumption	12%		-3%
Australian Production	10%	Australian Consumption	4%		+6%
New Zealand Production	3%	New Zealand Consumption	1%		+2%
Argentine Production	13%	Argentine Consumption	12%		+1%

www.fas.usda.gov 2002 data, accessed December 2003

Table 4 describes the distribution of consumption and production across the six countries as a percent of the total. These numbers do not differentiate between fed and non-fed beef production, nor consumption. The percentages represent the portion of aggregate production and consumption attributed to each country. Thus Table 4 provides a summary of the "net needs" for each country. That is, a country with consumption exceeding production would have a negative "net need", while a country with production in excess of demand would have a positive "net need". The hypothesis assumes that the six countries can only trade amongst themselves, stemming from the initial argument that the United States may not need to compete with imports. The five countries are those the United States imports from primarily. From the table, the two deficient countries are the United States and Mexico. From the trade flow model in Figures 1 and 2 it can be seen that Mexico and the United States are not the only countries trading beef products. The discrepancy is due to the differentiation between fed beef products and non-fed beef products that is not captured in the data.

Current trade flows of beef by quantity and value and were acquired from the United Nations Comstat database are provided in Figure 1 and 2. The quantities are in 1,000s of metric tons on an aggregated basis, not differentiating between fed and non-fed beef. The values in Figure 2 are in United States dollars.

Figures 1 and 2 show that in 2002 the largest value of beef was traded from Canada to the United States. The second largest flow of beef in value is from the United States to Mexico, and the third largest flow is between the United States and Canada. In the first three scenarios, it is evident that the quality of beef traded between the United States and Canada is two separate products. There is a considerable amount of counter trade-flow between Canada and the United States, as well as Canada and Mexico, Canada being on the net exporting side of each trade relationship. Canada exhibits a –25% return for the production of fed beef and –28% return for non-fed beef. Again, with the negative returns production may occur as a result of capacity limits in the countries trading with Canada or be the result of government intervention through subsidies and tariffs. Since the analysis was for the determination of competitive advantage government programs may be imbedded in the cost of inputs.

Figure 1, Current Trade flow by Quantity, 2002

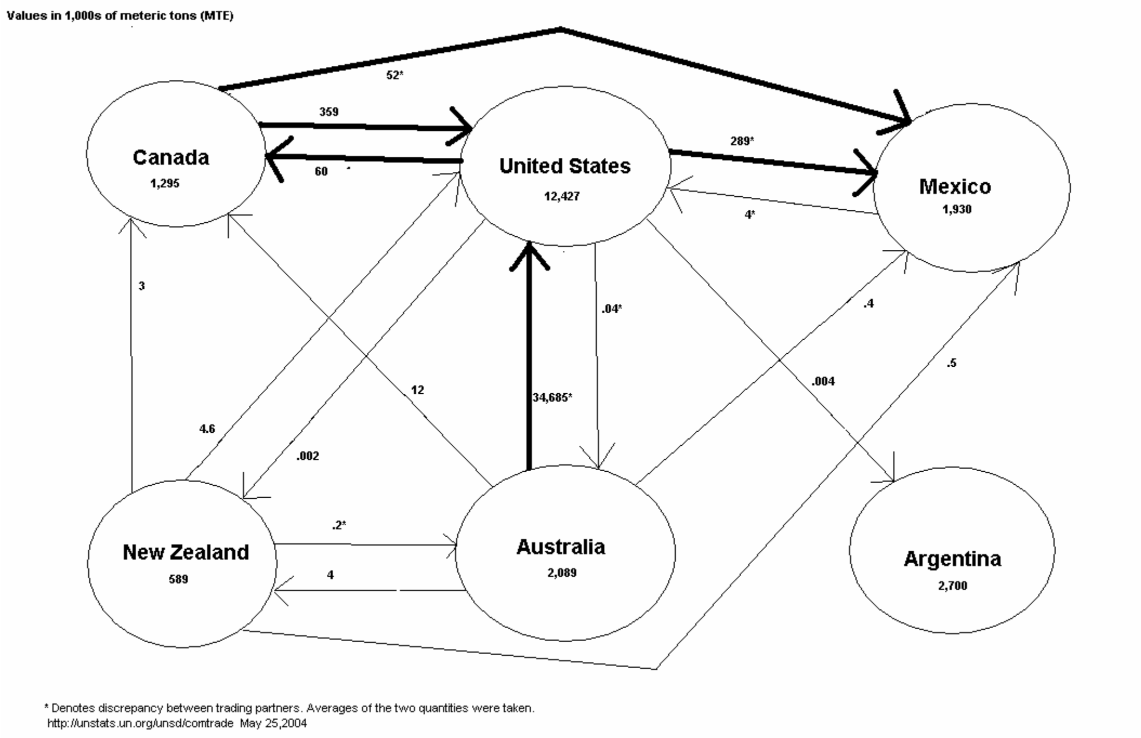
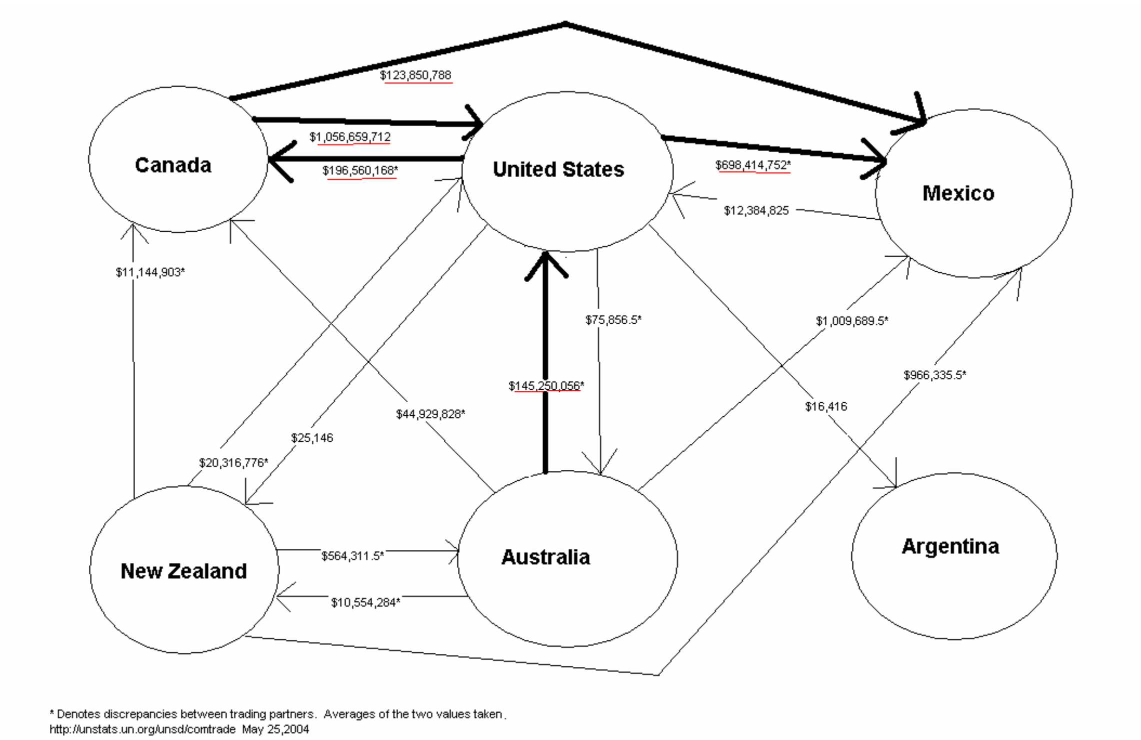


Figure 2, Current Trade Flow by Value, 2002



Canada

Canada exports beef products to Mexico. With Canada's returns to operating capital of –25% for fed beef and –28% for non-fed beef, there is the question as to why Mexico, a country with production returns of 15% and 5% respectively, would import beef products from Canada. In the case where Mexico is operating at maximum production capacity and demand is greater than supply this result would occur. However, over time one might expect that capital would be put into the Mexican cattle market to increase production. The rationale would be that an influx of capital should become available to the Mexican beef industry in an attempt to increase the capacity and efficiency of production. The governments' ability to nationalize industries could quite possibly threaten efficiency and capital flow. Due to external, governmental, non-economic decisions, there may exist a lag on the expansion of the Mexican beef industry as a whole.

At a loss of 25% in returns, the beef exported to Mexico from Canada at current would most likely be fed beef. The capital loss in fed beef production for Canada is less than that of non-fed beef. On the assumption that Mexico is producing at maximum capacity, they should produce enough non-fed beef for domestic consumption, but still lack the availability of grain for ample production of fed beef. Subsidies from the Canadian government possibly enable Canada to achieve prices that are less than that of Mexican producers, in conjunction with Mexico's less than fully developed animal finishing market.

Mexico

On the assumption that all countries are producing at full capacity, the United States and Mexico would most likely be importing fed beef products from Canada. In the

United States, reasoning may be cost advantages on the part of Canada or the lack of United States supply to meet domestic demand. Mexico does not have the infrastructure or the inputs available for a large grain finishing industry, though the industry is growing. The returns established in the enterprise budgets for the Mexican market, though 15%, do assume grain and land availability. The amount of government intervention is, again, not quantifiable in this analysis, but can be theorized. Given the returns stated in the budget, the viability of Mexico to import grain and finish a greater amount of domestically produced cattle would curb the country's appetite for Canadian and American fed beef imports, in addition to developing a large cattle industry and contributing to the Mexican economy as a whole. Currently, consumers' demand for fed beef products are also increasing in Mexico, justifying imports of fed beef. Given industry structure, grain availability, and cattle breeds, it would be advantageous for Mexico to continue to import fed beef.

Australia

The United States imports a considerable amount of beef from Australia, both in quantity and in value, fifth highest in trade within the countries examined. The Australian returns are calculated to be 21% for the production of fed beef, -22% for non-fed beef. With an understanding of the Australian cattle market, the returns to fed beef are quite significant but the fed cattle industry is just developing. Approximately 5% of the cattle in Australia are finished on grain, the remainder pastured until slaughter. An assumption can be made that the calculated returns do not include government involvement. Australia has a marketing board in place that markets animals and beef produced as a single entity. It is possible that support may play a significant role in the viability of the non-fed beef industry, though it is questionable as to if it would be enough intervention to offset a 22% loss on returns to production. The impacts of intervention can only be theorized. From a capital standpoint, there is increasing interest in the Australian fed beef industry. There are published articles mentioning increased interest, none of the materials being of benefit to this research.

The beef exported from Australia to the United States should be fed beef based on the positive returns to operating capital and the trade flow illustration. Australia produces fed beef for domestic consumption and currently does not have enough excess production in order to export. Currently however, surplus non-fed beef Australia exports. The United States imports non-fed beef from Australia for monetary advantages as well as the lack of capacity to produce additional quantities of non-fed beef. Given time and market maturation, the quantities of fed beef produced in Australia should increase, especially with a 21% return to operating capital. Beef producers cannot afford to ignore such an opportunity.

Assuming that Canadian tastes and preferences are similar to that of the American public, in addition to the desire for leaner meat products, Canada also imports large quantities of beef. Canada produces fed-beef products at a loss of 25%, and non-fed beef products at a loss of 28%, according to the enterprise budgets generated. Based on a comparison of competitive costs, Canada could increase social welfare by importing non-fed beef and fed beef products. Australia produces fed beef at 21% return to operating capital, and non-fed at -22%. By analyzing the budget numbers alone, Canada should import all of its beef demand from somewhere outside of its borders. It has already been established that Canada is a large exporter of fed beef, but due to the lack of a fed beef industry of any magnitude in Australia, non-fed beef is the likely product that Canada imports from Australia.

United States

In regards to importing beef from Canada into the United States, trade should be based on a cost advantage, trade negotiations, or production capacity. The United States maintains a higher return for fed beef and less of a loss in returns on non-fed beef. If the United States was to economically import fed beef, the production capacity would have to be exhausted or the price of such would need to be less than the United States domestically produced beef products. Thus, there is either a greater demand than availability for fed beef in the Unites States, or there are external influences, i.e. subsidies that are not transparent in the cost of beef production, such as subsidies to corn producers. This price discrepancy would also have an impact on the quantities produced. The conclusion is that current demand surpasses supply in the United States and imports of non-fed beef are necessary. The imports provided allow the fed beef industry to produce at a level sufficient to satisfy domestic demand and export quantities of fed beef that are of greater value than the non-fed, lean beef, which is predominately imported.

New Zealand

Through analysis of trade flow numbers, there is not a considerable amount of trade coming out of New Zealand in comparison to what large consuming nations produce themselves, i.e. the United States, Canada, and Mexico. New Zealand's returns to cost of production are an astronomical 162% for non-fed beef, and 8% for fed beef. Of the budgets that were developed, there are reasons that the return to non-fed beef is so high. The 7% return to production of fed beef is theoretical. Due to the lack of land available for the production of grain needed in a finishing operation, New Zealand's beef industry is currently based on non-fed, grass fattened cattle production. A fed beef industry may be financially viable and grain would have to be imported. Since the budgets were comprised without considering market conditions specifically, the true viability of creating the industry is completely implausible. Since the industry doesn't exist, the budget numbers compiled for fed beef production in New Zealand are an adaptation of the Mexican Holstein market, due to similar pricing, market structure, and breeds available. Fed beef production is not currently a viable enterprise in New Zealand and therefore is not practiced. The cost of production for non-fed beef is so profitable that currently New Zealand does export most of their beef to the United States and Canada. Though the relative quantity is not large, if New Zealand producers had enough production to impact the world non-fed beef markets there would be a large margin of 'squeeze' available to New Zealand before the United States, Canadian, or even Mexican producers could compete. Production capacity appears to be the only limitation for expansion of the non-fed beef industry in New Zealand.

Argentina

Argentina has had problems in recent history in regards to their export markets. Argentina has land available for beef production, though historically production has been solely grass-fattened beef. Due to the emergence of hoof-and-mouth disease, Argentina has not had the ability to export fresh or chilled meats to major importers. Under international regulations, only pre-cooked meats may be shipped from a country with hoof and mouth disease. Current trade flow data indicates that Argentina imports a very small amount of beef from the United States. If Argentina were to produce fed beef products, the return to operating capital would be -11%, while their return to non-fed beef production would be -4%. Since the United States has a positive return on fed beef production and it is from the United States that Argentina imports beef products, the conclusion can be drawn that the beef products traded between the two countries are fed beef products. The trade flow could be driven by returns, lack of capacity to satisfy domestic fed beef demand, or health concerns. From a policy standpoint, it would most likely be the health concerns of consuming nations that keep Argentina from trading beef. Government subsidies or trade agreements in the future could make it profitable for the government to support a growing beef industry.

It is difficult to quantify the amount of government involvement that exists in a single industry or commodity. The OECD, or Organization for Economic Co-operation and Development has put together a list of calculations in an attempt to quantify different country's involvement in particular commodities and trade flow itself. The calculations used are the Producer Support Estimate (PSE), Consumer Support Estimate (CSE), Producer Nominal Assistance Coefficient (Prod. NAC), Consumer Nominal Assistance Coefficient (Con. NAC), Producer Nominal Protection Coefficient (Prod. NPC), Consumer Nominal Protection Coefficient (Con. NPC), and the General Services Support Estimate (GSSE). The PSE is a calculation of all government transfers directly to the producer through tariffs, subsidies, and price supports. The CSE is likewise a calculation of all government payments that go directly to consumers. Both the PSE and CSE are commodity specific calculations, while the GSSE is a calculation based on the economy as a whole and the cumulative value of support devoted to all services.

The Prod. NAC is calculated by summing the value of gross farm receipts along with budgetary supports, dividing the whole by the value of production at the world market price, less any supports. Con. NAC is the value of consumption expenditures from domestically produced commodities in addition to supports to producers, divided by the value of consumption at the world market price. Prod. NPC is the average price received by producers, in addition to payments based on output, divided by the border price without payments. Cons. NPC is the domestic price including consumer supports, divided by the border price.

