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Implementing Four Modeling Improvement Strategies to Measure the Economic Contribution of the Alligator Farming Industry in Louisiana

Ilich Fernan Rosales Chiessa
Louisiana State University and Agricultural and Mechanical College

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IMPLEMENTING FOUR MODELING IMPROVEMENT STRATEGIES TO MEASURE THE ECONOMIC CONTRIBUTION OF THE ALLIGATOR FARMING INDUSTRY IN LOUISIANA

A Thesis
Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Master of Science in The Department of Agricultural Economics and Agribusiness

by
Ilich Fernán Rosales Chiessa
B.S., Escuela Agrícola Panamericana Zamorano, 2018
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ABSTRACT

The alligator industry in Louisiana has not had a study in thirty years that has measured its economic contribution. The industry has changed structurally over that period, and it produces more alligator skins but is concentrated in a smaller number of producers. With current threats to the industry through potential bans on alligator sales in states like California, the importance of these studies for the industry are more important now than ever. This study measures the economic contribution of American alligator across the supply chain of the state of Louisiana through four different modeling improvement strategies. These consist of using IMPLAN's conventional input-output model, re-assessing IMPLAN's production functions, performing an Analysis-by-Parts approach, and estimating Regional Purchase Coefficients derived from local spending patterns. The results discovered that alligator farming in Louisiana had generated a direct economic contribution of $80,201,270 based on a Low Revenue approach for class sizes for alligator skins. When analyzing the High Revenue approach, a direct contribution of $100,189,697 was identified. Additionally, the highest expense categories identified, on a per hatchling basis, included Hatchlings ($33.73), Feed ($26.27), and Labor Costs ($25.18). Additionally, it was found that when using the Analysis-by-Parts – Survey RPCs strategy, the total economic contributions ranged from $217 million to $272 million to the Louisiana economy. As a result, this generated an Output Multiplier of 2.71. Finally, by comparing the modeling improvement strategies, it was revealed that having additional information about the distribution of spending increases the Baseline Multiplier size by 26%. However, by combining a more accurate distribution of spending and the location of that spending, there is an increase from the Baseline Multiplier strategy of 53%. From the alligator industry's point of view, an additional $75.4 million in Output Effects were measured by including the local spending pattern.
CHAPTER 1. INTRODUCTION

1.1. Background

Since the 1970s, a law in California has banned the import and sales of specific exotic animal parts (hides, skins, and meat), but alligator was exempted from these bans. On January 1, 2020, California Penal Code Section 653o was scheduled to go into effect, making the import and sale of animal parts for alligator and crocodile a misdemeanor. As a result, the state of Louisiana sued the state of California, accusing California of trying to detriment the lucrative market for American alligator products. Currently, the ban has already resulted in a measurable drop in the price for alligator skins, according to the lawsuit filed by the state of Louisiana in federal court in Sacramento (Burnsons, 2019). Exporting alligator skins and other products out of the country is handled by the CITES Treaty. CITES (Convention for International Trade in Endangered Species of Wild Fauna and Flora) (CITES) was first introduced in 1975 and is overseen by the U.S. Fish and Wildlife Service (USFWS). This treaty helps regulate the international trade in protected species and controls for the United States. The American alligator is included in the CITES Treaty with other crocodilian species that are more endangered than alligator is in the United States (Louisiana Alligator Advisory Council, 2020).

According to the Louisiana Department of Wildlife and Fisheries (LDWF), Louisiana’s alligator management program has sustained use of the species successfully over the past three decades in both growing an industry for alligator hides, meat, and related products while at the same time sustaining and improving the wild alligator habitat and inventory of wild alligators. Woods (2006) emphasized how fundamental the alligator farming industry is for other industries such as the leather manufacturing industry and fashion designers. These industries, which depend on this species' byproducts, are more inclined to the American alligator skin due
to the higher quality than others in the market. The appreciation for this quality can be observed in the $25 million impact on the state of Florida’s economy (Woods, 2006).

Constituencies on the Alligator Advisory Council includes representation from alligator farmers, alligator hunters, and landowner representatives has been a significant challenger to California’s ban on alligator products. Through the years, there have been many attempts by the Louisiana Alligator Advisory Council to eliminate the sunset clause to Penal Code 653o; however, they have been unsuccessful. With the Penal Code Section 653o originally scheduled to go into effect after January 1, 2020, the sale of non-endangered alligator or crocodile products in California has already seen a reduction in the number of producers.

1.2. Problem Definition

While the alligator industry has had economic contribution assessments that are very limited, there has been tremendous growth in this industry that has been observed over the years and simultaneously reduced the number of alligator producers in the state. This has created a different structural environment in which an economic contribution can be assessed. Hence, this requires the adequate measure of contributions where such structural change in the production process has been identified. Additionally, a sensitivity analysis will be required to consider different model improvement strategies. Research studies and data involving the economics of the U.S. alligator industry as an economic model are scarce. The lack of recent economic data for the U.S. alligator industry and aquaculture related studies limits the ability to determine the socioeconomic contributions of current regulations fully. Currently, there is little information regarding aspects of economic contribution studies in aquaculture itself. Brannan et al. (1991) performed the last comprehensive study of the production of farm-raised alligators and the contribution this industry had to the state of Louisiana in 1991. LSU Coastal Fisheries Institute and the Louisiana Sea Grant College Program cooperated in elaborating this
study that now serves as a baseline for the new results that will describe this sector's economic influence on the state. That study implemented primary data collection from alligator farmers through surveys, which were sufficient to estimate the economic contribution but not well enough to yield other results such as financial feasibility estimates.

The limitations faced by the previous study make a case for the importance of updating data and creating a new benchmark for future related studies. For this reason, this research is designed to develop information regarding the need for a greater understanding of appropriate methods in performing economic contributions and impacts in aquaculture-related studies. The goal of establishing measures is to avoid some of the tendencies that inflate economic impacts and multipliers. These often incurred less desirable practices result from entities driven by a desire to demonstrate their sponsor’s positive contribution to the economic prosperity of a region.

1.3. Research Questions

The following research questions will be addressed in this study:

1) What is the economic contribution of the American alligator species (Alligator mississippiensis) to the Louisiana economy?
2) How sensitive are economic contribution valuations to the choice of modeling improvement strategy for the alligator industry?

1.4. Objectives

This study will measure the economic contribution of alligators across the supply chain to the state of Louisiana. Indirectly, it will evaluate the vulnerability potentially created by reduced demand from California’s statewide demand. It will identify the economic contribution of this industry through the following objectives:
1) Conduct a thorough economic contribution analysis to quantify and estimate the specified sector's direct contribution to the Louisiana economy.

2) Implement four modeling improvement strategies to evaluate the total economic contributions of the alligator industry.

3) Identify the strengths and weaknesses of each of the strategies implemented in the study and identify the optimal method given contribution purposes.