Table 5 is a summation of the data calculations desribed in the preceeding paragraph. The values are all in United States dollars. The magnitudes and comparable values contribute to the explanatory nature of the impacts that government intervention has on the flow of trade. The values herein partly justify some of the production decisions in the heavily subsidized and support countries.

Table 5, OECD Support Values

	Beef and Veal						
USD($)	PSE	CSE	Producer NPC	Producer NAC	Consumer NPC	Consumer NAC	GSSE
Australia	127.00	0.00	1.00	1.04	1.00	1.00	512.63
Canada	648.24	-8.33	1.02	1.14	1.00	1.00	1,629.05
Mexico	192.67	-58.03	1.03	1.09	1.02	1.02	647.98
New Zealand	5.84	0.00	1.00	1.01	1.00	1.00	105.46
United States	1,418.68	3,078.39	1.00	1.04	1.00	0.91	27,159.30

http://www.oecd.org 2001-2003 Beef and Veal averages

Argentina is not one of the countries that OECD acquires data for. The five remaining countries are available for comparison and assumptions can only be made as to the level of support from Argentina. From the calculations, it is seen that the United States and Canada heavily support their producers of beef and veal. The United States supports consumers three-times as much as the their own producers, a high level of support in comparison to the other countries. The concern with the data provided, again, is that the calculations are on an aggregated basis, exhibiting no differentiation between the supports to fed or non-fed beef. Based on these estimates of government supports, the United States clearly offers considerable support to the beef and veal industry. Canada, Mexico and Australia all subsidize producers though not consumers. In the case of Canada and Mexico there is actually a negative consumer support estimate. New Zealand does not have a large support mechanism for either producers or consumers. The conclusion should be that the New Zealand market is functioning in accordance with *laise' faire* economics, both producers and consumers receiving and paying what the market will bare.

Countries are generally best suited at following one production practice or another. This is a direct result of market structure, breeding programs, available inputs, and historically established production practices. The inclusion of a non-fed beef industry under the umbrella of a fed industry is a viable proposition due to slaughter cows. Attempting to create a fed beef industry structure under an established grass fed beef industry tends to be a conflict of interest, requiring inputs that would otherwise not be available to the market. Inputs that would not be a focus for production in a grass fed industry, would primarily be feed grains, available cattle, and capital to appropriate towards production, the capital and the feed grains being the most limiting of the three.

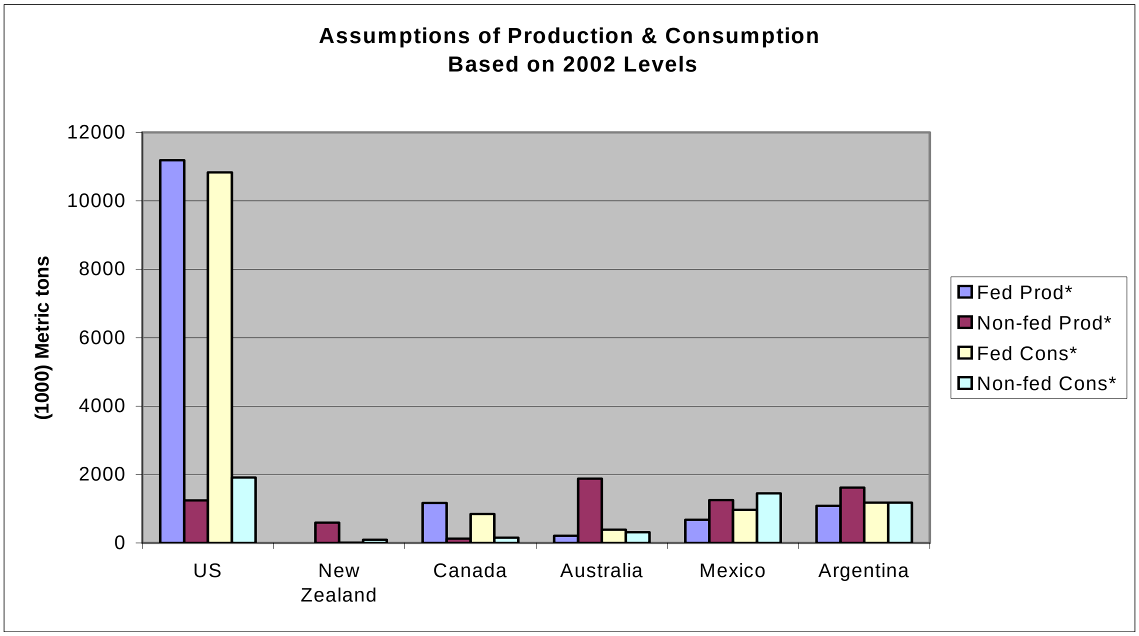
Market structure is the size and number of components of the industry. The United States' market structure contains cow/calf producers, stocker/feeders, feedlots, and slaughtering plants. The ability to successfully move a calf from one phase of the growing process to another and the profitability reached in each stage is important to the survival of the industry as a whole. In many instances retained ownership from one stage to another takes place. Without an established flow of beef production through the industry, the market structure breaks down. In the United States, this pass-through of production that is one reason the feeding out of cattle is profitable. In New Zealand and Argentina, for example, this infrastructure is not available, making the commercial production of fed beef non-profitable and cumbersome. The attempt to create a fed industry within a grass fed market structure lacks some inherent inputs.

The same can be said for the non-fed beef market structure. New Zealand and Argentina have beef industries that maintain production of beef on grass pastures, New Zealand's industry being focused on dairy production, while Argentina's industry is focused on producing cattle on pasture. Due to the lower return to capital associated with grasslands, there are diminished amounts of pastureland available in the United States or Canada. The returns on capital for the production of a non-fed beef product are not competitive with the returns attainable by non-fed beef exporters. These assessments are made based on the assumptions of full capacity. Taking market conditions into consideration, it could be the under-utilization of land that contributes to the lack of non-fed beef profitability in the United States and Canada. Through marketing, a niche could be developed by a few producers creating a profitable enterprise, specialization being paramount. Non-fed market structure is a non-viable production option under the stated assumptions due to both a lack in resources and the efficient appropriation of capital towards the production and exportation of fed beef products.

In the case of breeds available for production, the United States and Canadian industries have been built on foundations of British bred cattle, cattle that marble well when fattened, but need ample amounts of high protein feed in order to demonstrate genetic potential. When added into the United States and Canadian market structure it is evident that these cattle breeds are best adept at producing fed beef. If a New Zealand bred steer (dairy) was placed into a North American feed lot, the marbling characteristics would not be consistent with those of British bred origin, and the growth rate of the animal would differ due to the manner in which the animal would keep and put on additional weight. A shorthorn or dairy bred steer, as in New Zealand or Argentina, when placed on grass pastures will put on ample weight for its frame, the cows producing copious amounts of milk given the amount of inputs provided. The focus of these markets is not specifically the production of beef but dairy products, making beef a by-product.

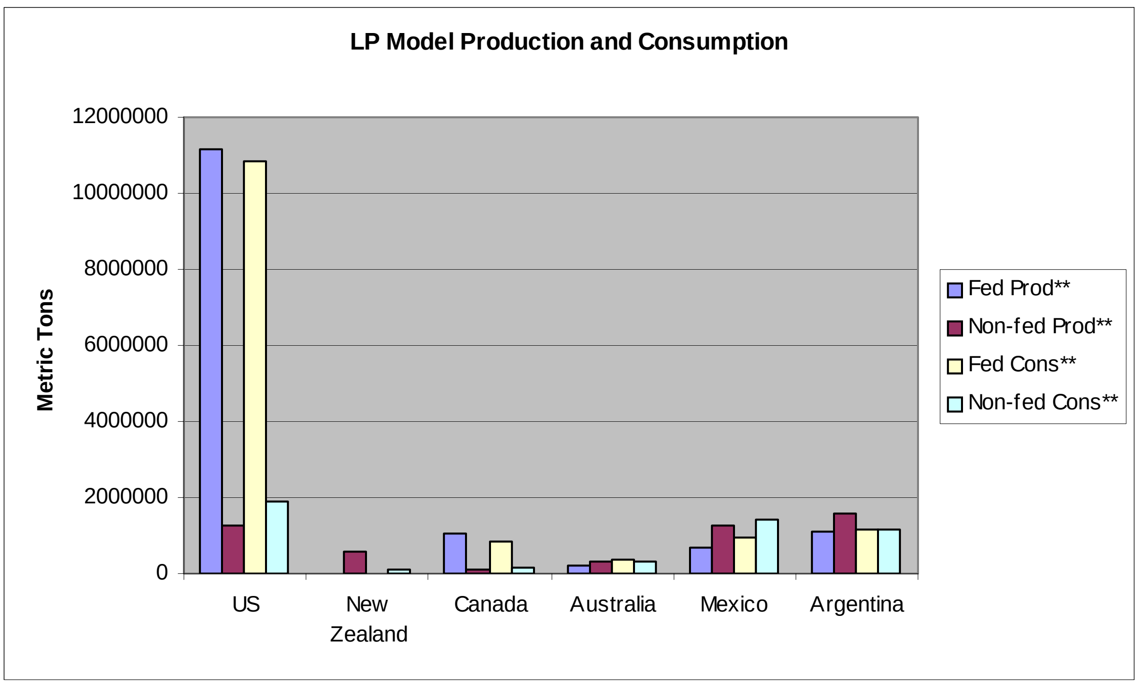
Inputs available for production practices are limiting and essential. The United States has a grain industry large enough that it can produce feed grains to support cattle finishing. Likewise, these lands have been cultivated into grain production and are no longer available for the production of grass pasture. In New Zealand, grain is not a heavily planted crop, the land having been kept out of cultivation and remaining in grass pasture, there is ample input for the production of non-fed beef. Grain is the most limiting input for the production of fed beef. Countries that produce fed beef by and large cannot effectively produce non-fed beef because all available land is in the production of grain.

Figure 3, Current Production & Consumption Levels



* Denotes assumptions based on actual current values

Figure 4, LP Model Production & Consumption



** Denotes assumptions included in model results

The linear programming model based on returns to capital and constrained by production and consumption, produced results that illustrate the optimal allocation of fed and non-fed beef production in differing countries. Figure 4 illustrates modeled allocation of production and consumption across the six countries.

Table 6 and 7 describe the trade flows estimated in the linear programming model. The flow of trade in each scenario is based on the assumptions for the two production practices in each country. The model results indicate that the domestic market supplies the majority of beef demanded for each country. The producers of beef are along the left margin of the tables, while the importing countries are along the top, representing the flows into and out or each respective country in addition to showing the amount of production that is consumed with in the country.

Table 6, LP Fed Trade Flow

FED MTE

		Importers					
		United States	New Zealand	Canada	Australia	Mexico	Argentina
Exporters	United States	10,827				288	69
	New Zealand						
	Canada		11	843	178		32
	Australia				209		
	Mexico					676	
	Argentina						1,080

Table 7, LP Non-fed Trade Flow

NON-FED MTE

		Importers					
		United States	New Zealand	Canada	Australia	Mexico	Argentina
Exporters	United States	1,243					
	New Zealand	439	97		53		
	Canada			130			
	Australia				264		
	Mexico					1,255	
	Argentina	229		19		191	1,181

The linear programming model indicates that the United States would most profitably produce 11,184 metric tons of fed beef and 1,243 metric tons of non-fed beef. United States returns are maximized by importing non-fed beef from New Zealand and

Argentina, freeing the resources needed to export quantities of fed beef to Mexico and Argentina. This is relatively consistent with the current trade that exists between New Zealand and Mexico, and the United States, which is estimated to be predominately non-fed beef. The linear programming model results differ more widely from current trade flows for fed beef. The United States is shown to export only to Mexico and Argentina, not to New Zealand, Australia, and Canada.

New Zealand was modeled to not produce fed beef due to the complete lack of a fed beef industry and thus production constrained to zero, which is entirely consistent with the current production in New Zealand. Model results indicate New Zealand would produce 589 metric tons of grass fed beef. The production of 11 metric tons of fed beef that New Zealand demands is provided from Canada. New Zealand produces 492 metric tons of excess non-fed beef for export to the United States. The model is relatively consistent with current trade flow of non-fed, lean trim beef, the exception being that New Zealand exports to more countries than modeled, trade includes exports to Mexico and Australia.

The Canadian results were similar to the United States results. Fed beef production in Canada is the most profitable. Canada would consume 843 metric tons of domestically produced meat, while 178 metric tons of fed beef would be shipped to Australia, the 11 metric tons to New Zealand, and 32 metric tons to Argentina. The discrepancy between the model results and current trade flow of fed beef from Canada is that exports flow to the United States and Mexico, not New Zealand, Australia, and Argentina. Discrepancies between current flow and modeled could be explained by assumptions used in transportation costs. Non-fed beef production was modeled as being advantageous enough for domestic consumption, though assumptions on current trade flow estimate that Canada exported non-fed beef to Mexico and the United States, importing lean trim from New Zealand and Australia.

In the cases of Australia, Mexico, and Argentina, there is enough production of each practice to satisfy a portion of domestic demand. Australia, Argentina, and New Zealand have as excess demand for fed beef that is supplied from Canada due to a shortcoming in meeting domestic consumption, which differs from current trade flow. Current trade flow depicts Australia and Argentina as importing fed beef from the United States, in addition to New Zealand, Canada, and Mexico drawing from the United States. Changes in production capacity would most likely increase these efficiencies.

Mexico is modeled to produce a large portion of the fed beef demand and makes up for shortfalls between consumption and production of fed beef with imports from the United States. This is consistent with current flows, in addition to imports from Canada. Mexico would produce a considerable amount of non-fed beef and import the remaining demand from Argentina, 191 metric tons of non-fed beef. In reality, non-fed beef is imported from New Zealand and Australia. The differences possibly attributable to either skewed transportation costs, or the existence of hoof and mouth disease concerns. Mexico’s consumption of both fed and non-fed beef currently exceeds the ability of domestic production capabilities.

Results from the linear programming model indicate that Argentina would be a producer of both fed and non-fed beef. Argentina provides fed beef products for its own consumption in addition to receiving imports from Canada and the United States. This is relatively consistent, for in 2002 Argentina only imported beef from the United

States. For non-fed beef, Argentina contributes to meeting demand in the United States, Canada, and Mexico. This trade flow would exemplify the counter-flow that could exist in the trade of differing qualities of beef. The assumption is made that the lack of trade that takes place currently in non-fed beef between Argentina and other countries stems from health and disease concerns.

Figures 5 and 6 are illustrations of Tables 7 and 8. They are visual representations of the trade flow prescribed by the linear programming model.

Figure 5, Trade Flow of Original LP Fed Beef Model

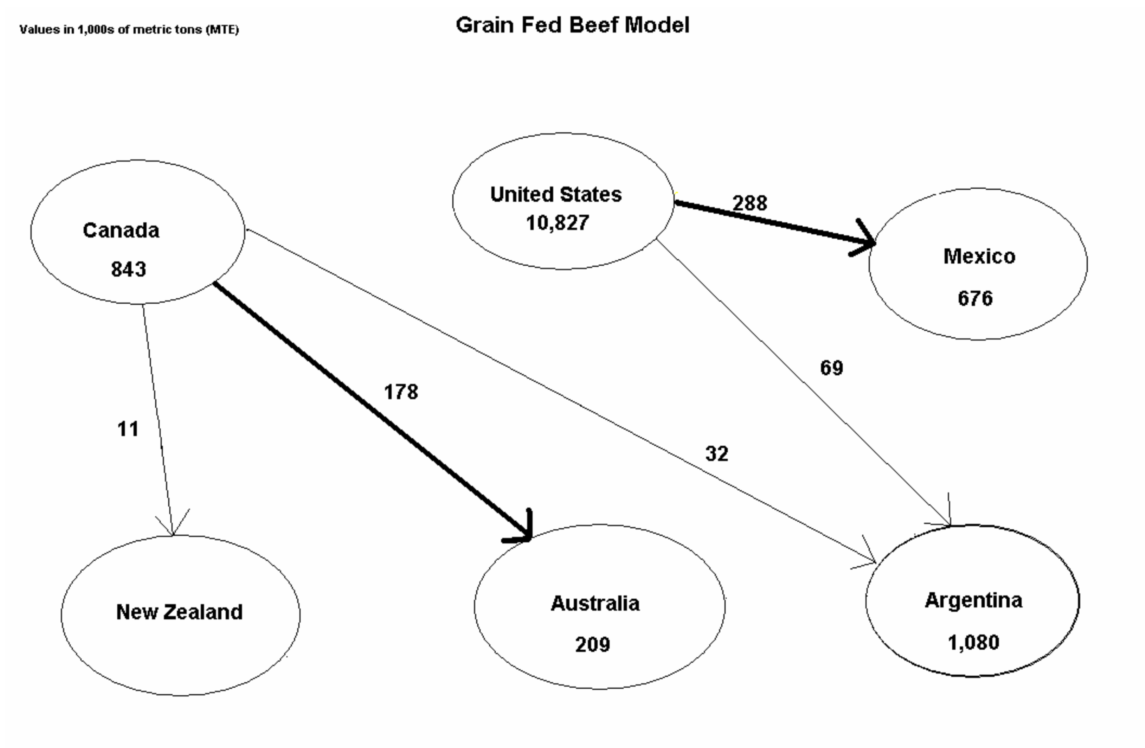
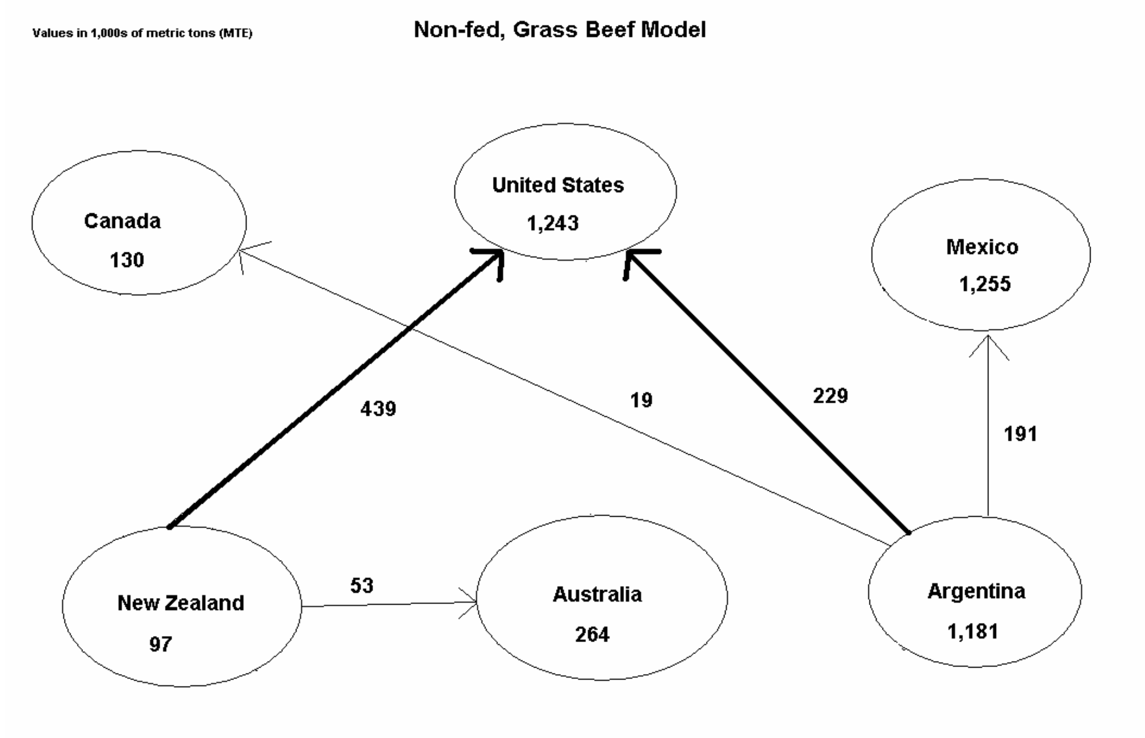


Figure 6, Trade Flow of Original LP Non-fed Beef Model



The sensitivity of the linear programming model is listed in Table 8. The allowable increase and decrease values are the amounts that the percentage returns from the budgets would need to change in order to impact the model solution. The 'infinite' values in the table indicate those production practices in which the returns to capital could increase or decrease infinitely and there would remain no impact. The only production practices that have impacts in a reasonable bandwidth are the grass production in Australia and Argentina. If the returns to grass-fed beef production increased 3.08% in Australia it would result in an increase of non-fed beef production. Likewise, if the percentage returns for Argentina were to decrease 1.11% there would be a decrease in the level of non-fed beef production. The remaining production practices have increases and decreases that are not within reasonable bandwidths, thus the model is not highly sensitive and reasonably large changes to production returns would not alter results.

The returns to capital from the enterprise budgets are the source of the sensitivity analysis. If the assumptions pertaining to production were inaccurate, or were to change dramatically, would they have an impact on the sensitivity of the model results?. In the case of the United States, if the production practice was found to differ from those used in the budget, such that it could be demonstrated that the United States reduced returns to capital by 24% on fed beef production, or lost 44% on non-fed beef production, the levels of production and trade would be altered for the United States in the linear programming model. The United States is an example of a case where the potential error is sufficiently bounded such that changes in assumptions are unlikely to change the model results. The five other country's results exhibit a similar conclusion with less the exception of the two scenarios mentioned above.

Mis-interpretations of applicable production practices, and more accurate transportation costs could possibly have an impact on the sensitivity. From the budget compilations, the optimal scenario would be to survey producers in each given country, providing applicable production practices and fully accurate variable costs. With such available input, the model would most certainly take on a differing result, the extent of which is arguable. From this analysis, the results maintain that increases or decreases that would be needed for shifts in production and trade flow, are outside of returns that are logically attainable.

As markets progress, it is conceivable that changes in methods of production will alter the returns to production in the respective countries and thus alter sensitivity and trade flow. This argument would be viable for both an increase in domestic supply of differing qualities of beef, as well as specialization practices.

Table 8, Sensitivity of Linear Programming Model

	Final Value	% Returns	Allowable Increase	Allowable Decrease
United States Fed	32,852	5%	infinite	29.97
United States Non-fed	5,168	(17%)	infinite	27.91
New Zealand Fed	-	7%	infinite	59.90
New Zealand Non-fed	2,772	162%	infinite	171.23
Canadian Fed	3,121	(25%)	25	infinite
Canadian Non-fed	515	(28%)	infinite	18.99
Australian Fed	695	21%	infinite	86.13
Australian Non-fed	807	(22%)	**3.08**	infinite
Mexican Fed	2,461	15%	infinite	65.46
Mexican Non-fed	4,987	5%	infinite	51.99
Argentine Fed	5,008	(11%)	infinite	35.72
Argentine Non-fed	13,773	(4%)	infinite	**1.11**

In Table 9 and 10 the flow of trade that would result from a 10% increase in production capacity illustrates the shifts trade flows that would result from the increase in capacity. The increases in capacity were executed by running the original model with modified values; one run encompassed both fed and non-fed scenarios. By production capacity being increased 10%, regions with the most advantageous returns to capital increase production. The increase in capacity results in a minor increase in the amount of fed beef produced in the United States. The flow of fed beef into the United States stays constant at zero while exports are increased to Australia, and eliminated to Argentina. Mexico continues to import fed beef from the United States, though decreases the quantity as a result of increasing its own fed beef capacity.

Table 9, 10% Increase LP Fed Trade Flow

FED MTE

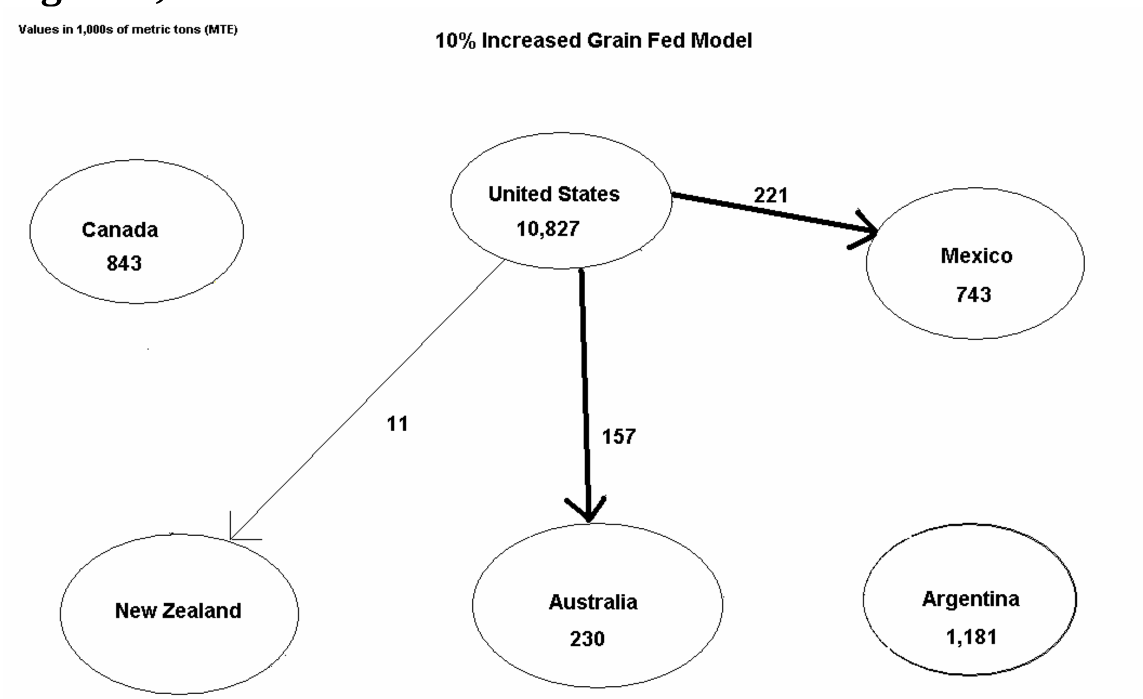
		Importers					
		United States	New Zealand	Canada	Australia	Mexico	Argentina
Exporters	United States	10,827	11		157	221	
	New Zealand						
	Canada			843			
	Australia				230		
	Mexico					743	
	Argentina						1,181

Table 10, 10% Increase LP Non-fed Trade Flow

NON-FED	MTE					
	Importers					
	United States	New Zealand	Canada	Australia	Mexico	Argentina
Exporters: United States	1,367					
New Zealand	168	97		317	65	
Canada			142			
Australia						
Mexico					1,380	
Argentina	375		6			1,181

Figures 5 and 6 are illustrations of the linear programming model for the current production and consumption constraints. With the linear programming illustrations, the disparity between the current flows and the trade flow that would exist in a perfectly competitive market can be seen. Figure 9 is a visual representation of the fed beef trade flow as a result of increased production capacity, 10% and 20% respectively. Figure 10 is a like representation of the capacity increases' influence on the non-fed beef trade flow.

Figure 7, Trade Flow of Increased LP Fed Beef Models



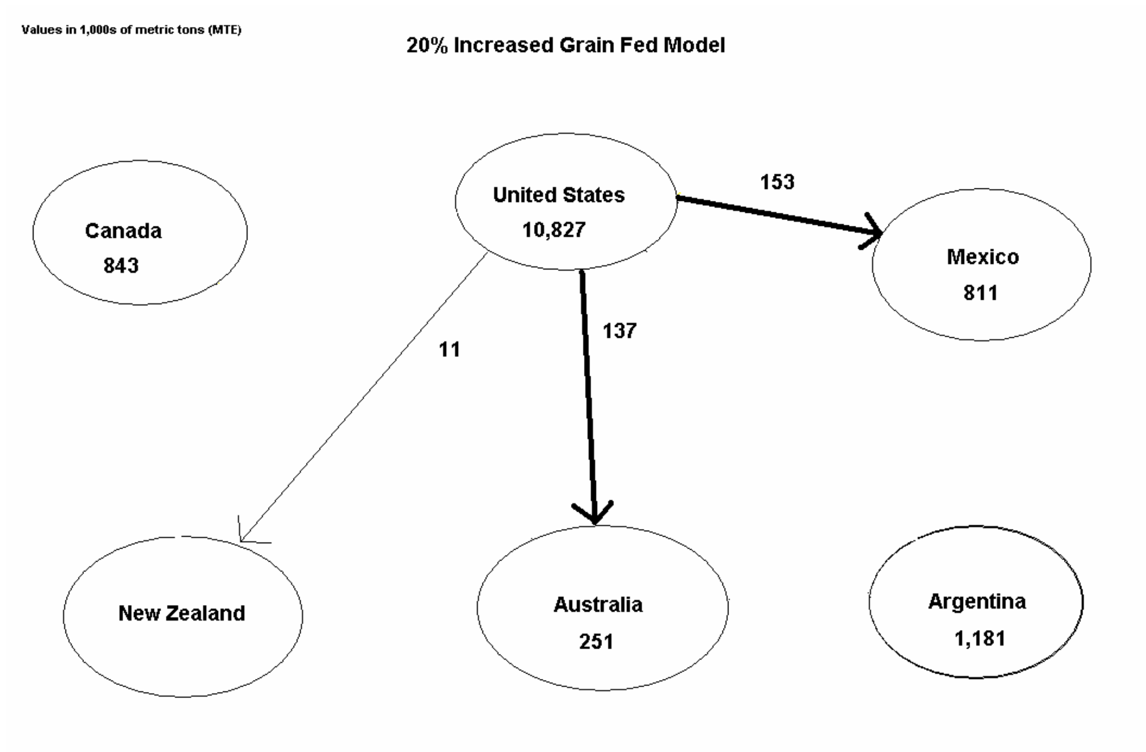
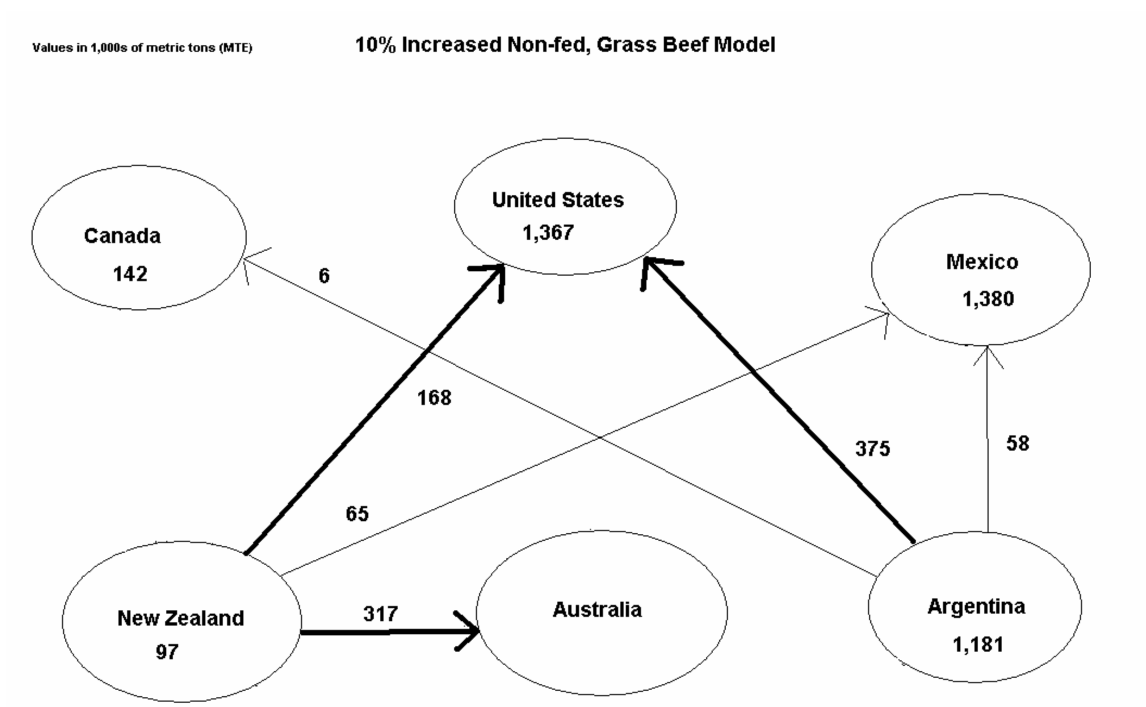
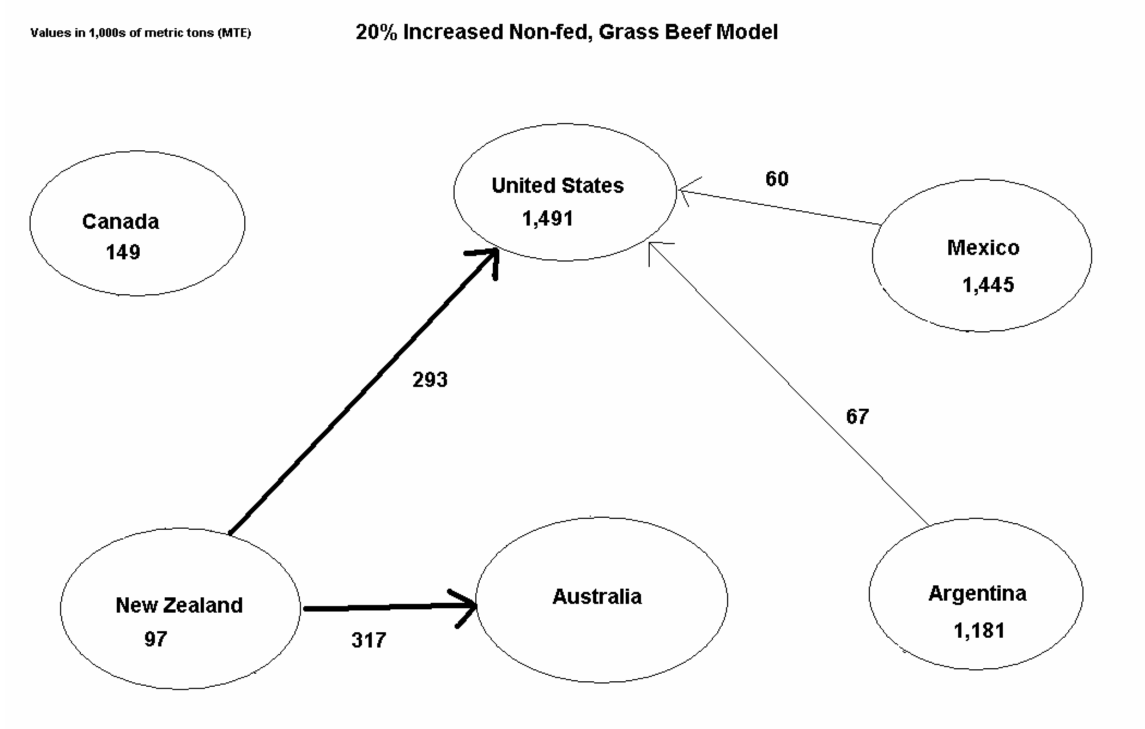