1.5. Accomplishment of Objectives

In Chapter 4, Section 4.2. analyzes the findings of the IRB approved survey of alligator farmers. The direct effects resulting from the survey are then employed into a standard Input-Output model in IMPLAN, where the economic contribution will be evaluated from the acquisition of eggs to the sale of alligator skins to brokers when the skins leave the state of Louisiana. The direct effects measured from the survey results accomplish Objective 1.

Furthermore, Section 4.3. presents the different modeling improvement strategies and their variation in the direct effects. The variation on the application of the direct effects into the IMPLAN Input-Output model will allow the accomplishment of Objective 2. The total output value will then be applied to the aggregated sector in IMPLAN that contains alligator production (Animal Production, except Cattle and Poultry and Eggs). This will provide baseline economic contribution results. Finally, Section 4.4. includes a comprehensive analysis of the comparison of the tradeoffs of using each modeling improvement strategy and will address Objective 3 of this study. This portion identifies the optimal strategy to use given contribution purposes.

The value of this economic contribution study is appreciated by the fact that there has not been a study done in thirty years that has comprehensively measured the contributions of the industry. During the time of the last study, the LDWF reported that the alligator industry
had sold a total of 188,976 skins with 134 alligator farmers in 1991. Since that time, it has been noted that the total number of skins increased measurably; however the number of alligator farmers declined during the same period. In 2019, the LDWF reported a total number of alligator skins sold of 438,577 with only 58 licensed alligator farmers.

1.6. Thesis Arrangement

This thesis is organized in the following sequence. Chapter 2, “The Alligator Industry in Louisiana,” which was mentioned before, is comprised of a thorough literature review of the history of the industry, the production process, and the industry’s regulatory environment. Subsequently, Chapter 3, “Modeling Improvement Strategies,” consists of an exhaustive review of studies concerning the four sensitivity analyses that this study applies. Moreover, Chapter 4 includes the results for each of the sensitivity analyses, and Chapter 5 concludes with a summary of the essential discoveries and recommendations made during this thesis.
CHAPTER 2. THE ALLIGATOR INDUSTRY IN LOUISIANA

2.1. Introduction

Louisiana residents have been hunting alligators for their hides since before the turn of the century. Alligator farming, on the other hand, is a much more recent activity from which commercial sales date back only to 1973. At this time, much of the original research regarding closed system alligator establishments in Louisiana was conducted at the Rockefeller Refuge, a state-owned research center managed by the Louisiana Department of Wildlife and Fisheries (LDWF). Incorporating information gained from earlier research, farmers have then continued to experiment with hut designs, feeding regimes, equipment, and waste treatment to develop their farms. This production effectiveness has now been reflected in the constant growth rates of farm-raised alligator populations (Brannan, 1991).

Currently, the alligator aquaculture production is ranked as one of the top five animal production industries in the state of Louisiana, with a farm-gate value surpassing $82 million each year (Reigh, 2018). Dissimilar to other kinds of animal production, alligator producers obtain their farm stock from the wild under approving authority of the LDWF, which applies an extensive management and research program to guarantee the sustainability of the use of the American alligator species.

Louisiana’s Alligator Management Program has become a wildlife conservation success and a model for managing similar crocodilian species throughout the world. Since the development of the program in 1972, conservative estimates have calculated over one million wild alligators harvested, over 9.5 million eggs collected, and over six million farm raised alligators sold bringing in millions of dollars of revenue (Louisiana Department of Wildlife and Fisheries, 2017). These returns have provided a direct economic benefit to private landowners and alligator hunters who lease land to protect, maintain, and enhance the alligator species.
This chapter comprises of an overview of the American alligator industry in Louisiana. This analysis highlights the history of the industry in Louisiana from its early beginnings, to its downfall, and all the way around to its recovery and current state. Moreover, this section features the essential components of the production process, and it emphasizes the national and state policies and regulatory environment that protect this industry. Similarly, this review addresses the policies that were set up in Louisiana that aided the jumpstart of the alligator farm industry while creating a sustainable habitat model. Also, it approaches the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) treaty and the implications this treaty has with regulation on the trade of exotic skins.

2.2. History of the Alligator Industry in Louisiana

The American alligator (Alligator mississippiensis) is inhabitant to the southeastern area of the United States and is common in the following states: Louisiana, Florida, Georgia, South Carolina, Texas, Arkansas, Mississippi, Alabama, and North Carolina. Their presence in this country was recorded by early settlers who reported an abundant population of crocodilians. As a result, alligators became utilized for commercial purposes for Louisianaans as a result of their high-quality leather for a global market (Nichols, Viehman, Chabreck, & Fenderson, 1976).

Initially, harvesting of alligators started in the 1850’s, and top harvests spiked in the late 1800’s, which eventually caused an extreme decline in the population by almost 80 percent between 1880 and 1904. The profitable alligator hides along with the animals’ vulnerability to hunting only provoked heavy harvests to continue and by 1950, alligators had been nearly eliminated from most of its original territory (Nichols et al., 1976; Shirley & Elsey, 2015). Consequently, this population decline resulted in harshly reduced harvests, which triggered the alligator season in Louisiana to close in 1962 for the next ten years. During this year, alligators
were considered an endangered species throughout all its territories and this initiated research studies to finally develop a thorough biological management program.

These all-time low populations in the 1950s prompted the U.S. Fish and Wildlife Service and State wildlife agencies to act accordingly to save these unique reptiles. From 1962 through August 1972, alligators were fully protected and by 1973 the American alligator was listed under the Endangered Species Act, meaning it was considered in danger of extinction throughout all or a significant portion of its range. At the time, countless state and federal laws regulating the methods of harvest, distribution, possession, transportation and export of live alligators and their byproducts were enacted. Successfully, the Louisiana Legislature identified the alligator's susceptibility to hunting required unique attention and legislation of a closely regulated commercial harvest was put into motion (Louisiana Department of Wildlife and Fisheries, 2017).

Louisiana has actively researched alligator farming programs since 1964. Earlier studies such as Chabreck (1959) emphasized the housing of adult animals in captivity for breeding purposes. Later investigations incorporated recent findings involving social and environmental parameters into pen design and stocking rates. Louisiana’s initial installations consisted of five ¼ acre breeding ponds stocked at various rates. Joanen et al. (1971) provided the first valuable information regarding breeding biology and pen design with their study on reproductive biology. In an effort to improve the severe decline of the wild populations of crocodilians at that time, the authors helped shed new light on the habitat requirements for the capture of wild adults. This study revealed that alligators can be propagated under captive conditions, however careful consideration must be considered to the following parameters: source of the alligators (wild or captivity), size and shape of the pen, source of water supply, size and depth of ponds, and stocking rates (Joanen & McNease, 1974).
By 1972, the number of alligators increased rapidly, and the Department of Wildlife and Fisheries was ready to initiate the new Alligator Management Program. This conservation program consisted of the actions taken by government agencies and alligator producers to ensure the maintenance of a viable population of the American alligator specie. One example of the actions taken by the LDWF was the closing of the alligator season for over a decade. After the alligator season was reopened, a total of 59 hunters harvested 1,350 alligators in Cameron Parish, which indicated the alligator season could be reopened in the Vermilion and Calcasieu Parishes (Louisiana Department of Wildlife and Fisheries, 2017). As it began to make a comeback, Louisiana and other southern States established alligator monitoring programs and used the information to ensure the population continued to increase. In 1987, the U.S. Fish and Wildlife Service declared the American alligator fully recovered and consequently removed from the list of endangered species (U.S. Fish & Wildlife Service, 2008). Similarly, by 1991 the total number of alligator producers in Louisiana increased to 134, with only 91 that sold hides. Most farms were of moderate size, producing several thousand alligators each year. As a result of the dramatic increase in Louisiana’s alligator ranching program, the Department of Wildlife and Fisheries required a quantity of juvenile alligators equal to 12% of the eggs hatched by the rancher to be returned to the wild within the first two years of hatching. These new regulations have all been product of the recently established Alligator Management Program (Shirley & Elsey, 2015).

Furthermore, in acknowledgment of the vital aspect that the Louisiana alligator industry plays in the Louisiana economy, the Louisiana legislature founded the Louisiana Alligator Resource Fund in 1991. This Act formed a source of revenue intended to help finance the costs of the alligator program in the Coastal and Nongame Resources Division of the Department. The fees associated to the alligator industry such as hide tag fees, shipping label fees, severance tax on alligator skins and alligator hunting license fees, are all deposited into the Alligator
Resource Fund. All aspects of the alligator management program, including biologists, staff, alligator disease research, education, promotion, and representation at CITES are all funded by the Alligator Resource Fund. Alligator producers and ranchers have supported these legislative endeavors despite national and international impediments to industry development, such as the California ban, which restricts the sale of alligator products in that state.

Research, biological investigation, management, and law enforcement have all been key players in the considerable growth and consolidation of the industry. Louisiana has increased its wild alligator population from less than 100,000 to over 1.5 million in the past 30 years. In 2018, the wild harvest of 20,165 alligators was valued at over $4.4 million, and farmers sold 449,523 skins which were valued at over $104 million. The wild harvest, egg collection, and farm raised alligators, has generated more than $120 million in economic benefit to the state of Louisiana (Louisiana Alligator Advisory Council, 2018). Currently, Louisiana and Florida alligator farms are attributed to more than 98 percent of the production. The Louisiana Alligator Farmers and Ranchers Association Meeting that took place on March 3rd, 2020, emphasized the year-end figures which have risen from last year’s harvest. The first item that was highlighted was the coastal nest count of 2019, which reported a high of 67,935 total nests identified to this date. As seen in Figure 2.1, the growth in coastal nest count from years 1970 to 2019 is increasing sizably due to the successful management program.
Additionally, it’s important to mention that there were some increasing changes in farm inventory from December 2018 to December 2019. The total number of animals in farm inventory increased from approximately 901,000 in 2018 to 998,000 in 2019’s year-end inventory. Similarly, the number of hatchlings increased from 576,000 to 613,000 from 2018 to 2019, respectively. Figure 2.2. highlights the number of alligator establishments by parish and quantities in the state of Louisiana. The map reveals that the parishes with the highest inventories of alligators in 2019 were Lafourche and Livingston Parishes, with inventories greater than 200,000 total alligators each. In a second tier, Vermilion parish showed an inventory of between 100,000 and 200,000 total alligators. Caldwell, Saint Tammany, and Terrebonne are behind in density with estimates between 50,000 and 100,000.
Also, it’s important to mention that the number of older alligators currently shedding has increased from 312,000 in 2018 to 378,000 in 2019. Skin shedding in alligators is much different than other reptiles. A healthy alligator will shed his scales regularly by rubbing against trees and rocks to rub off the dead skin. As they shed their scales, newer, larger, and denser scales are formed as the alligator grows in age and size. This increase in number of older alligators shedding is an indicator of a viable industry with a rising wild population. Figure 2.3. highlights the increase in number of farm alligators harvested from 2018 to 2019.
Figure 2.3. Farm Alligators Harvested (thousands).

Source: (Elsey, 2020)

The Louisiana Alligator season consists of dividing the state into east and west alligator hunting zones. The east zone opens the last Wednesday of August, while the West zone opens the first Wednesday in September. Each zone remains open for 30 days from the opening date. According to the LDWF, the 2020 Louisiana alligator hunting season was extended to 60 days this past year and ended in late October in both east and west zones.

Alligator farming in Louisiana has become a valuable industry since its modern recovery. State, federal, and international regulations ensure the sustainable use of this renewable resource and the conservation of the species and its wetland habitat. Specifically, Louisiana’s Alligator Management Program has been operating under strict and intensive supervision for over 40 years. Wise utilization of their alligator resources has led to a viable
industry with a stable and rising wild population. Intensive use and scientific effort have enabled the industry to defend itself based on proven science. The Louisiana Alligator Management Program has become a model of wise environmental management and this conclusion is supported by the analysis of extensive scientific data and the support of a wide range of professional scientific bodies. Furthermore, it is essential to mention that the efforts made by government agencies and private industry stakeholders made possible the integration of market-based alligator farming through conservation. Specifically, the release of juvenile alligators has contributed to removing the American alligator species from the Endangered Species Act of 1973.

2.3. Production Process

Early alligator farms in Louisiana were generally small, family-owned operations who often run more as a hobby than a commercial business. Extensive studies such as the one mentioned before by Joanen et al. (1971) revealed that alligator could effectively be cultured in captivity. Egg ranching, which comprises the collection of alligator eggs from the wild, proved more economical and successful than captive breeding.

Understanding the reptilian nature of alligators is essential in their commercial production. In their natural habitat, alligator grow slowly, taking 3 to 4 years to reach 48 inches, the market size of most farm-raised alligators. Under optimal conditions and the ideal temperature, alligators should reach this size in 12 to 15 months. Wild alligators reach their sexual maturity in about 8 to 10 years when they are at least 6 feet long. Nesting, which refers to the adult female’s instinct to prepare a home for upcoming newborns, occurs during early summer and the average clutch size, number of eggs laid in a single nesting, is of 30 to 35 eggs. Incubation of these eggs takes about 65 to 70 days.
Alligators are carnivorous and prey on food corresponding their size. Therefore, alligator farms are stocked with walk-in freezers to maintain sizable amounts of meat. Some of the meat sources that have been used to feed alligators historically include beef, horse, chicken, muskrat, fish, beaver, and deer. Currently, modern feed regimes have removed the need of fresh or frozen meat products. A local feed mill in Franklinton, LA is the dominant provider of pelleted feed for the industry. This feed consists mostly of meat and bone meal, fish meal, vegetable protein, and blood meal with vitamins and minerals. The majority of alligator farmers are relying on feeding diets that are commercially available; however, some continue to feed a combination of meats and pelleted feed diets (Masser, 1993b). Presently, there is few proven data on alligator nutritional requirements for optimal growth.