Figure 8, Trade Flow of Increased LP Non-fed Beef Models





In the original linear programming model base results the United States exported fed beef to Argentina, in the 10% increased model Argentina gains additional capacity to satisfy it's own demand. The major decrease in the amount of production found from a 10% increase in capacity is that of non-fed production in Australia, a zero change from the original model to 10%, and a significant 79% drop between the 10% capacity model to the 20% model. Australia originally supplied itself without an advantage to export non-fed beef. Through the increased production capacity, New Zealand exhibited enough production to cover itself and the United States. With the 20% production capacity increase, results prescribe that it is more efficient for Australia to import quantities of lean non-fed beef. Argentina also experienced a decline in the quantity of non-fed beef produced in the 20% production capacity increase model. With increases in capacity of more efficient regions, the United States increases imports from New Zealand, decreasing the need for Argentine and Australian non-fed beef.

The increase of 20% production capacity leads to a net loss in the production of fed beef for Canada and the United States. Canada has a decline in the production of fed beef from the 10% increase in production capacity due to New Zealand and Australia's ability to import fed beef from the United States more efficiently. From the 10% increase to the 20% the United States shows a decrease in production due to the remaining countries ability to produce additional fed beef themselves. This may possibly be attributed to the transportation costs in addition to hypothetical fed beef production increases. With the increases in domestic production available, New Zealand continues to need imports but Australia and Mexico have the ability to produce a greater quantity, thus decreasing the need for American fed beef.

The trade shifts are primarily for grain fed beef. Australia increases its production for itself and decreases the amount originally imported from the United States. Mexico's increase in production adds to domestic supply. Mexico decreases importation of fed beef from the United States. Argentina is able to supply beef domestically and discontinues imports from the United States and Canada.

On the non-fed side there are decreases in the exports of grass-fattened beef by all regions that produce non-fed beef. Domestic increases in the supply of non-fed beef are evident in all regions. It is hypothesized that this trend would continue, converging back towards the cheaper imports, depending upon transportation costs. Due to Mexico's increase in production of non-fed beef products, imports are curtailed from New Zealand. Argentina doesn't change its domestic production of non-fed beef, though exports to the United States decrease as United States capacity increases. As seen in Figure 6, non-fed beef production capacity has the largest impact in terms of changes, all of them stemming from the regions increasing their ability to produce lean trim.

Total fed and non-fed production and consumption remain constant. The shifts in efficient production are the only impacts. Those regions that can produce their own supply and avoid transportation costs are better off and thus increase production to the threshold of capacity.

Table 11 and 12 describe the trade flow shifts, mostly being for the production and supply of non-fed beef more than fed beef. Changes were similar to those evident when increasing 10% from the base. Increases in domestic production of fed beef continued in Australia and Mexico, imports then declining, decreasing the United State's export and production of fed beef. It was seen from the original linear programming model that there exist more excess capacity in non-fed beef production than in that of fed beef production.

Table 11, 20% Increase LP Fed Trade Flow

FED MTE

		Importers					
		United States	New Zealand	Canada	Australia	Mexico	Argentina
Exporters	United States	10,827	11		137	153	
	New Zealand						
	Canada			843			
	Australia				251		
	Mexico					811	
	Argentina						1,181

Table 12, 20% Increase LP Non-fed Trade Flow

NON-FED MTE

		Importers					
		United States	New Zealand	Canada	Australia	Mexico	Argentina
Exporters	United States	1,491					
	New Zealand	293	97		317		
	Canada			149			
	Australia						
	Mexico	60				1,445	
	Argentina	67					1,181

The greatest changes in production at the 10% capacity level come from a shift in fed beef production in Canada, and at the 20% level, a decrease in Australia and Argentina for the production of non-fed beef, thus increasing non-fed production in New Zealand, the most profitable of all. This indicates that New Zealand is by far a more efficient producer of non-fed beef than the competing regions. The model implemented trade through other countries, or the demand was satisfied through domestic production. Increases in production seem to be divided more broadly among the more efficient production countries, all of them compensating for trade that was advantageous prior to increases in capacity.

Figure 9, Fed Beef Capacity Changes

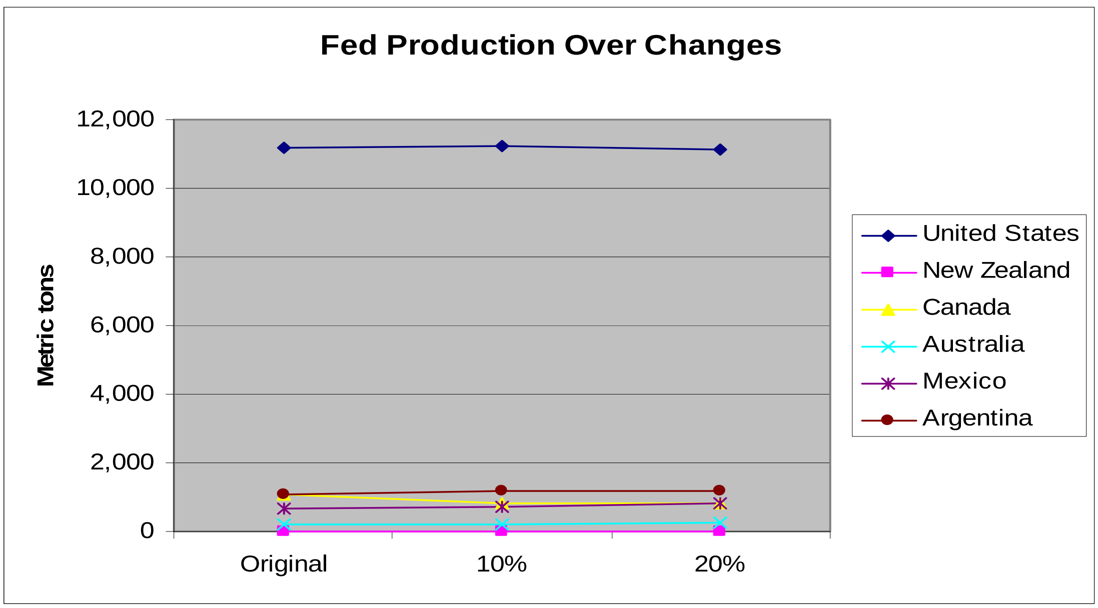
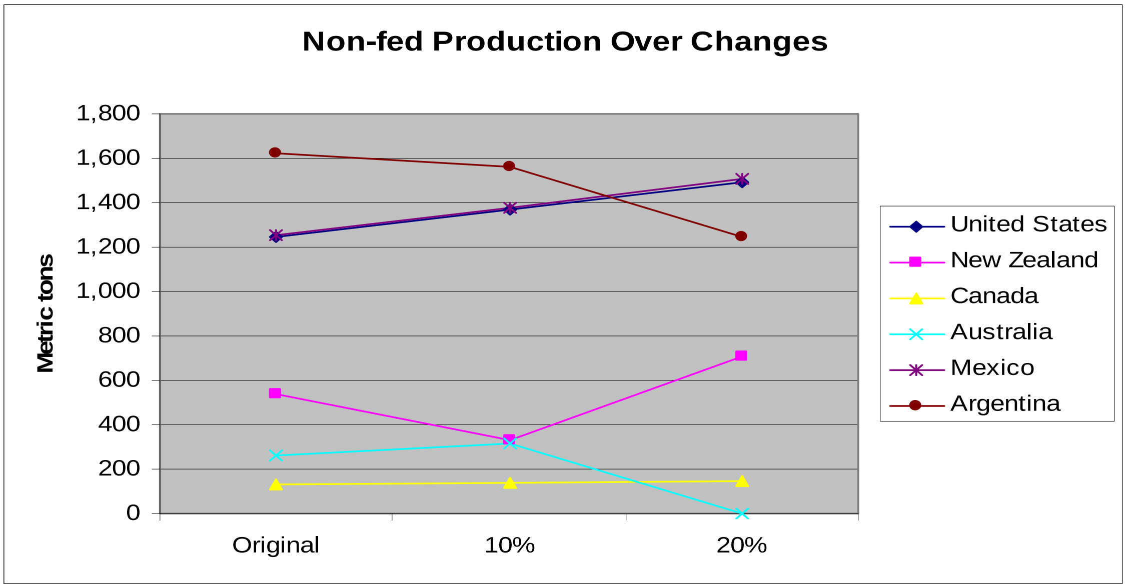


Figure 10, Non-fed Beef Capacity Changes



With a 20% capacity increase, changes were evident in the domestic production of non-fed beef and fed beef. From shifts in non-fed beef, the United States increased imports from Mexico as opposed to Argentina. The implication being that a decrease in the cost of transportation in combination with Mexico's increased capacity, makes Mexico a more efficient market for United States demand. Argentinean supply of grass-fattened beef to the United States decreases to zero.

Long established habits are hard to break. In the case of beef production the industries are generally hard to change once there are decades upon decades of historical production practices followed. Alterations in the amount of beef produced in a given region is essential in maintaining stable prices, taken from changes in supply and consumer demand. There is a difference between varying the amount of production and changing the practice all together. In the United States there could be land taken out of grain production and seeded back into native pastureland. The ease at which this would be done and convincing producers to undertake the commitment would be extreme. A complete upheaval of the market and industry would ensue, setting every phase of the beef industry off balance. The same goes for the changes that would need to take place in grass fattening countries in order to achieve the production of fed beef. This is not to say that an upheaval would not be profitable in the long run, but the sociological, psychological, and economic turmoil that would take place would not be healthy. The viability of a grass finishing industry to converge into a grain finished structure would be more easily implemented, in addition to being potentially more profitable if all additives became, or were made to be, available than the converse.

VI. Conclusions

This research was through the use of many assumptions where data was unavailable. Future research efforts in this area could be improved by the addition of the following factors:

- Disaggregated production, consumption, import, and export data
- Complete and perfectly comparable budget data
- Congruent production practices
- Exact transportation costs

The production practices in each of the regions examined differed as did the budget and production data. Thus, changing prices of inputs would not necessarily produce comparable changes in percent returns to capital. The transportation rates between countries are not published nor do industry participants know them. Of the production and consumption data gathered from both the USDA and the United Nations, neither differentiate between differing qualities of beef (e.g fed and non-fed, or boxed cuts and lean trim). It is also reasonable to assume that production practices in the various countries would differ as a result of the climatic differences among them. To increase the accuracy of this research, transportation costs and defined differentiation of product supply and demand would be necessary. The differences are noted throughout the manuscript and listed in Appendix A.

Export partners, such as those along the Pacific Rim, were not included because the focus of the research was United States imports and the Pacific Rim countries are net importers of beef. Additional research in this area may include these countries to demonstrate any benefits for United States fed beef demand and possibly price support resulting from changing trade flows. This research should be considered as a first attempt to quantify factors that affect fed and non-fed beef trade flows. The data available greatly limited the accuracy of the research, though given sensitivity results the model is fairly robust. In formulating the question at hand, a serious attempt was made to uncover all related research on the subject of beef and cattle production pointed to the question that spurred this research. The impacts, both positive and negative, on the prices of various beef products and animals has been discussed in the literature, but not a comparison based on the actual returns to production.

From a price and production standpoint, the assessment has been that imports negatively impact beef prices. The majority of United States imports are non-fed, grass fattened beef products. The countries from which the United States predominately imports were the focus of this research and the profitability of each country to produce both fed and non-fed beef was estimated. Disparities between markets were included in the assessment, concluding that the United States is profitable at producing fed cattle, enough in quantity to export. The research also established that the United States is not profitable at producing non-fed beef, that other countries do produce non-fed beef products profitably, in large enough quantity, at such a price as to economically justify the United States' imports. Through previous research and modeling tools the depression upon United States domestic price has been empirically established. Producing fed beef in the United States and exporting a higher valued product than non-fed beef better utilizes available resources given returns to production. Market structure and available inputs create the appropriate climate for different regions of the world to produce differing meat quantities. Regions without grain production are not adequately equipped for grain finishing, just as regions without extensive pastureland are not well suited for grass fattening cattle.

From the returns to operating capital it was found that countries that efficiently produced fed beef are generally not as efficient in the production of non-fed beef. Certain regions are better at producing either fed or non-fed beef dependant upon production and consumption constraints, trade flow being justified through returns to operating capital along with the inclusion of transportation costs. Increases to available production capacity shift trade flows so long as the demand warrants domestic production and then imports. The linear programming model maximizing production returns as an objective, illustrated the most efficient flow of trade given the production and consumption constraints.

Production returns for fed beef in Australia should support a growing industry. Mexico imports a greater quantity than would be expected given returns to production, though constraints to the market may be evident in addition to availability of resources, the most likely being a pure exhaustion of production capacity. Argentina is estimated to be unprofitable in the production of beef at current, in addition to health concerns impacting trade. In reality, from the 2002 United Nations data, Argentina is not an exporter.

In the United States, the conclusion is that the current production practice of raising fed beef is the most profitable enterprise. The resource requirements to compete with quantities and values of imports would not be beneficial to the beef industry or the economy as a whole. The value and profitability of fed beef in the United States is such that producers are better off producing fed beef for export and importing the lower valued non-fed beef product. All countries analyzed produce the most profitable product within the confines of the beef industry. If a beef product is not produced profitably, it is a more efficient use of resources to import.