More recently in 2018, the Aquaculture Research Station at the LSU AgCenter emphasized developing alligator feeds to improve nutrient consumption and develop a better cost control through the use of substitute ingredients. (Reigh, 2018), evaluated the different protein concentrations in alligator feeding regimes. These investigations have assessed protein and energy digestibility, and the availability of amino acids. Moreover, they have examined plant-based feeding regimes to be able to define the significance of the use of plant-derived products as alternatives for animal products in modern diets. Among his findings, the author revealed that a nutritionally balanced diet that contains approximately 80 percent of plant-based products such as soybean meal, wheat gluten and yellow corn, can be successfully consumed by alligators without any negative effects on their physical condition or body. Additionally, it is important to highlight the impacts of incubating conditions on egg-hatching success. Later studies demonstrated that maintaining oxygen concentrations above 21 percent (normal levels) does not increase the egg-hatching success. However, relative humidity is a critical aspect influencing embryo development. The alligator research program developed yearly by the LSU
AgCenter collaborates with alligator farmers, personnel from the USDWF and private industry stakeholders.

Shirley et al. (2015) presented an introduction on the production of the American alligator. According to the authors, there is a small amount of alligator farms that sustain a reproducing population of adult alligators for many reasons. These include time, costs, and the space conditions needed in order to produce a substantial number of viable eggs. For these reasons, each year alligator producers incur in a practice known as alligator ranching. This is a method in which alligator farmers acquire eggs from suitable nest sites in the wild in order to stock their operations with new alligator hatchlings each year. The LDWF regulates the number of eggs that can be collected per alligator producer in order to maintain the sustainability of the industry and the wild alligator populations. However, whatever the source of eggs, all production facilities are referred to as alligator farms. Masser (1993) states that in Louisiana, Texas, and Florida, eggs and hatchlings may be taken from the wild under special permit regulations. In other states, however, it is illegal to take eggs or hatchlings from the wild. Currently, alligator farmers and potential farmers purchase eggs or hatchlings from another producer, or they produce their own. Hatchlings can be purchased from other existing farms or hatcheries in Louisiana, Florida, and Texas (Masser, 1993a).

In Louisiana, alligator producers engage in contracts with landowners to acquire eggs where suitable nesting habitats are available. The LDWF issues permits to alligator producers where they specify the permitted quota of eggs for each property. To comply with LDWF guidelines, a fraction of the group that hatched from these eggs must be released back to the wild as juveniles (minimum of 36 to a maximum of 60 inches long). Moreover, landowners endorse the ranching guidelines since it provides a source of revenue and guarantees the sustainability of the species as a natural resource in their property. Nests are located by aerial search (mostly helicopters) and airboats are used to get to the nest site and collect the eggs. As
mentioned before, appropriate incubation conditions are crucial for optimal hatchability (Shirley & Elsey, 2015).

In alligator farming, there are many different designs of production facilities. Masser (1993) suggests that a commonly used building plan consists of a building facility with 5,000 square feet (33 x 150 ft) with an aisle down the middle and pens on either side. These grow-out establishments are heavily insulated by metal buildings, wood, or concrete with heated foundations. The building foundation involves a concrete slab reinforced with hot water tubing, which helps keep a constant temperature. Pools, drains and feeding areas are designed into the foundation. Usually, two-thirds of the pen is a pool about one foot deep at the drain, while the other one-third of the pen is above the normal water level and is used as a feeding and basking deck. The pool bottom slopes to a central drain to facilitate cleaning. Individual pens are built within a structure using concrete block walls that are three feet tall. Smaller pens are used for raising small alligators and as they grow, larger pens are used (Masser, 1993b). Table 2.1 provides examples of pen size to alligator size and their corresponding densities.

Table 2.1. Recommended pen sizes for grow-out operations.

<table>
<thead>
<tr>
<th>Gator length</th>
<th>Pen Size Sq ft (l x w)²</th>
<th>Gators/pen</th>
<th>Sq ft/gator</th>
<th>Sq ft needed 350 gators</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-15&quot;</td>
<td>9 (3x3)</td>
<td>20</td>
<td>0.45</td>
<td>158</td>
</tr>
<tr>
<td>15-30&quot;</td>
<td>120 (10x12)</td>
<td>80</td>
<td>1.50</td>
<td>525</td>
</tr>
<tr>
<td>30&quot;-4'</td>
<td>168 (12x14)</td>
<td>50</td>
<td>3.36</td>
<td>1,176</td>
</tr>
<tr>
<td>4-5'</td>
<td>192 (12x16)</td>
<td>50</td>
<td>3.84</td>
<td>1,344</td>
</tr>
<tr>
<td>5-6'</td>
<td>216 (12x18)</td>
<td>40</td>
<td>5.40</td>
<td>1,890</td>
</tr>
</tbody>
</table>

Source: Smith & Cardeilhac, 1981.

Many producers construct several sizes of grow-out pens and simply reduce the density by moving the animals as they grow into different pens. One commonly used stocking regime is 1 square foot per animal until 2 feet in length, 3 square feet per animal until 4 feet in length, or 6 square feet per animal to 6 feet in length. Pen length is usually about 12 feet and a three-foot high concrete block walls separate individual pens from the aisle. Additionally, one must
take into consideration another common facility design, the “round house”. “Round house” designs are 15 to 25 feet in diameter and are constructed as single pens. Many round houses are constructed from a single section and roof component of a prefab metal silo. This facility design is constructed on concrete slab on which the house sets are sloped from the outer edge to a central drain. Additionally, this design is set to be filled with water to leave about one-third of the outer floor above the water level. What attracts the most to producers is the fact that the single pen design does not disturb alligators in other pens during routine feeding, cleaning, and handling operations (Masser, 1993b). These are some of the facility designs that have been used throughout the industry’s history; however, it is important to emphasize that this proposal by Masser is dated in 1993. Recent designs consist of slight updates to these commonly used facilities.

Alligator farms are designed to maintain a warm aquatic environment so that the animals continue to grow throughout the year. The temperature is maintained normally at 80° to 88° F (27 to 31 °C) with a water depth of 14 to 18 inches (25 to 45 cm) for optimum growth. Another component that is crucial in maintaining this environment is a room that holds the heating system. This element is part of any alligator facility and it usually consists of water heaters and pumps to circulate warm water through the concrete slab. Warm water is usually needed to warm the building and to clean the pens. Other types of heating systems consist of a flash type heater to heat water for cleaning and for circulation through the slab (Shirley & Elsey, 2015).