This research adds to the debate as to whether United States producers should be concerned with the importation of non-fed beef. Certainly a price depressing impact on feeder and fed slaughter cattle prices exists as has been theorized and documented by Brester and Marsh (1998, 1999) and Brester and Wohlgenant (1997). United States producers should be better off producing the higher valued product, the more profitable, and further increasing the United States' world market share of fed beef exports. Continuing to bicker over the impact of non-fed or lean-trim imports appears to be counter-productive. Increasing the resources available for the production of fed beef will increase the United States producers' welfare in the long run, and keep consumer demand satisfied.

The Unites States should be better off importing non-fed beef from countries that have excess capacity in non-fed beef. The constraint for non-fed producing countries in fed beef is grain, and capital to support a grain feeding industry, both of which the United States has the availability.

Impediments to efficient trade flow have been theorized as tariffs, quotas, and subsidies. As noted in results, the estimates of support noted by the OECD explain some levels of beef production. The United States is the most heavily subsidized of the countries examined, based on the OECD data.

It is apparent in the increased 10% and 20% production capacity models that both fed and non-fed production, through an increase in production capacity, the market becomes more efficient; an increase in production and trade where it is beneficial to all regions.

VII. Appendices

Appendix A

Fed beef production assumptions in budgets:

United States, Fed beef

In weight	249.48 kg (550 pounds)
Out weight	521.64 kg (1150 pounds)
Production system	Weaned calves bought and fed a ration of corn, corn silage, and hay. 230 days on feed. 1% death loss.
Total feed used	1,491.29 kg (3,287.72 pounds)
Rate of daily gain	1.18 kg/day (3.968 #/day)
Feed Conversion rate	5.4795 kg feed / kg animal (www.abs.sdstate.edu/ag_econ/budgets)
Units measured	Pounds converted to kilograms

Canada, Fed beef

In weight	249.48 kg (550 pounds)
Out weight	521.64 kg (1150 pounds)
Production system	A combination of hay, corn, corn silage, and supplement. 300 days on feed with growth stimulants. 2% death loss.
Total feed used	1381.21 kg feed (3045 pounds)
Rate of daily gain	.9072 kg (2 pounds) / day
Feed Conversion rate	5.075 kg feed / kg animal; dry matter basis
Units measured	Pounds converted to kilograms

Mexico, Fed beef

In weight	270 kg (595 pounds)
Out weight	420 kg (926 pounds)
Production system	Heifers fed grain and supplement. Assumed .5% death loss. 112 days on feed.
Total feed used	1080 kg feed
Rate of daily gain	1.339 kg / day
Feed Conversion rate	7.188 kg feed / kg animal (Peel, 2001)
Units measured	Kilograms

Australia, Grain finished beef

In weight	240 kg (529 pounds)
Out weight	460 kg (1014 pounds)
Production system	Contract square baled silage, stored grain, and round bale crop stubbles. Possibly local grain or fodder crops if available. 2% death loss.
Total feed used	8.48 dse's (dry sheep equivalent)
Rate of daily gain	.603 kg/day
Feed Conversion rate	.5289 kg / ha feed; 1.18 ha / animal; .00536 ha / kg
Units measured	Hectares of feed per animal

New Zealand, Grain finished beef

In weight	100kg (220.46 pounds)
Out weight	420 kg (926 pounds)
Production system	Heifer finishing, the actually industry does not exist so assumptions were made stemming from the Mexican feeding of Holsteins and the Australian industry for grain finishing. 240 days on feed. Assumed 1% death rate.
Total feed used	2300 kg
Rate of daily gain	1.333 kg / dy
Feed Conversion rate	16.8 kg DM / kg animal (18 month bulls, Beef NZ); 7.188 from Holstein budget
Units measured	Per head totals

Argentina, Fed beef

In weight	170 (heifers)/180 (steers) kg
Out weight	290 (heifers)/370 (steers) kg
Production system	Heifers and steers are finished on pasture and supplemented with silage. Hay that would otherwise be consumed is harvested into round bales and is shown as an income. Stocking rate 3.75 animals/ha
Total feed used	(table provided values only)
Rate of daily gain	(table provided values only)
Feed Conversion rate	(table provided values only)
Units measured	Per hectare converted by stocking rates

Non-fed beef production assumptions in budgets:

United States, Non-fed beef

In weight	249.48 kg (550 pounds)
Out weight	368.32 kg (812 pounds)
Production system	Grazing of cattle on summer pasture. Assumed 1% death loss. 150 days on pasture.
Total feed used	3.39 AUM
Rate of daily gain	.7938 kg/day (1.75 pounds/day)
Feed Conversion rate	(Quality of forage and conversion not available)
Units measured	AUM

Canada, Non-fed beef

In weight	294.84 kg (650 pounds)
Out weight	385.56 kg (850 pounds)
Production system	Grazing animals on dry-land pasture at 4 AUM per animal over 120 days, May through September. Assumed 2% death loss.
Total feed used	4 AUM
Rate of daily gain	.756 kg (1.667 pounds)
Feed Conversion rate	(Quality of forage and conversion not available)
Units measured	AUM converted to kg

Mexico, Grass finished beef

In weight	320 kg (705 pounds)
Out weight	440 kg (970 pounds)
Production system	Grass feeding of bulls over 90 days, with mineral supplement
Total feed used	900 kg
Rate of daily gain	1.333 kg/day
Feed Conversion rate	7.5
Units measured	Kg

Australia, Grass finished beef (cows)

In weight	480kg (1058.208 pounds)
Out weight	500kg (1102.30 pounds)
Production system	Primary source of grass-finished beef consists of the feeding of cull cows. Cow value depreciated for the budget. Pasture finishing may include grain supplements during dry falls. Creep fed for 50-60 days before sale. 2% death rate.
Total feed used	1.94 ha pasture / cow
Rate of daily gain	.33 kg/day
Feed Conversion rate	(Quality of forage and conversion not available)
Units measured	Hectares of feed per animal

New Zealand, Grass fattened beef

In weight	300 kg (661.38 pounds)
Out weight	400 kg (881.84 pounds)
Production system	Dairy steers and dairy bulls fattened on pasture and a bit of silage. Most all production is done in conjunction with lamb and wool production. Pasture contributes 95% of all beef diets. Cattle are considered complimentary to sheep production.
Total feed used	(Not available)
Rate of daily gain	1.00-2.00 kd / hd / day (Beef NZ)
Feed Conversion rate	19.2 kg DM / kg animal (bull) (Beef NZ)
Units measured	Per head totals

Argentina, Complete cycle beef

In weight	170 (heifers)/180 (steers) kg
Out weight	170/180 (steers) kg
Production system	Steers and heifers fed on just pasture, cost of seeding pasture is included in the budget. Stocking rate 2.6 animals/ha
Total feed used	(table provided values only)
Rate of daily gain	(table provided values only)
Feed Conversion rate	(table provided values only)
Units measured	Per hectare converted by stocking rates

Appendix B

Fed Budgets

Fed Budget, U.S.

Gross Income		units	price	value	Revenue & Costs	
Slaughter steer		11.5cwt*	$ 76.50*******	$ 879.75		
Death loss 1%***				$ 8.80	$ 870.95	
Operating Costs						
yearling steer		5.5cwt*	$ 82.00*******	$ 451.00		
buy animals						
minerals		0.6cwt	$ 23.00****	$ 13.80		
supplement		2.93cwt	$ 10.00****	$ 29.30		
veterinary				$ 9.00		
marketing				$ 13.00		
Feed						
	Rollo					
	Fodder crops					
	corn	53bu	$ 3.00****	$ 159.00		
	oats	0bu	$ 1.20****	$ -		
	barley					
	hay	0.21ton	$ 52.00*	$ 10.92		
	silage	6ton	$ 23.75**	$ 142.50		
	pasture	0AUM	$ 13.00*****	$ -		
Transportation		748.885*******	0	0	$ -	
					$ 828.52	
Returns						5%

*Iowa State University, finishing steers budget, 2002
**Penn State College of Agricultural Sciences, Sample Slaughter Yearling Budget, 2001
***Kansas State University, Rodney Jones, 2003
****www.abs.sdstate.edu/ag_econ/budgets.hmt (South Dakota State University)
*****Compilation of high production region budgets (ISU, Penn, KSU, SDS)
******65.2% carcass body weight
*******www.ams.usda.gov/mnreports/am_ls830.txt accessed June 9, 2004

Fed Budget, Canada

Gross Income		units		price		value	Revenue & Costs	
Feeder steer sale		99	1150 $	0.78******		$897.92		
Death Loss 2%						$17.96	$879.96	
Operating Costs								
yearling steer			600 $	1.05******	100	$630.00		
buy animals								
minerals		0.09lbs/day*		$0.23*		$6.14		
supplement		0.8lbs/day*		$0.14*		$32.74		
vet		$ 6.00 hd			100	$6.00		
marketing		$ 16.50 hd			99	$16.50		
Feed				$/tonne				
	Rollo							
	Fodder crops							
	corn	15.4lbs/day*		$ 0.0659*		$304.46		
	barley	lbs/day		$ 0.0730**				
	hay	5.5lbs/day*		$ 0.0364*		$59.99		
	silage	13.2lbs/day*		$ 0.0136*		$54.00	$1,109.82	
	pasture			$ 90.00				
Transportation		749.8*****	0.0489****		$48.87	***		
							$59.97	
Returns								-25%

*www.omaf.gov.on.ca Ontario Feedlot Cost of Production Calculator
**Planning for Profit, Province of British Columbia, Ministry of Agriculture, Fisheries, and Food, Spring 1992
***Currency conversion 1.354 Canadian: $1 U.S. (www.cnbc.com accessed May 11, 2004)
****Orient Overseas Container Line Limited, Richard Gallagher
*****65.2% carcass body weight
******www.agr.gc.ca/misb/aisd/redmeat/03tabl11.xls accessed June 9, 2004

Fed Budget*, New Zealand

Gross Income			unit	price	value	Revenue & Costs	
Steer sale		420	kg/hd	$3.15*****	$1,323.00		
Death loss 1%					$13.23	$1,309.77	
Operating Costs							
yearling steer		100	kg/hd	$3.05*****	$305.00		
buy animals							
minerals							
supplement							
veterinary					$100.00		
marketing							
Feed					$288.00		
	Rollo						
	Fodder crops						
	corn						
	oats						
	barley						
	hay						
	silage					$1,173.00	
	yardage				$480.00		
Transportation	537.0406pounds/carcass**		0.065	***	$55.50****		
						$ 1,228.50	
Returns							7%

*from Darrell Peel's 2003 Mexican Holstein feeding budget, in it's entirety
**420kg animal at 58% dressing percentage, conversion to pounds for shipment calculation
*** Orient Overseas Container Line Limited, Richard Gallagher
****Currency conversion 11.283Peso:$1U.S. Mexican Holstein to New Zealand non-fed, with transportation costs (www.cnbc.com accessed May 11, 2004)
*****www.agri-fax.co.nz accessed June 9, 2004

Fed Budget, Australia

Gross Income	unit	price		value		AU$	Revenue & Costs	
	88steers	$ 162.07*****	$745.53	hd		$65,606.27 *		
	10steers	$ 162.07*****	$745.53	hd		$7,455.26 *		
Death loss 2%*						$1,461.23	$73,061.53	$716.00
Operating Costs - Total Variable Costs			kg					
livestock purchase		100	240	180.2*****	432.57	$43,257*		
buy animals								
minerals								
supplement								
vet						$786*		
marketing						$4,821*		
Feed								
	Rollo							
	Fodder crops					$1,440*		
	corn							
	oats							
	barley							
	hay							
	silage							
	pasture					$3,180*		$534.84
Transportation	661.2036**		0.065***		$58.71****		$53,484	$593.55
Returns								21%

*NSW Agriculture Farm Enterprise Budget, August 2003, 100 steers 240kg-460kg in 12 months
**65.2% body carcass weight
*** Orient Overseas Container Line Limited, Richard Gallagher
****Currency conversion 1.366AU$:$1 U.S. (www.cnbc.com accessed May 11, 2004)
*****Kieran Kelly Cattle Market Analyst National Livestock Reporting Service Meat & Livestock Australia, 2004 averages

Fed Budget*, Argentina

Gross Income		units	price	value	Revenue & Costs
Sell heifers		290	$0.85	$122.13	
Sell steers		370	$0.85	$160.27	
Rollo				$7.73	
Death loss 1%				2.824	$287.31
Operating Costs					
yearling steer			$0.98	$ 90.40	
yealing heifer			$0.90	$78.40	
minerals					
supplement					
vet					
marketing				$20.80	
Feed					
	Fodder crops				
	corn				
	oats				
	barley				
	hay				
	silage			$32.00	
AUM	pasture			$12.53	$234.13
Transportation		474.3417**	0.065***	$87.96****	
					$322.10
Returns					-11%

*www.inta.gov.ar/balcare/info (January 2003 numbers)
**65.2% carcass body weight
*** Orient Overseas Container Line Limited, Richard Gallagher
****Currency conversion 2.853 AG$: $1 U.S. (www.cnbc.com accessed May 11, 2004)

Fed Budget*, Mexico

Gross Income				value	Revenue & Costs	
Slaughter steer		12.96	420	5,443.20		
Death loss .5%				27.22	5,415.98	
Operating Costs						
yearling steer		14.50	270	3,915.00		
buy animals						
minerals						
supplement						
veterinary				80.00		
marketing						
Feed				168.00		
	Rollo					
	Fodder crops					
	corn					
	oats					
	barley					
	hay					
	silage					
	pasture			224.00	4,387.00	
Transportation		603.7077pounds**	0.04077***	342.18****		
					4,729.18	
Returns						15%

*Darrell Peel, 2001
**65.2% carcass body weight
*** Orient Overseas Container Line Limited, Richard Gallagher
**** Currency conversion 11.283 Peso: $1 U.S. (www.cnbc.com accessed May 11, 2004)

Non-Fed Budgets

Non-Fed Budget, U.S.