As mentioned before, most alligator farmers are feeding only commercially available diets. These diets, however, can be blended with approximately 30 to 50 percent raw meat. The pellets, meat and vitamins proceeded to be ground together in a meat grinder to a consistency that is readily palatable to the size alligator being fed. Feed conversion rates decrease as alligators grow larger, but average approximately 40 percent or between 2:1 and 3:1, up to a length of 6 feet. Growth rates of young alligators can be as much as 3 inches or greater per
month when fed a quality diet and protected from stress. Table 2.2 provides average length and weight of wild and farm-raised alligators (Masser, 1993b). In more recent years, there has been a general move away from the use of raw meat to a ration that is 100 percent pelletized feed.

Table 2.2. Length-weight relationships for wild and farm-raised alligators.

<table>
<thead>
<tr>
<th>Lengths/_inches</th>
<th>Wild weight pounds/(ounces)</th>
<th>Farm-raised weight pounds/(ounces)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>0.15/ (2.4)</td>
<td>0.16/ (2.6)</td>
</tr>
<tr>
<td>18</td>
<td>0.42/ (6.7)</td>
<td>0.47/ (7.5)</td>
</tr>
<tr>
<td>24</td>
<td>0.68/ (10.8)</td>
<td>0.75/ (12.1)</td>
</tr>
<tr>
<td>30</td>
<td>3.5</td>
<td>3.9</td>
</tr>
<tr>
<td>36</td>
<td>8.6</td>
<td>9.5</td>
</tr>
<tr>
<td>42</td>
<td>13.0</td>
<td>14.7</td>
</tr>
<tr>
<td>48</td>
<td>17.7</td>
<td>19.8</td>
</tr>
<tr>
<td>54</td>
<td>28.0</td>
<td>31.1</td>
</tr>
<tr>
<td>60</td>
<td>39.6</td>
<td>44.0</td>
</tr>
<tr>
<td>66</td>
<td>45.4</td>
<td>50.4</td>
</tr>
<tr>
<td>72</td>
<td>49.6</td>
<td>55.1</td>
</tr>
</tbody>
</table>


In most states written approval and tags must be obtained from the state regulatory agency before alligators can be processed for harvest. In some states, there is a minimum length condition (alligators must be of at least 4 feet in length unless they have died from natural causes) at harvest. Additionally, all animals must be labeled with tags from the state regulatory agency as soon as they are slaughtered and can only be skinned at authorized sites with specific skinning instructions issued by the state agency. The skinning process, which involves the scraping and curing of the alligator hide, must be done meticulously to guarantee quality.

Alligator farmers have expressed that this process requires thoroughness since hides that are cut, scratched, or stretched have a reduced market value and buyers may pay less for damaged hides. Hides are scraped carefully to remove all meat and fat and then proceed to be washed to remove all the blood. Following this, fine grain mixing salt is used to preserve the hide. This salt is then rubbed completely into the skin, making sure to apply it into all creases and flaps so that the curing process can begin. Hides are then completely covered in 1 inch of salt and
continue to be tightly rolled. This will allow the hides to drain and dry in a well ventilated, cool place. Hides must be checked and resalted as necessary after three to five days. It is not without mention that producers processing these alligators must comply with all sanitation requirements of federal, state, and local authorities. One of these requirements involve labelling the size of meat cartons (not larger than 5 pounds) with the names of the seller and buyer, date of sale, and tag number that corresponds to the hide (Masser, 1993b). Table 2.3 provides insight on the average deboned yield of alligator meat from an alligator ranging in the 4 to 6-foot range. Following the salting process, alligator skins are shipped to tanneries and the carcasses are processed for the meat market.

Table 2.3. Percent yield of deboned alligator meat on alive-weight basis.

<table>
<thead>
<tr>
<th></th>
<th>Tail</th>
<th>Leg</th>
<th>Torso</th>
<th>Ribs</th>
<th>Jaw</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16-17</td>
<td>4-5</td>
<td>6-12</td>
<td>7-10</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: (Masser, 1993b)

One significant aspect to take into consideration when addressing alligator production is stress. In his alligator grow-out guide, Masser argues alligators are relatively shy and reclusive animals. These reptilians do not normally congregate together except during breeding season; therefore, putting them all under cultural conditions is already unnatural and stressful for this species. Factors such as stress and water management are common sources to a condition known to alligator farmers as “Brown Spot Disease”. This condition occurs on the abdominal scales of the animal and appears as a small discoloration at the corner or edge of a scale with a brownish color from which the disease gets its name. This lesion usually starts on the edge of a scale and progresses inward until it becomes a hole in the skin when it’s processed. Alligator skins are graded upon tanning; therefore, those with these defects suffer a fall in economic value of the skin (Barnett & Cardefhac, 1998). As a result, alligator producers have developed approaches to reduce the amount of stress in the animal. There are many beliefs that alligators are vulnerable to light and sound, which has eventually led some producers to establish reduced
light conditions to help reduce stress. Additionally, there are other producers that believe that alligators should be fed and cleaned by the same personnel each day since allegedly alligators are able to recognize individual humans. Handling alligators must be done with care and with the proper management practices that ensure the animal’s welfare as well as to maximize skin value (Shirley & Elsey, 2015).

Presently, market demand for farmed alligators is for watch straps and luxury leather products, which require an alligator between 36 and 48 inches (91 and 122 cm) in length. Contract tanning is often based upon the measurement of the skin in centimeters measured at the widest point in the belly after crust tanning or dyeing to the specified color choice, polishing, or glazing. Occasionally, there will be those manufacturers who will use the alligator teeth to manufacture jewelry, buttons, and cane handles. Similarly, the oils of these reptiles are also used as antimicrobial or anti-inflammatory to help cure skin diseases by using the fatty acids produced by the American alligator. Furthermore, being a top-rate material for luxurious designer handbags, the alligator industry has witnessed an incredible increase in the demand for alligator skins. The fact that there is a limited number of skins available and that distributors don’t typically stock alligator skins, has led tanneries to manage purchases by order only. Tanneries usually use skins (mostly alligator bellies and tails) 39 cm wide by 31 cm tall for the front and back panel of the handbags. The alligator head is often used for the handles and other adornments. Moreover, one must not forget that alligators are a tourist attraction in many swamp tours and airboat tour establishments, as well as in zoos, especially in Louisiana and Florida (Mendal, 2012; Seay, 2019).
2.4. Alligator Policy and Regulatory Environment

There are number of topics that must be discussed when addressing the alligator policy. First, I must reiterate the policies that were set up in Louisiana that facilitated the re-birth of the alligator farm industry while creating a sustainable habitat model. In addition, this study addresses the CITES treaty and the implications this treaty has with regulation on the trade of exotic skins. Also, this literature review will tackle the recent course case from which there is an injunction on it in California and some of the other policy challenges facing both domestic and international production and marketing of exotic animal species.

Before analyzing the challenges, this industry is currently facing, it is important to understand the policies that have promoted a sustainable habitat model. First, it is fundamental to mention the strict supervision of the LDWF and their methods to protect sustainability of this species. One example is the coastal nest survey that the LDWF conducts each year to determine alligator nest densities in various regions. Each year after the nest density is obtained, an allowable quota is calculated. Nest densities may vary depending on condition; during droughts they can decline, or they can increase dramatically during peak nesting season with promising water levels. The state will then proceed to issue individual and sequential numbered lockable alligator harvest tags. These tags are designed to ensure that, once properly applied, any tampering with them will be evident. Therefore, each alligator taken by the licensed harvester must possess this tag fixed to it and this way the state keeps track of details such as the exact number of tags used, where the tags were used, details of the animal, and which animals have been released from ranches in previous years. The state monitors the release and use of tags to ensure the harvest in any area does not exceed the quota (Louisiana Alligator Advisory Council, 2020).

Another example of the State of Louisiana monitoring this industry is the fact that Louisiana alligator farmers must possess a valid nongame quadruped breeder’s license. Also,
farmers are required to possess on his/her person a copy of the fully executed alligator egg collection permit to perform this activity. Similarly, the collection of eggs can only be made after contacting the appropriate regional supervisor of the Enforcement Division no less than 24 hours prior to each collection trip (Wildlife and Fisheries Commission, 2020). On the other hand, alligator hunters are provided a license and a series of tags corresponding to the property on which they have the authorization to hunt. Each property receives a proper tag distribution based on the coastal nest count per property. Further, farmers are required to comply with facility standards and best management practices during the required facility assessment by the USDWF personnel before obtaining a license. Alligator farms are inspected by state personnel to check housing and water conditions before approving the facility for licensing. Some of the strictly inspected aspects include sanitary conditions, temperature control, feeding, and spacing availability. Additionally, an extensive database is used to archive information such as who hunted or farmed which specific skins and the number of eggs are equally monitored. The three-party transaction is consolidated by a contract between the landowner, the farmer collecting the eggs, and the Louisiana Department of Wildlife and Fisheries. Through regulation measures, the LDWF determines the allowable quota of eggs available for collection on a specific piece of property. As part of the contract, the rancher must report how many eggs were collected during this practice and how many hatched. Afterward, farmers have two years to return at least 10% of those healthy alligators at 4-foot length. The state monitors the returns to ensure healthy alligators are released (Louisiana Alligator Advisory Council, 2020).

Moreover, at the state level, the LDWF released their latest alligator regulations for year 2020. In terms of alligator egg collection, it states that that the farmer who holds the egg collection permit, as well as the landowner, are both responsible for the return of the percentage of live alligators to the wild described on the alligator egg collection permit. The minimum return rates are based upon the state’s average hatching success, which currently is a 78 percent.
These live alligators are to be returned to the area where they were collected in a maximum of two years from the date they hatched. The LDWF also states the alligators must possess a length between 36 inches minimum and 60 inches maximum in order to be returned. To secure breeding and the sustainability of this industry, at least 50 percent of the returned animals must be females. Releases back to the wild are only approved between March 15 and August 25 of each calendar year provided that environmental conditions are favorable for survival. Failure of compliance requires the permittee to purchase additional alligators from other farmers in order to meet compliance. These regulations are supervised by the LDWF and violation of these regulations may be subject to criminal prosecution under provisions of the Louisiana Revised Statutes, under Federal law (Wildlife and Fisheries Commission, 2020).

At the national level, the USDWF has developed a complex set of prerequisites to fulfill CITES requirements, with which the individual states, including Louisiana, must comply in order to be granted export approval for harvested alligator skins and byproducts. The most critical component in these requirements is that the LDWF must certify on an annual basis that the harvest programs they administer will not be detrimental to the survival of the species. Moreover, the management program must provide for a rigorously controlled harvest with calculated harvest level objectives. All alligators and their eggs must be harvested from identified properties and all hides must be specifically identified by their properties and individually tagged with CITES export tags. Then, the USDWF requires strict accountability for each tag allocated to the harvester, requiring all unused tags to be returned at the close of the season (Louisiana Department of Wildlife and Fisheries, 2019).

At the international level, the export of alligator skins and products out of the United States is regulated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This treaty, which became effective in 1975, regulates the international trade in protected species; its aim is to ensure that international trade in specimens
of wild animals and plants does not threaten their survival. The U.S. Fish and Wildlife Service administers CITES requirements and controls for the United States. The species covered by CITES are listed on one of three of their appendices, according to the degree of protection needed by each species. Currently, the alligator is listed on Appendix II of CITES, because of their similarity in the appearance to other crocodilians that are endangered (Louisiana Department of Wildlife and Fisheries, 2011). All this regulation has contributed to the sustainability and legitimacy of this growing industry that has proven results in all biological aspects.

One of the ongoing challenges that the alligator industry has been facing over the years is California’s restriction over alligator products. The state of California’s Penal Code Section 653o states that the following, “(1) Commencing January 1, 2020 it is unlawful to import into this state for commercial purposes, to possess with intent to sell, or to sell within the state, the dead body, or a part or product thereof, of a crocodile or alligator. (2) This subdivision does not authorize the importation of any alligator or crocodilian species, or products thereof, that are listed as endangered under the federal Endangered Species Act, or to allow the importation or sale of any alligator or crocodilian species, or products thereof, in violation of federal law or international treaty to which the United States is a party (State of California, 2019). This restriction has represented a considerable impasse for the entire Louisiana industry since California represents a substantial fraction of the exportation market.

In 2019, the LDWF attempted to facilitate the successful passage of legislation that would eliminate the sunset clause to Penal Code 653o. During this time, the sale of alligator and crocodile products within the state of California was permitted as an exemption to anti-wild-life trade laws until the sunset clause activated on January 1st, 2020. The LDWF contracted with Advocacy and Consulting to pass the Assembly Bill (AB 527), which promoted the various benefits of alligator products and gained the support of stakeholder groups. However
unsuccesful in front of a key Assembly Committee, AB 527 would have eliminated the sunset clause within the Section 653o, hence allowing the continued sale of alligator products in California (Louisiana Alligator Advisory Council, 2018).

Later that year, Louisiana and other plaintiffs (alligator-related businesses in Florida, Texas and California) filed a federal lawsuit challenging California’s ban on the import and sale of alligator skins and other products before the sunset clause was activated on January 1st, 2020. Louisiana Attorney General Jeff Landry claimed the ban was “in direct conflict with federal law” since allegedly the state of California can’t prohibit the sale of these products if the federal government says it’s legal. The lawsuit was filed on December 12th, 2019 in the Eastern District of California on behalf of the LDWF. Supporters of the ban claim it’s nearly impossible to distinguish Louisiana alligator products from the items made with the skins of other truly endangered alligator or crocodile species. Moreover, supporters claim the ban will help reduce illegal hunting in Asia, South America, and other parts of the world. Jack Montoucet, Wildlife and Fisheries Secretary, said California accounts for 30% of the world’s alligator skin market, therefore this ban could cripple the industry and trigger similar prohibitions in other potential states (Baurick, 2019). Along with industry stakeholders, plaintiffs also include luxury retailers from the state of California who have also joined in the lawsuit that has only resulted in a temporary halt on enforcement.