Gross Income		unit	price	value	Revenue & Costs
Slaughter steer		8.12cwt*	$68.50******	$556.22	
Death loss 1%				$5.56	$ 550.66
Operating Costs					
yearling steer		5.5cwt*	$82.00******	$451.00	
buy animals					
minerals			$4.56*	$4.56	
supplement				$ -	
veterinary				$12.00	
marketing				$10.00	
Feed					
	Rollo				
	Fodder crops				
	corn	bu	$2.40**	$ -	
	oats	0bu	$1.20**	$ -	
	hay	2.5ton	$52.00***	$130.00	
	silage	0ton	$23.75****	$ -	
	pasture	4AUM	$13.00***	$52.00	
Transportation	528.96*****		0	$ -	
					$ 659.56
Returns					-17%

*Summer Grazing of Steers in Eastern Kansas, Kansas State University, Rodney Jones, October 2003
**www.abs.sdstate.edu/ag_econ/budgets.hmt (South Dakota State University)
*** Compilation of high production region budgets (ISU, Penn, KSU, SDS)
****Penn State College of Agricultural Sciences, Sample Slaughter Yearling Budget, 2001
*****65.2% carcass body weight
******www.ams.usda.gov/mnreports/am_ls830.txt accessed June 9, 2004

Non-Fed Budget, Canada

Gross Income		unit		price	value	Revenues & Costs
Slaughter animal		99	850	$0.68*******	$ 57,222.00	$578.00
Death Loss 2%					$11.56	$566.44
Operating Costs						
yearling steer		100	650 $1.05*******		$682.50	
buy animals						
minerals		99	0.09* $ 0.23*		$2.45	
supplement		99	0* $0.14*		$ -	
veterinary		100	1 $4.00**		$ 4.00	
marketing		99	1 $18.40**		$18.40	
Feed			AUM			
	Rollo					
	Fodder crops					
	corn					
	oats					
	barley					
	hay					
	silage					
AUM	pasture	99	4*** $10.50**		$ 42.00	$749.35
Transportation	553.3987****		0.0489*****		$36.07******	
Returns						-28%

*www.omaf.gov.on.ca Ontario Feedlot Cost of Production Calculator
** Planning for Profit, Province of BC, Ministry of Agriculture, Fisheries and Food, Spring 1992
*** Yearlings on dry-land, BC Ministry of Agriculture, Fisheries and Food; Spring 1992.
****65.2% carcass body weight
***** Orient Overseas Container Line Limited, Richard Gallagher
****** Currency conversion 1.354 Canadian$: $1 U.S. (www.cnbc.com accessed May 11, 2004)
*******www.agr.gc.ca/misb/aisd/redmeat/03tabl11.xls accessed June 9, 2004

Non-Fed Budget, New Zealand

Gross Income		units	price	value	Revenues & Costs	
2 yr Bull		330	$3.20	$1,056.00*		
Death loss 1%				$10.56		
					$ 1,066.56	
Operating Costs						
yearling steer		100	$ 3.50******	$350.00*		
buy animals						
minerals				$ -		
supplement				$ -		
veterinary				$3.59**		
marketing				$1.41**		
Feed				$0.52**		
	corn			$ -		
	oats			$ -		
	barley					
	hay			$1.02**		
	silage					
	pasture			$1.48**	$358.02	
Transportation	467.3752***	0.065****		48.30*****		
Returns					$406.32	162%

*Beef NZ, "Intensive Beef Production Systems", Massey University, Steve Morris, 2002
** Sheep and Beef Monitoring Report - July 2002, Ministry of Agriculture and Forestry, New Zealand
*** 53% carcass body weight http://www.agri-fax.co.nz/calculators/screenshots/bull_profit_calc.cfm accessed June 9, 2004
**** Orient Overseas Container Line Limited, Richard Gallagher
***** Currency conversion 1.59 NZ$: $1 U.S. (www.cnbc.com accessed May 11, 2004)
******www.agri-fax.co.nz/ accessed June 9, 2004

Non-Fed Budget, Australia

Gross Income	unit		value	price	Revenue& Costs	
98cows	500	122.8*****hd	$60,165.88	613.9375		
Death loss 2%			$1,227.88	$58,938.00	$601.41	
Operating Costs - Total Variable Costs						
livestock purchase	100.00cows	122.8*****480	$58,938.00*	$589.38		
buy animals						
minerals						
supplement						
veterinary			$698.00*	$6.98		
livestock selling costs			$2,996.72*	$29.97		
Feed			$ 3,000.00*	$30.00		
Rollo						
Fodder crops						
corn						
oats						
barley						
hay						
silage						
pasture			$5,370.00*	$53.70	$710.03	
Transportation	718.6996**	0.065***		$63.81****		
					$773.84	
Returns						-22%

*NSW Agriculture Farm Enterprise Budget, August 2003 Local trade/feeders (creep feed) 100 cows
**65.2% carcass body weight
*** Orient Overseas Container Line Limited, Richard Gallagher
**** Currency conversion 1.366 AU$: $1 U.S. (www.cnbc.com accessed May 11, 2004)
*****Kieran Kelly Cattle Market Analyst National Livestock Reporting Service Meat & Livestock Australia

Non-Fed Budget*, Argentine

Gross Income		units	price	value	Revenues & Costs
Sell heifers			$0.85	$ 120.77	
Sell steers			$0.85	$160.38	
Death loss 1%				$2.81	$278.34
Operating Costs					
Buy heifers			$0.98	$78.85	
Buy steers			$0.90	$93.85	
minerals					
supplement					
veterinary				$3.46	
marketing				$20.38	
Feed					
	Rollo			$18.08	
	corn				
	grain				
	barley				
	hay				
	silage				
	pasture			$26.54	$241.15
AUM					
Transportation		258.7319pounds**	0.065***	$47.98****	
					$289.13
Returns					-4%

* www.inta.gov.ar/balcare/info (January 2003 numbers)
**65.2% carcass body weight
*** Orient Overseas Container Line Limited, Richard Gallagher
**** Currency conversion 2.853 Peso: $1 U.S. (www.cnbc.com accessed May 11, 2004)

Non-Fed Budget*, Mexico

Gross Income		unit		price	value	Revenues & Costs
Slaughter bull		440kg		15.0	6600.0	
Death loss 4%					33.0	6,567.0
Operating Costs						
yearling steer		320kg		14.5	4,640.0	
buy animals						
minerals						
supplement						
veterinary						
marketing						
Feed		900kg*	1.10*		990.0*	
	Rollo					
	Fodder crops					
	corn					
	oats					
	barley					
	hay					
	silage					
	yardage				180.0	5,870.00
Transportation		553.4**		0.0443***	358.5	6,228.5
Returns						5%

*Darrell Peel fed heifer budget, 2001
**65.2% carcass body weight
*** Orient Overseas Container Line Limited, Richard Gallagher
**** Currency conversion 11.283 Peso: $1 U.S. (www.cnbc.com accessed May 11, 2004)

Appendix C

Matrix j=Matrix k

United States
New Zealand
Canada
Australia
Mexico
Argentina

Matrix i

Fed, Grain
Non-fed, Grass

Matrix a

	i=Fed, Grain	i=Non-fed, Grass
j=United States	0.34044	0.240467
j=New Zealand	0.244139	0.2124687
j=Canada	0.34085908	0.251575
j=Australia	0.300583	0.326721
j=Mexico	0.274446	0.251575
j=Argentina	0.215636	0.1176195

Matrix C

	i=Fed, Grain	i=Non-fed, Grass
j=United States	828.52	659.56
j=New Zealand	487.8425	225.16981
j=Canada	799.068213	584.8597
j=Australia	391.5373	519.7856
j=Mexico	517.5042	353.2748
j=Argentina	82.06566	84.526409

Matrix R

	k=United States	k=New Zealand	k=Canada	k=Australia	k=Mexico	k=Argentina
j=United States	0	143.33	105.91	143.33	110.52	143.33
j=New Zealand	143.33	0	143.33	23.89	143.33	143.33
j=Canada	105.91	143.33	0	143.33	143.33	143.33
j=Australia	143.33	23.89	143.33	0	143.33	143.33
j=Mexico	110.52	143.33	143.33	143.33	0	143.33
j=Argentina	143.33	143.33	143.33	143.33	143.33	0

Figure 11, Linear Programming Tableau

			RHS	MTE					1 hd returns to operation capital			
			V	US Grain	US Grass	NZ Grain	NZ Grass	Can Grain	Can Grass	AU Grain	AU Grass	Mex Grain
MTE (1,000)	Obj Fxn	0.00		5.00	-17.00	7.00	162.00	-25.00	-28.00	21.00	-22.00	15.00
	US Fed Balance	0	0	-0.34044								
	US Non-Fed Balance	0	0		-0.2404666							
	NZ Fed Balance	0	0			-0.2441388						
	NZ non-Fed Balance	0	0				-0.212468675					
	Canadian Fed Balance	0	0					-0.34085908				
	Canadian Non-Fed Balance	0	0						-0.251575049			
	Australian Fed Balance	0	0							-0.300583157		
	Australian NF Balance	0	0								-0.326720838	
	Mexican Fed Balance	0	0									-0.27444552
	Mexican Non-Fed Balance	0	0									
	Arg Fed Balance	0	0									
	Arg Non-fed Balance	0	0									
Demd	US Fed Consumption	0.00	10,827.30									
Demd	US Non-Fed Consumption	0.00	1,910.70									
Demd	NZ Fed Consumption	0.00	10.80									
Demd	NZ Non-Fed Consumption	0.00	97.20									
Demd	Canadian Fed Consumption	0.00	843.20									
Demd	Canadian NF Consumtpion	0.00	148.80									
Demd	Australian Fed Consumption	0.00	387.20									
Demd	Australian NF Consumption	0.00	316.80									
Demd	Mexico Fed Consumption	0.00	963.60									
Demd	Mexico Non-Fed Consumption	0.00	1445.40									
Demd	Arg Fed Consumption	0.00	1180.50									
Demd	Arg Non-Fed Consumption	0.00	1180.50									
	Max US Fed	0.00	11184.30	0.34044								
	Max US Grass	0.00	1242.70		0.2404666							
	Max NZ Fed	0.00	0.00			0.2441388						
	Max NZ Grass	0.00	589.00				0.212468675					
	Max Can Fed	0.00	1165.50					0.34085908				
	Max Can Grass	0.00	129.50						0.251575049			
	Max Austr Fed	0.00	208.90							0.300583157		
	Max Austr Grass	0.00	1880.10								0.326720838	
	Max Mexico Fed	0.00	675.50									0.27444552
	Max Mexico Grass	0.00	1254.50									
	Max Arg Grain	0.00	1080.00									
	Max Arg Grass	0.00	1620.00									

Figure 11 continued

					MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE
		Mex Grass	Arg Grain	Arg Grass	US fed to US	NZ fed to US	Can fed to US	AU fed to US	Mex fed to US	Arg fed to US	NZ fed to NZ	US fed to NZ	Can fed to NZ	AU fed to NZ	Mex fed to NZ
MTE (1,000)	Obj Fxn	5.00	-11.00	-4.00	0.00	-143.33	-105.91	-143.33	-110.52	-143.33	0.00	-143.33	-143.33	-23.89	-143.33
	US Fed Balance				1							1			
	US Non-Fed Balance														
	NZ Fed Balance					1					1				
	NZ non-Fed Balance														
	Canadian Fed Balance						1						1		
	Canadian Non-Fed Balance														
	Australian Fed Balance							1						1	
	Australian NF Balance														
	Mexican Fed Balance								1						1
	Mexican Non-Fed Balance	-0.251575049													
	Arg Fed Balance		-0.215635737							1					
	Arg Non-fed Balance			-0.11761952											
Demd	US Fed Consumption				1	1	1	1	1	1					
Demd	US Non-Fed Consumption														
Demd	NZ Fed Consumption										1	1	1	1	1
Demd	NZ Non-Fed Consumption														
Demd	Canadian Fed Consumption														
Demd	Canadian NF Consumtpion														
Demd	Australian Fed Consumption														
Demd	Australian NF Consumption														
Demd	Mexico Fed Consumption														
Demd	Mexico Non-Fed Consumption														
Demd	Arg Fed Consumption														
Demd	Arg Non-Fed Consumption														
	Max US Fed														
	Max US Grass														
	Max NZ Fed														
	Max NZ Grass														
	Max Can Fed														
	Max Can Grass														
	Max Austr Fed														
	Max Austr Grass														
	Max Mexico Fed														
	Max Mexico Grass	0.251575049													
	Max Arg Grain		0.215635737												
	Max Arg Grass			0.117619522											

Figure 11 continued

all transportation costs per MTE, in US $

		Arg fed to NZ	Can fed to Can	US fed to Can	NZ fed to Can	AU fed to Can	Mex fed to Can	Arg fed to Can	Au fed to AU	US fed to AU	NZ fed to AU	Can fed to AU	Mex fed to AU	Arg fed to AU	Mex fed to Mex	US fed to Mex	NZ fed to Mex
		MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE
MTE (1,000)	Obj Fxn	-143.33	0.00	-105.91	-143.33	-143.33	-143.33	-143.33	0.00	-143.33	-23.89	-143.33	-143.33	-143.33	0.00	-110.52	-143.33
	US Fed Balance			1						1						1	
	US Non-Fed Balance																
	NZ Fed Balance				1						1						1
	NZ non-Fed Balance																
	Canadian Fed Balance		1									1					
	Canadian Non-Fed Balance																
	Australian Fed Balance					1			1								
	Australian NF Balance																
	Mexican Fed Balance						1						1		1		
	Mexican Non-Fed Balance																
	Arg Fed Balance	1						1						1			
	Arg Non-fed Balance																
Demd	US Fed Consumption																
Demd	US Non-Fed Consumption																
Demd	NZ Fed Consumption	1															
Demd	NZ Non-Fed Consumption																
Demd	Canadian Fed Consumption		1	1	1	1	1	1									
Demd	Canadian NF Consumtpion																
Demd	Australian Fed Consumption								1	1	1	1	1	1			
Demd	Australian NF Consumption																
Demd	Mexico Fed Consumption														1	1	1
Demd	Mexico Non-Fed Consumption																
Demd	Arg Fed Consumption																
Demd	Arg Non-Fed Consumption																
	Max US Fed																
	Max US Grass																
	Max NZ Fed																
	Max NZ Grass																
	Max Can Fed																
	Max Can Grass																
	Max Austr Fed																
	Max Austr Grass																
	Max Mexico Fed																
	Max Mexico Grass																
	Max Arg Grain																
	Max Arg Grass																

Figure 11 continued

		MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE
		Can fed to Mex	AU fed to Mex	Arg fed to Mex	Arg fed to Arg	US fed to Arg	NZ fed to Arg	Can fed to Arg	AU fed ro Arg	Mex fed to Arg	US grs to US	NZ grs to US	Can grs to US	AU grs to US	Mex grs to US	Arg grs to US	NZ grs to NZ
MTE (1,000)	Obj Fxn	-143.33	-143.33	-143.33	0.00	-143.33	-143.33	-143.33	-143.33	-143.33	0.00	-143.33	-105.91	-143.33	-110.52	-143.33	0.00
	US Fed Balance					1											
	US Non-Fed Balance										1						
	NZ Fed Balance						1										
	NZ non-Fed Balance											1					1
	Canadian Fed Balance	1						1									
	Canadian Non-Fed Balance												1				
	Australian Fed Balance		1						1								
	Australian NF Balance													1			
	Mexican Fed Balance									1							
	Mexican Non-Fed Balance														1		
	Arg Fed Balance			1	1												
	Arg Non-fed Balance															1	
Demd	US Fed Consumption																
Demd	US Non-Fed Consumption										1	1	1	1	1	1	
Demd	NZ Fed Consumption																
Demd	NZ Non-Fed Consumption																1
Demd	Canadian Fed Consumption																
Demd	Canadian NF Consumtpion																
Demd	Australian Fed Consumption																
Demd	Australian NF Consumption																
Demd	Mexico Fed Consumption	1	1	1													
Demd	Mexico Non-Fed Consumption																
Demd	Arg Fed Consumption				1	1	1	1	1	1							
Demd	Arg Non-Fed Consumption																
	Max US Fed																
	Max US Grass																
	Max NZ Fed																
	Max NZ Grass																
	Max Can Fed																
	Max Can Grass																
	Max Austr Fed																
	Max Austr Grass																
	Max Mexico Fed																
	Max Mexico Grass																
	Max Arg Grain																
	Max Arg Grass																

Figure 11 continued

all transportation costs per MTE, in US $

	MTE (1,000)	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE	MTE
		US grs to NZ	Can grs to NZ	AU grs to NZ	Mex grs to NZ	Arg grs to NZ	Can grs to Can	US grs to Can	NZ grs to Can	AU grs to Can	Mex grs to Can	Arg grs to Can	AU grs to AU	US grs to AU	NZ grs to AU	Can grs to AU	Mex grs to AU
	Obj Fxn	-143.33	-143.33	-23.89	-143.33	-143.33	0.00	-105.91	-143.33	-143.33	-143.33	-143.33	0.00	-143.33	-23.89	-143.33	-143.33
	US Fed Balance																
	US Non-Fed Balance	1						1						1			
	NZ Fed Balance																
	NZ non-Fed Balance								1						1		
	Canadian Fed Balance																
	Canadian Non-Fed Balance		1				1									1	
	Australian Fed Balance																
	Australian NF Balance			1						1			1				
	Mexican Fed Balance																
	Mexican Non-Fed Balance				1						1						1
	Arg Fed Balance																
	Arg Non-fed Balance					1						1					
Demd	US Fed Consumption																
Demd	US Non-Fed Consumption																
Demd	NZ Fed Consumption																
Demd	NZ Non-Fed Consumption	1	1	1	1	1											
Demd	Canadian Fed Consumption																
Demd	Canadian NF Consumtpion						1	1	1	1	1	1					
Demd	Australian Fed Consumption																
Demd	Australian NF Consumption												1	1	1	1	1
Demd	Mexico Fed Consumption																
Demd	Mexico Non-Fed Consumption																
Demd	Arg Fed Consumption																
Demd	Arg Non-Fed Consumption																
	Max US Fed																
	Max US Grass																
	Max NZ Fed																
	Max NZ Grass																
	Max Can Fed																
	Max Can Grass																
	Max Austr Fed																
	Max Austr Grass																
	Max Mexico Fed																
	Max Mexico Grass																
	Max Arg Grain																
	Max Arg Grass																