More recently, the situation has advanced in favor of the plaintiffs with federal judge Kimberly J. Mueller of California’s Eastern District ruling out California’s claims on October 15th, 2020. Judge Mueller claimed enforcement of this ban would impact a “profound and immediate” harm to crocodile populations and thousands of people who rely on this income. Not only these negative externalities helped tipped the balance to the plaintiff’s side, but the strong showing from Louisiana that federal law, including the Endangered Species Act, controls trade in those products also helped in the rejection of California’s argument. This has
represented a significant success for farmers, retailers, landowners, and state officials since the now worth over 100 million dollars a year-industry, can remain operating in California and beyond for the short-term (McConnaughey, 2020). Nonetheless, environmental and animal rights groups claim similar alligator products still represent a danger to truly endangered species of alligators. This long-lasting dispute has been temporarily halted with one side overcoming the other.

Overall, the alligator regulatory environment has proven to be carefully monitored in Louisiana today. Regulations such as the coastal nest survey, the licenses for hunters and farmers, annual regulations by the LDWF, CITES requirements and regulations, and policies by the USDWF, have all played a fundamental role in the sustainability and protection of this industry.

2.5. Post-Management Program Alligator Research

After its recovery in 1987 and the implementation of the alligator management program, the alligator industry has documented its production process and has worked efficiently with regulatory agencies to maintain a competent documentation for purposes of following the CITES treaty. However, in the literature on alligator research, there is a dearth of studies in the economic contributions and impact sector of the alligator industry in Louisiana. The economics of the alligator industry has had much less work applied to it, which is evident in the most recent comprehensive analysis dating back 30 years, making it extremely outdated for economic and policy application. Most of the research regarding the economic aspect of the industry has been with economic impact analysis, more recently with research by Brannan et al. (1991).

Brannan evaluated the economic contribution of the Louisiana alligator farming industry. They sought to identify and specify the costs of alligator production systems to estimate the revenues from both the wild and farm raised alligator industries, and to specify the
costs incurred by farming businesses. Their study revealed that the alligator farming practices have increased in revenue exponentially in the five years preceding their report, and additionally, it brought in new dollars from out-of-state sales. The information collected in this study will serve as a benchmark for the updated economic contribution of this industry (Brannan, 1991).

Quantitative studies involving the economics of the U.S. alligator industry as an economic model are also limited. Heykoop et al. (1999) determined the optimal values for alligator producers’ main decision variables. Their study contributed to model alligator production and included wild and domestic segments of the overall population, along with optimal catch and hatchling removal rates for wildlife agencies in the future. This study showed that domestic alligator production was and still is instrumental in the recovery of the wild population (Heykoop, 1999). Once again, the success of this industry depends on the proper management of alligators as a renewable resource in the wild as well as in captivity, since each depend on the other for their mutual survival.

Similarly, Nichols et al. (1976) constructed a model that simulated the dynamics of a commercially harvested alligator population inhabiting privately owned coastal marshland of Cameron and Vermilion parishes, in Louisiana. This study’s main goal was to analyze the consequences of various management strategies and the effects of variable environmental parameters on the alligator population. Among their findings, the authors discovered through a deterministic simulation that a base population of 100,000 alligators should be maintained for 20 years when subjected to an annual hunting rate slightly greater than 5 percent. Moreover, small base populations can withstand greater hunting rates than larger populations because of the density dependent effects of cannibalism. Also, an environmentally stochastic simulation discovered that harvest strategies should not be based on assumed average survival rates but should be monitored and considered in the formulation of management plans (Nichols et al.,
These results only highlighted the influence of integrating investigations that advise management plans, production, and breeding of this species.

2.6. Conclusion

As seen in this section, alligator hunting and farming have a significant history in the state of Louisiana. The story of the American alligator has been one of prominent success of one of the nation’s endangered species program. After rebuilding the population through research, management and law enforcement during the 1960’s, the wild harvest from 1972 through 2019 has produced over 1,105,812 wild skins according to the latest Alligator Advisory Council Annual Report (Louisiana Alligator Advisory Council, 2019). The industry has overcome many challenges throughout history including a massive downfall in population numbers and a ban on the import of its products within its most lucrative market. This success would not been possible without the great collaboration of farmers, state officials, landowners, retailers, and researchers who have worked to build a solid and sustainable industry on which thousands of working families rely on for income earned from this exotic resource.

Chapter 3 presents an overview of the four approaches that can be used when estimating an economic contribution study and introduces the historic scholarly sources related to each. The four practices that are used to increase precision in the contribution estimation include: 1) applying a conventional Input-Output model’s sectoral multiplier, performing an Analysis-by-Parts (ABP) approach, re-estimating ABP using survey Regional Purchase Coefficients (RPCs), and augment default production functions in ready-made models such as IMPLAN. Each of these sections will describe the purpose of including these methods and will also illustrate the process of executing these techniques.
CHAPTER 3. MODELING IMPROVEMENT STRATEGIES

3.1. Introduction

This chapter facilitates an understanding of Input-Output analysis and the necessary components of how to model these interrelations within this modeling system at the regional and interregional level. As a part of this chapter, a discussion of several modern “ready-made” secondary data constructed input output models are presented with a focus on IMPLAN. An overview of how Input-Output modeling has been applied in economic contribution and impact studies is presented including applications within the state of Louisiana. Further, this chapter highlights the controversial criticism by academics of the misuse of Input-Output in economic impact methodology of in the past two decades. While being a valuable tool, Input-Output analysis has been associated in the past with unethical procedures and less accurate measures. Since researchers tend to respond to the challenge of seeking more accurate measures, a review of three modeling improvement strategies to improve the credibility of applying Input-Output methods and the results that come from its application are presented.