Figure 12, Original Model

Activities

Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
US Grain	32,852	-	5	1E+30	29.96926296
US Grass	5,168	-	-17	1E+30	27.91273379
NZ Grain	-	-	7	1E+30	59.89733232
NZ Grass	2,772	-	162	1E+30	171.2313969
Can Grain	3,121	-	-25	25	1E+30
Can Grass	515	-	-28	1E+30	18.98749516
AU Grain	695	-	21	1E+30	86.12707985
AU Grass	807	-	-22	3.084346757	1E+30
Mex Grain	2,461	-	15	1E+30	65.4598533
Mex Grass	4,987	-	5	1E+30	51.98749516
Arg Grain	5,008	-	-11	1E+30	35.72159948
Arg Grass	13,773	-	-4	2.44592E+16	1.110365021
US fed to US	10,827	-	0	1E+30	105.9102
NZ fed to US	-	(287)	-143.325	286.65	1E+30
Can fed to US	-	(106)	-105.9102	105.9102	1E+30
AU fed to US	-	(287)	-143.325	286.65	1E+30
Mex fed to US	-	(221)	-110.517	221.034	1E+30
Arg fed to US	-	(287)	-143.325	286.65	1E+30
NZ fed to NZ	-	-	0	1E+30	23.8875
US fed to NZ	-	-	-143.325	0	1E+30
Can fed to NZ	11	-	-143.325	23.8875	0
AU fed to NZ	-	(24)	-23.8875	23.8875	1E+30
Mex fed to NZ	-	(111)	-143.325	110.517	1E+30
Arg fed to NZ	-	(143)	-143.325	143.325	1E+30
Can fed to Can	843	-	0	1E+30	105.9102
US fed to Can	-	(106)	-105.9102	105.9102	1E+30
NZ fed to Can	-	(287)	-143.325	286.65	1E+30
AU fed to Can	-	(287)	-143.325	286.65	1E+30
Mex fed to Can	-	(254)	-143.325	253.842	1E+30
Arg fed to Can	-	(287)	-143.325	286.65	1E+30
Au fed to AU	209	-	0	1E+30	23.8875
US fed to AU	-	-	-143.325	0	1E+30
NZ fed to AU	-	(24)	-23.8875	23.8875	1E+30
Can fed to AU	178	-	-143.325	23.8875	0
Mex fed to AU	-	(111)	-143.325	110.517	1E+30
Arg fed to AU	-	(143)	-143.325	143.325	1E+30
Mex fed to Mex	676	-	0	1E+30	110.517
US fed to Mex	288	-	-110.517	110.517	32.808
NZ fed to Mex	-	(176)	-143.325	176.133	1E+30
Can fed to Mex	-	(33)	-143.325	32.808	1E+30
AU fed to Mex	-	(176)	-143.325	176.133	1E+30
Arg fed to Mex	-	(176)	-143.325	176.133	1E+30
Arg fed to Arg	1,080	-	0	1E+30	143.325
US fed to Arg	69	-	-143.325	32.808	0

Figure 13, continued

Activities

NZ fed to Arg	-	(143)	-143.325	143.325	1E+30
Can fed to Arg	32	-	-143.325	0	32.808
AU fed ro Arg	-	(143)	-143.325	143.325	1E+30
Mex fed to Arg	-	(111)	-143.325	110.517	1E+30
US grs to US	1,243	-	0	1E+30	105.9102
NZ grs to US	439	-	-143.325	9.44031233	0
Can grs to US	-	(106)	-105.9102	105.9102	1E+30
AU grs to US	-	(24)	-143.325	23.8875	1E+30
Mex grs to US	-	(111)	-110.517	110.517	1E+30
Arg grs to US	229	-	-143.325	0	9.44031233
NZ grs to NZ	97	-	0	1E+30	47.775
US grs to NZ	-	(287)	-143.325	286.65	1E+30
Can grs to NZ	-	(287)	-143.325	286.65	1E+30
AU grs to NZ	-	(48)	-23.8875	47.775	1E+30
Mex grs to NZ	-	(287)	-143.325	286.65	1E+30
Arg grs to NZ	-	(143)	-143.325	143.325	1E+30
Can grs to Can	130	-	0	1E+30	75.47447665
US grs to Can	-	(106)	-105.9102	105.9102	1E+30
NZ grs to Can	-	-	-143.325	0	1E+30
AU grs to Can	-	(24)	-143.325	23.8875	1E+30
Mex grs to Can	-	(143)	-143.325	143.325	1E+30
Arg grs to Can	19	-	-143.325	75.47447665	0
AU grs to AU	264	-	0	9.44031233	23.8875
US grs to AU	-	(263)	-143.325	262.7625	1E+30
NZ grs to AU	53	-	-23.8875	23.8875	9.44031233
Can grs to AU	-	(263)	-143.325	262.7625	1E+30
Mex grs to AU	-	(263)	-143.325	262.7625	1E+30
Arg grs to AU	-	(119)	-143.325	119.4375	1E+30
Mex grs to Mex	1,255	-	0	1E+30	110.517
US grs to Mex	-	(111)	-110.517	110.517	1E+30
NZ grs to Mex	-	-	-143.325	0	1E+30
Can grs to Mex	-	(143)	-143.325	143.325	1E+30
AU grs to Mex	-	(24)	-143.325	23.8875	1E+30
Arg grs to Mex	191	-	-143.325	110.517	0
Arg grs to Arg	1,181	-	0	1E+30	143.325
US grs to Arg	-	(287)	-143.325	286.65	1E+30
NZ grs to Arg	-	(143)	-143.325	143.325	1E+30
Can grs to Arg	-	(287)	-143.325	286.65	1E+30
AU grs to Arg	-	(167)	-143.325	167.2125	1E+30
Mex grs to Arg	-	(287)	-143.325	286.65	1E+30

Figure 12, continued

Constraints

Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
Max US Fed	11,184.30	88.03	11184.3	31.6	68.9
Max US Grass	1,242.70	116.08	1242.7	263.7	53.1
Max NZ Fed	0.00	245.34	0	10.8	0
Max NZ Grass	589.00	805.91	589	263.7	53.1
Max Can Fed	1,063.90	0.00	1165.5	1E+30	101.6
Max Can Grass	129.50	75.47	129.5	19.3	53.1
Max Austr Fed	208.90	286.53	208.9	178.3	101.6
Max Austr Grass	263.70	0.00	1880.1	1E+30	1616.4
Max Mexico Fed	675.50	238.52	675.5	31.6	68.9
Max Mexico Grass	1,254.50	206.65	1254.5	190.9	53.1
Max Arg Grain	1,080.00	165.66	1080	31.6	101.6
Max Arg Grass	1,620.00	9.44	1620	263.7	53.1
US Fed Balance	0	73	0	31.6	68.9
US Non-Fed Balance	0	187	0	263.7	53.1
NZ Fed Balance	0	217	0	10.8	0
NZ non-Fed Balance	0	43	0	263.7	53.1
Canadian Fed Balance	0	73	0	1063.9	101.6
Canadian Non-Fed Balance	0	187	0	19.3	53.1
Australian Fed Balance	0	217	0	178.3	101.6
Australian NF Balance	0	67	0	263.7	1616.4
Mexican Fed Balance	0	184	0	31.6	68.9
Mexican Non-Fed Balance	0	187	0	190.9	53.1
Arg Fed Balance	0	217	0	31.6	101.6
Arg Non-fed Balance	0	43	0	263.7	53.1
US Fed Consumption	10,827.30	-73.34	10827.3	68.9	31.6
US Non-Fed Consumption	1,910.70	-186.77	1910.7	53.1	263.7
NZ Fed Consumption	10.80	-216.67	10.8	101.6	10.8
NZ Non-Fed Consumption	97.20	-43.45	97.2	53.1	97.2
Canadian Fed Consumption	843.20	-73.34	843.2	101.6	843.2
Canadian NF Consumption	148.80	-186.77	148.8	53.1	19.3
Australian Fed Consumption	387.20	-216.67	387.2	101.6	178.3
Australian NF Consumption	316.80	-67.34	316.8	1616.4	263.7
Mexico Fed Consumption	963.60	-183.86	963.6	68.9	31.6
Mexico Non-Fed Consumption	1,445.40	-186.77	1445.4	53.1	190.9
Arg Fed Consumption	1,180.50	-216.67	1180.5	101.6	31.6
Arg Non-Fed Consumption	1,180.50	-43.45	1180.5	53.1	263.7

Figure 14, 10% Increase Production Capacity Model

Activities

Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
US Grain	36,138	-	5	1E+30	5
US Grass	5,685	-	-17	1E+30	25.64265398
NZ Grain	-	-	7	1E+30	41.99119351
NZ Grass	3,049	-	162	1E+30	169.2256262
Can Grain	2,474	-	-25	25	11.10045333
Can Grass	566	-	-28	1E+30	16.61254813
AU Grain	764	-	21	1E+30	64.08108091
AU Grass	-	(3)	-22	3.084346757	1E+30
Mex Grain	2,707	-	15	1E+30	45.33089558
Mex Grass	5,485	-	5	1E+30	49.61254813
Arg Grain	5,475	-	-11	11	19.90599198
Arg Grass	13,281	-	-4	4	1.110365021
US fed to US	10,827	-	0	1E+30	179.2542928
NZ fed to US	-	(287)	-143.325	286.65	1E+30
Can fed to US	-	(179)	-105.9102	179.2542928	1E+30
AU fed to US	-	(287)	-143.325	286.65	1E+30
Mex fed to US	-	(221)	-110.517	221.034	1E+30
Arg fed to US	-	(194)	-143.325	194.3369527	1E+30
NZ fed to NZ	-	-	0	1E+30	23.8875
US fed to NZ	11	-	-143.325	23.8875	23.8875
Can fed to NZ	-	(73)	-143.325	73.34409281	1E+30
AU fed to NZ	-	(24)	-23.8875	23.8875	1E+30
Mex fed to NZ	-	(111)	-143.325	110.517	1E+30
Arg fed to NZ	-	(51)	-143.325	51.01195267	1E+30
Can fed to Can	843	-	0	1E+30	32.56610719
US fed to Can	-	(33)	-105.9102	32.56610719	1E+30
NZ fed to Can	-	(213)	-143.325	213.3059072	1E+30
AU fed to Can	-	(213)	-143.325	213.3059072	1E+30
Mex fed to Can	-	(180)	-143.325	180.4979072	1E+30
Arg fed to Can	-	(121)	-143.325	120.9928599	1E+30
Au fed to AU	230	-	0	1E+30	23.8875
US fed to AU	157	-	-143.325	23.8875	23.8875
NZ fed to AU	-	(24)	-23.8875	23.8875	1E+30
Can fed to AU	-	(73)	-143.325	73.34409281	1E+30
Mex fed to AU	-	(111)	-143.325	110.517	1E+30
Arg fed to AU	-	(51)	-143.325	51.01195267	1E+30
Mex fed to Mex	743	-	0	1E+30	110.517
US fed to Mex	221	-	-110.517	110.517	83.81995267
NZ fed to Mex	-	(176)	-143.325	176.133	1E+30
Can fed to Mex	-	(106)	-143.325	106.1520928	1E+30
AU fed to Mex	-	(176)	-143.325	176.133	1E+30
Arg fed to Mex	-	(84)	-143.325	83.81995267	1E+30
Arg fed to Arg	1,181	-	0	1E+30	92.31304733
US fed to Arg	-	(92)	-143.325	92.31304733	1E+30

Figure 13, continued

Activities

NZ fed to Arg	-	(236)	-143.325	235.6380473	1E+30
Can fed to Arg	-	(166)	-143.325	165.6571401	1E+30
AU fed ro Arg	-	(236)	-143.325	235.6380473	1E+30
Mex fed to Arg	-	(203)	-143.325	202.8300473	1E+30
US grs to US	1,367	-	0	1E+30	105.9102
NZ grs to US	168	-	-143.325	0	0
Can grs to US	-	(106)	-105.9102	105.9102	1E+30
AU grs to US	-	(24)	-143.325	23.8875	1E+30
Mex grs to US	-	(111)	-110.517	110.517	1E+30
Arg grs to US	375	-	-143.325	0	0
NZ grs to NZ	97	-	0	1E+30	47.775
US grs to NZ	-	(287)	-143.325	286.65	1E+30
Can grs to NZ	-	(287)	-143.325	286.65	1E+30
AU grs to NZ	-	(48)	-23.8875	47.775	1E+30
Mex grs to NZ	-	(287)	-143.325	286.65	1E+30
Arg grs to NZ	-	(143)	-143.325	143.325	1E+30
Can grs to Can	142	-	0	1E+30	66.03416432
US grs to Can	-	(106)	-105.9102	105.9102	1E+30
NZ grs to Can	-	-	-143.325	0	1E+30
AU grs to Can	-	(24)	-143.325	23.8875	1E+30
Mex grs to Can	-	(143)	-143.325	143.325	1E+30
Arg grs to Can	6	-	-143.325	66.03416432	0
AU grs to AU	0	-	0	9.44031233	23.8875
US grs to AU	-	(263)	-143.325	262.7625	1E+30
NZ grs to AU	317	-	-23.8875	23.8875	9.44031233
Can grs to AU	-	(263)	-143.325	262.7625	1E+30
Mex grs to AU	-	(263)	-143.325	262.7625	1E+30
Arg grs to AU	-	(119)	-143.325	119.4375	1E+30
Mex grs to Mex	1,380	-	0	1E+30	110.517
US grs to Mex	-	(111)	-110.517	110.517	1E+30
NZ grs to Mex	65	-	-143.325	110.517	0
Can grs to Mex	-	(143)	-143.325	143.325	1E+30
AU grs to Mex	-	(24)	-143.325	23.8875	1E+30
Arg grs to Mex	-	-	-143.325	0	1E+30
Arg grs to Arg	1,181	-	0	1E+30	143.325
US grs to Arg	-	(287)	-143.325	286.65	1E+30
NZ grs to Arg	-	(143)	-143.325	143.325	1E+30
Can grs to Arg	-	(287)	-143.325	286.65	1E+30
AU grs to Arg	-	(167)	-143.325	167.2125	1E+30
Mex grs to Arg	-	(287)	-143.325	286.65	1E+30

Figure 13, continued

Constraints

Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
Max US Fed	12,302.73	14.69	12302.73	1E+30	1086.67
Max US Grass	1,366.97	106.64	1366.97	375.28	219.87
Max NZ Fed	0.00	172.00	0	10.8	0
Max NZ Grass	647.90	796.47	647.9	375.28	168.45
Max Can Fed	843.20	0.00	1282.05	1E+30	438.85
Max Can Grass	142.45	66.03	142.45	6.35	142.45
Max Austr Fed	229.79	213.19	229.79	157.41	229.79
Max Austr Grass	0.00	0.00	2068.11	1E+30	2068.11
Max Mexico Fed	743.05	165.17	743.05	220.55	743.05
Max Mexico Grass	1,379.95	197.21	1379.95	65.45	168.45
Max Arg Grain	1,180.50	0.00	1188	1E+30	7.5
Max Arg Grass	1,562.13	0.00	1782	1E+30	219.87
US Fed Balance	-1,087	0	0	1E+30	1086.67
US Non-Fed Balance	0	177	0	375.28	219.87
NZ Fed Balance	0	143	0	10.8	0
NZ non-Fed Balance	0	34	0	375.28	168.45
Canadian Fed Balance	0	73	0	843.2	438.85
Canadian Non-Fed Balance	0	177	0	6.35	142.45
Australian Fed Balance	0	143	0	157.41	229.79
Australian NF Balance	0	58	0	316.8	0
Mexican Fed Balance	0	111	0	220.55	743.05
Mexican Non-Fed Balance	0	177	0	65.45	168.45
Arg Fed Balance	0	51	0	1180.5	7.5
Arg Non-fed Balance	0	34	0	1562.13	219.87
US Fed Consumption	10,827.30	0.00	10827.3	1086.67	10827.3
US Non-Fed Consumption	1,910.70	-177.33	1910.7	219.87	375.28
NZ Fed Consumption	10.80	-143.33	10.8	1086.67	10.8
NZ Non-Fed Consumption	97.20	-34.01	97.2	168.45	97.2
Canadian Fed Consumption	843.20	-73.34	843.2	438.85	843.2
Canadian NF Consumption	148.80	-177.33	148.8	219.87	6.35
Australian Fed Consumption	387.20	-143.33	387.2	1086.67	157.41
Australian NF Consumption	316.80	-57.90	316.8	168.45	316.8
Mexico Fed Consumption	963.60	-110.52	963.6	1086.67	220.55
Mexico Non-Fed Consumption	1,445.40	-177.33	1445.4	168.45	65.45
Arg Fed Consumption	1,180.50	-51.01	1180.5	7.5	1180.5
Arg Non-Fed Consumption	1,180.50	-34.01	1180.5	219.87	1180.5

Figure 15, 20% Increase Production Capacity Model

Activities

Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
US Grain	39,423	-	5	1E+30	5
US Grass	6,201	-	-17	1E+30	25.64265398
NZ Grain	-	-	7	1E+30	41.99119351
NZ Grass	3,327	-	162	1E+30	169.2256262
Can Grain	2,474	-	-25	25	11.10045333
Can Grass	591	-	-28	10.03181563	16.61254813
AU Grain	834	-	21	1E+30	64.08108091
AU Grass	-	(3)	-22	3.084346757	1E+30
Mex Grain	2,954	-	15	1E+30	45.33089558
Mex Grass	5,984	-	5	1E+30	21.80922843
Arg Grain	5,475	-	-11	11	19.90599198
Arg Grass	10,603	-	-4	4	1.110365021
US fed to US	10,827	-	0	1E+30	179.2542928
NZ fed to US	-	(287)	-143.325	286.65	1E+30
Can fed to US	-	(179)	-105.9102	179.2542928	1E+30
AU fed to US	-	(287)	-143.325	286.65	1E+30
Mex fed to US	-	(221)	-110.517	221.034	1E+30
Arg fed to US	-	(194)	-143.325	194.3369527	1E+30
NZ fed to NZ	-	-	0	1E+30	23.8875
US fed to NZ	11	-	-143.325	23.8875	23.8875
Can fed to NZ	-	(73)	-143.325	73.34409281	1E+30
AU fed to NZ	-	(24)	-23.8875	23.8875	1E+30
Mex fed to NZ	-	(111)	-143.325	110.517	1E+30
Arg fed to NZ	-	(51)	-143.325	51.01195267	1E+30
Can fed to Can	843	-	0	1E+30	32.56610719
US fed to Can	-	(33)	-105.9102	32.56610719	1E+30
NZ fed to Can	-	(213)	-143.325	213.3059072	1E+30
AU fed to Can	-	(213)	-143.325	213.3059072	1E+30
Mex fed to Can	-	(180)	-143.325	180.4979072	1E+30
Arg fed to Can	-	(121)	-143.325	120.9928599	1E+30
Au fed to AU	251	-	0	1E+30	23.8875
US fed to AU	137	-	-143.325	23.8875	23.8875
NZ fed to AU	-	(24)	-23.8875	23.8875	1E+30
Can fed to AU	-	(73)	-143.325	73.34409281	1E+30
Mex fed to AU	-	(111)	-143.325	110.517	1E+30
Arg fed to AU	-	(51)	-143.325	51.01195267	1E+30
Mex fed to Mex	811	-	0	1E+30	110.517
US fed to Mex	153	-	-110.517	110.517	83.81995267
NZ fed to Mex	-	(176)	-143.325	176.133	1E+30
Can fed to Mex	-	(106)	-143.325	106.1520928	1E+30
AU fed to Mex	-	(176)	-143.325	176.133	1E+30
Arg fed to Mex	-	(84)	-143.325	83.81995267	1E+30
Arg fed to Arg	1,181	-	0	1E+30	92.31304733
US fed to Arg	-	(92)	-143.325	92.31304733	1E+30

Figure 16, continued
Activities

Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
NZ fed to Arg	-	(236)	-143.325	235.6380473	1E+30
Can fed to Arg	-	(166)	-143.325	165.6571401	1E+30
AU fed ro Arg	-	(236)	-143.325	235.6380473	1E+30
Mex fed to Arg	-	(203)	-143.325	202.8300473	1E+30
US grs to US	1,491	-	0	1E+30	106.6370713
NZ grs to US	293	-	-143.325	9.44031233	23.8875
Can grs to US	-	(40)	-105.9102	39.87603568	1E+30
AU grs to US	-	(24)	-143.325	23.8875	1E+30
Mex grs to US	60	-	-110.517	110.517	66.81596008
Arg grs to US	67	-	-143.325	34.00796008	9.44031233
NZ grs to NZ	97	-	0	1E+30	47.775
US grs to NZ	-	(287)	-143.325	286.65	1E+30
Can grs to NZ	-	(221)	-143.325	220.6158357	1E+30
AU grs to NZ	-	(48)	-23.8875	47.775	1E+30
Mex grs to NZ	-	(176)	-143.325	176.133	1E+30
Arg grs to NZ	-	(143)	-143.325	143.325	1E+30
Can grs to Can	149	-	0	1E+30	66.03416432
US grs to Can	-	(172)	-105.9102	171.9443643	1E+30
NZ grs to Can	-	(66)	-143.325	66.03416432	1E+30
AU grs to Can	-	(90)	-143.325	89.92166432	1E+30
Mex grs to Can	-	(99)	-143.325	98.84216432	1E+30
Arg grs to Can	-	(66)	-143.325	66.03416432	1E+30
AU grs to AU	0	-	0	9.44031233	23.8875
US grs to AU	-	(263)	-143.325	262.7625	1E+30
NZ grs to AU	317	-	-23.8875	23.8875	9.44031233
Can grs to AU	-	(197)	-143.325	196.7283357	1E+30
Mex grs to AU	-	(152)	-143.325	152.2455	1E+30
Arg grs to AU	-	(119)	-143.325	119.4375	1E+30
Mex grs to Mex	1,445	-	0	1E+30	110.517
US grs to Mex	-	(221)	-110.517	221.034	1E+30
NZ grs to Mex	-	(111)	-143.325	110.517	1E+30
Can grs to Mex	-	(188)	-143.325	187.8078357	1E+30
AU grs to Mex	-	(134)	-143.325	134.4045	1E+30
Arg grs to Mex	-	(111)	-143.325	110.517	1E+30
Arg grs to Arg	1,181	-	0	1E+30	143.325
US grs to Arg	-	(287)	-143.325	286.65	1E+30
NZ grs to Arg	-	(143)	-143.325	143.325	1E+30
Can grs to Arg	-	(221)	-143.325	220.6158357	1E+30
AU grs to Arg	-	(167)	-143.325	167.2125	1E+30
Mex grs to Arg	-	(176)	-143.325	176.133	1E+30

Figure 14, continued

Constraints

Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
Max US Fed	13,421.16	14.69	13421.16	1E+30	2293.54
Max US Grass	1,491.24	106.64	1491.24	66.66	696.84
Max NZ Fed	0.00	172.00	0	10.8	0
Max NZ Grass	706.80	796.47	706.8	66.66	292.8
Max Can Fed	843.20	0.00	1398.6	1E+30	555.4
Max Can Grass	148.80	0.00	155.4	1E+30	6.6
Max Austr Fed	250.68	213.19	250.68	136.52	250.68
Max Austr Grass	0.00	0.00	2256.12	1E+30	2256.12
Max Mexico Fed	810.60	165.17	810.6	153	810.6
Max Mexico Grass	1,505.40	86.69	1505.4	66.66	60
Max Arg Grain	1,180.50	0.00	1296	1E+30	115.5
Max Arg Grass	1,247.16	0.00	1944	1E+30	696.84
US Fed Balance	-2,294	0	0	1E+30	2293.54
US Non-Fed Balance	0	177	0	66.66	696.84
NZ Fed Balance	0	143	0	10.8	0
NZ non-Fed Balance	0	34	0	66.66	292.8
Canadian Fed Balance	0	73	0	843.2	555.4
Canadian Non-Fed Balance	0	111	0	148.8	6.6
Australian Fed Balance	0	143	0	136.52	250.68
Australian NF Balance	0	58	0	66.66	0
Mexican Fed Balance	0	111	0	153	810.6
Mexican Non-Fed Balance	0	67	0	66.66	60
Arg Fed Balance	0	51	0	1180.5	115.5
Arg Non-fed Balance	0	34	0	1247.16	696.84
US Fed Consumption	10,827.30	0.00	10827.3	2293.54	10827.3
US Non-Fed Consumption	1,910.70	-177.33	1910.7	696.84	66.66
NZ Fed Consumption	10.80	-143.33	10.8	2293.54	10.8
NZ Non-Fed Consumption	97.20	-34.01	97.2	292.8	66.66
Canadian Fed Consumption	843.20	-73.34	843.2	555.4	843.2
Canadian NF Consumption	148.80	-111.30	148.8	6.6	148.8
Australian Fed Consumption	387.20	-143.33	387.2	2293.54	136.52
Australian NF Consumption	316.80	-57.90	316.8	292.8	66.66
Mexico Fed Consumption	963.60	-110.52	963.6	2293.54	153
Mexico Non-Fed Consumption	1,445.40	-66.82	1445.4	60	66.66
Arg Fed Consumption	1,180.50	-51.01	1180.5	115.5	1180.5
Arg Non-Fed Consumption	1,180.50	-34.01	1180.5	696.84	1180.5

VIII. Bibliography

Asuming-Brempong, S., and J. M. Staatz. “Effects of More Open Trade on Cattle Production, Beef Consumption, and Welfare in the Central Corridor of West Africa,” Paper presented at American Agricultural Economics Association Annual Meeting, Tampa, Florida, July 2000.

Barrett, C.B. “Measuring Integration and Efficiency in International Agricultural Markets,” *Review of Agricultural Economics,* 23 (1)(Spring/Summer 2001):19-32

Bond, E.W. “Transportation Infrastructure Investments and Regional Trade Liberalization,” Policy Research Working Paper 1851, The World Bank Development Research Group, November 1997.

Brester, G. W., and J. M. Marsh. “U.S. Beef and Cattle Imports and Exports: Data Issues and Impacts on Cattle Prices.” Montana State University, Policy Issues Paper No. 9, April 1999.

_______ “Impacts of the Uruguay Round Trade Agreement on U.S. Beef and Cattle Prices.” Montana State University, Policy Issues Paper No. 6, September 1998.

Brester, G. W, and V. H., Smith. “Beef at the Border: Here’s the Beef.” Choices, 2000 2nd Quarter, Vol. 15 (2):28.

Brester, G. W, and M. K. Wohlgenant. “Impacts of the GATT/Uruguay Round Trade Negotiations on U.S. Beef and Cattle Prices.” *Journal of Agriculture and Resource Economics,* 22(1)(1997):145-156.

Casario, M. “North American Free Trade Agreement Bilateral Trade Effects,” *Contemporary Economic Policy*, 14 (1) (January 1996):36-47.

Conner, J. R., and R. W. Rogers. “Ground Beef: Implications for the Southeastern U.S. Beef Industry.” *Southern Journal of Agricultural Economics*, 11(1979):21-26.

Fang, C., and J. Fabiosa. “Does the U.S. Have a Cost Advantage Over China in Producing Corn, Soybeans, and Hogs?” Midwest Agribusiness Trade Research and Information Center, MATRIC Research Paper 02-MRP 4, August 2002.

Freebairn, J.W., and G. C. Rausser. “Effects of Changes in the Level of U.S. Beef Imports.” *American Journal of Agricultural Economics,* 57 (1975):676-688.

Gaitan, B., and F. Pavel. “Is ‘Getting the Prices Right’ Always Right? How Trade Liberalization Can Fail,” Economic Development Center, Department of Economics, Bulletin Number 00-1, University of Minnesota, March 2000.

Goto, J. “Regional Economic International and Agricultural Trade,” Policy Research Working Paper 1805, The World Bank International Economics Department Commodity Policy and Analysis Unit, August 1997.

Green, W. “Free Trade Floods U.S. with Imported Food,” freerepublic.com/focus/f-news/968178/posts, August 21, 2003, accessed June 18, 2004

Hahn, W. F., T. L. Crawford, L. Bailey, and S. Shagam. “The World Beef Market – Government Intervention and Multilateral Policy Reform.” Staff Report No. AGES9051, USDA, Economic Research Service, Commodity Economics Division, Washington DC, August 1990.

Hayes, D. J., and F. Fuller. “Optimal Chinese Agricultural Trade Patterns Under the Laws of Comparative Advantage,” Center for Agricultural and Rural Development, Working Paper 99-WP 233, Iowa State University, December 1999.

Kalantar, J., R. L. Gum, and E. L. Menzie. “Interregional Price Flexibilities: An Application to the Fed Beef Industry.” *Southern Journal of Agricultural Economics*, 7 (1975):129-133.

Koo, W.W., D. Karemera, and R. Taylor. “A Gravity Model Analysis of Meat Trade Policies,” *Agricultural Economics: the Journal of the International Association of Agricultural Economists*, 10(1) (January1994):81-88.

Landstra, J.A. “Liberalization of Agricultural Trade: The Way to Strong and Profitable Agriculture,” Extension Bulletin No. 324, Food and Fertilizer Technology Center, Republic of China, Taiwan, December 1990.

Melton, B.E., and W.E. Huffman. “NAFTA and U.S.-Mexican Beef Trade: Long-Run Implications for Changes in Trade Flows from Technology Transfers,” Staff Paper #294, Department of Economics, Iowa State University, December 1997.

Parcell, J. L., T. C. Schroeder, and T. L. Kastens. “The Effects of Meat Exports and Imports on Wholesale Primal Prices.” Presented at the AAEA Annual Meeting, Salt Lake City, Utah, May 13, 1998.

Peel, D.S. “U.S. and Mexican Cattle and Beef Trade.” Paper presented at Tri-National Research Symposium, NAFTA and Agriculture: Is the Experiment Working? San Antonio, TX, 1-2 November 1996.

Peel, D.S. (data from Mexico sabbatical in 2001)

Roberts, K. R., and W. J. Martin. “State-Level Analysis of National Beef Policy: The Use of State Econometric Models.” *Southern Journal of Agricultural Economics*, 16 (1984):63-72.

Rogowsky, R.A., L.A. Linkins, and K.S. Tsuji. *Trade Liberalization, Facts and Fears*. Westport, Conneticut: Praeger, 2001.

Sharples, J.A. “Cost of Production and Productivity in Analyzing Trade and Competitiveness.” *American Journal of Agricultural Economics* 72 (1990):1278-1282.

Welsh, R. and V. Llanes, “Comparison of New Zealand and the United States Industry Exporting and Marketing Practices” *Journal of Food Distribution Research* 27 (1996):102-106.

VITA

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Scope and Method of Study: The percentage returns to operating capital in fed and non-fed cattle budgets for the production countries of the United States, Canada, Mexico, New Zealand, Australia, and Argentina are compiled in an effort to compare, on a percentage basis, the competitive advantage that may exist in specific production countries. The primary interest is in the production of non-fed beef, hypothesizing that there is need for the United States to import non-fed, lower value, beef products due to the returns available for the United States' production of fed beef. A linear programming model is developed using percentage returns, along with transportation costs, in the maximization of the objective function, maximizing the returns to all production countries, satisfying consumption with in production capabilities. Constraints considered are the production and consumption parameters for each production country respectively, assumptions included for the analysis of fed and non-fed beef independently.

Findings and Conclusions: The results of the model indicate the most advantageous production regions and trade flows given a competitive comparison based on returns to capital. It is evident that the United States is most efficient at producing fed beef, and importing non-fed beef to satisfy demand. New Zealand is dominantly efficient at producing non-fed beef. The greater the increase in production capacity, the more efficient trade flow becomes. Government intervention is theorized to affect trade flow efficiency. Further research is needed to separate governmental impacts.

Advisor's Approval: Dr. Michael Dicks