3.2. Input-Output Methods

Input-Output analysis is defined as a form of regional analysis based on the interdependence between different economic sectors or industries. In previous generations when modeling software had not yet been developed, Input-Output analysis consisted only of the use of Input-Output tables. These tables, later called transaction tables, include a series of rows and columns of data that quantify the supply chain for all sectors of an economy. For a one-year production period, the transaction table reflects the value of goods and services exchanged between sectors of the regional economy. Input-Output tables were originally developed by Wassily Leontief, who later won the Nobel Memorial Prize in Economic Sciences for his work in this area (Kenton, 2020).
One can think of these transaction tables as an extensive “spreadsheet” of the economy where columns represent buying agents within the economy, and rows represent selling agents in the economy. This spreadsheet is referred as a transactions table in the Input-Output modeling terminology (Deller, Hoyt, Hueth, & Sundaram-Stukel, 2006). An illustrative example is provided in Table 3.1 In this example, the economy is composed of five industries including: extraction, construction, manufacturing, trade, and services. Here, each column represents a monetary payment to the row element and each cell represents the demand for each industry, which can be written algebraically as Equation 3.1:

\[ X_i = z_{i1} + z_{i2} + z_{i3} + \cdots z_{in} + Y_i \]  

(3.1)

where \( X_i \) is the total output of sector \( i \) in dollar values, \( Y_i \) represents the total final demand for sector \( i \)'s product, and \( z_{ij} \) is the inter-industry demand from row sector \( i \) to column sector \( j \). One example of interpreting elements of the table is in the third row and first column of Table 3.1, where the Manufacturing industry is producing and selling $142 million in goods and services to the Extraction industry (row three, column one), $414 million to the Construction industry (row three, column two), $110 million to the Trade industry (row three, column five), and $356 to the Services industry (row three, column five). One key assumption in the building and implementation of Input-Output modeling is that supply equals demand (for industries). In the concept of the “spreadsheet” mentioned before, the row total (supply or industry revenue) for any specific industry must equal the column total (demand or industry expenditures), in other words, industry inflows must equal industry outflows. In the example for the Extraction Industry, the inputs (total expenditures, or total costs) total $1.674 billion, and outputs (total sales, or total output value) also total $1.674 billion. This structure allows for the trace of how shocks to one part of the economy can affect the entire economy.
However, when these transactions are displayed as the fractional dollars’ worth of an input used to produce one dollar’s worth of output for a sector, they are re-interpreted as technical coefficients (Miller & Blair, 2009). The collection of all technical coefficients in the transaction table is identified as the Technical Coefficient Matrix. An illustration is provided below in Table 3.2 Technical coefficients are algebraically represented by Equation 3.2:

\[ a_{ij} = \frac{z_{ij}}{\sum_{i=1}^{n} z_{ij}} \]  

(3.2)

where \( z_{ij} \) represents the total dollars value of inputs from row sector (i) used to produced output of column sector (j), and \( \sum_{i=1}^{n} z_{ij} \) represents the column total of all the row inputs (total expenditures, or total costs). If the previous example is applied to the algebraic equation, the resulting technical coefficients can be observed in Table 3.2. One example of the interpretation for this coefficient is that for $1 of total inputs sold to the extraction sector, $0.0084 are attributed to the Construction Sector, $0.0848 credited to the Manufacturing sector, $0.0311 come from Trade Sector and $0.0609 are accountable to the Services sector.
Wassily Leontief stated that if one can estimate changes in final demand, then one can predict how an economy will react as measured in an output change. To show this, Leontief’s prime contribution is referred to as the Leontief Inverse. To understand this concept, it is appropriate to go back to Equation 3.1. and reorganize the technical coefficients found before in Equation 3.2. into the following Equation 3.3. (Schaffer, Deller, & Marcouiller, 2004):

\[ z_{ij} = a_{ij}x_j \]  (3.3.)

where each variable still represents the values from Equation 3.1. Then, we must substitute Equation 3.3. into Equation 3.1., to arrive at the following statement for sectoral output in a model including two sectors. Equation 3.4. presents the new array of equations:

\[ x_1 = a_{11}x_1 + a_{12}x_2 + y_1 \]  for sector 1  (3.4.)

\[ x_2 = a_{21}x_1 + a_{22}x_2 + y_2 \]  for sector 2

This set of equations are further reorganized until they reach the final equation which is represented in Equation 3.5.:

\[ (1 - a_{11})x_1 - a_{12}x_2 = y_1 \]  for sector 1  (3.5.)
\[-a_{21}x_1 + (1 - a_{22})x_2 = y_2 \quad \text{for sector 2}\]

If I were to extend this simple model and decide to include more sectors, it will become very complex and challenging to some point of the computation. To simplify this, matrix notation is used to recreate Equation 3.5., which can be rewritten as:

\[
\begin{bmatrix}
1 - a_{11} & -a_{12} \\
-a_{21} & 1 - a_{22}
\end{bmatrix}
\begin{bmatrix}
x_1 \\
x_2
\end{bmatrix}
= 
\begin{bmatrix}
y_1 \\
y_2
\end{bmatrix}
\]  
(3.6.)

For explanation purposes and better simplification, the first array of this matrix notation can be rewritten as:

\[
\begin{bmatrix}
1 & 0 \\
0 & 1
\end{bmatrix}
- 
\begin{bmatrix}
a_{11} & a_{12} \\
a_{21} & a_{22}
\end{bmatrix}
\]  
(3.7.)

which simplified can be represented as \((I - A)\). As seen, Leontief’s form of Input-Output analysis goes through a series of equation rearrangements in order to set up the Input-Output foundation. The following equations present the alternative form from their matrix form:

\[
X = AX + Y 
\]  
(3.8.)

\[
X - AX = Y
\]  
(3.9.)

\[
(I - A)X = Y
\]  
(3.10.)

In matrix form, the quotient operation is represented as an inverse. By multiplying the inverse of \((I - A)\) to both sides of the equation, it results in the classical output equation containing the Leontief Inverse Matrix (inverse of \((I-A)\)):

\[
X = (I - A)^{-1}Y
\]  
(3.11.)

Equation 3.11. can be explained as the final demand change in vector \(Y\) will affect the change in output (vector \(X\)) by the product of the Leontief Inverse matrix post-multiplier by the final demand vector, \(Y\). These sectors in \(X\) will change their output through increasing
inputs, which eventually will create further change in other sectors of X in a diminishing way until no further of spending occurs. These round-by-round effects are completely accounted for in the Leontief Inverse. The Leontief Inverse can be explained mathematically by the following equation:

\[
[I - A]^{-1} = I + A + A^2 + A^3 + \cdots A^n
\]  \hspace{1cm} (3.12)

where \( I \) represents an identity matrix, which consists of a matrix with main diagonal elements with a value of one, while the rest of the matrix elements are equal to zero; \( A \) represents the Technical Coefficient Matrix (Schaffer et al., 2004). The Leontief Inverse Matrix for the example presented in this section is illustrated below in Table 3.3. One example of the interpretation of this matrix is that for a one dollar increase in the final demand for products of the Extraction sector, there is a total increase in output for the Construction sector of $0.0230 (row 3, column one), which includes the total direct, indirect, and induced effects. Furthermore, since the Leontief Inverse Matrix is equal to the sum of the round-by-round spending effects, it’s possible to calculate the multipliers by using this matrix.

Table 3.3. Leontief Inverse Matrix.

<table>
<thead>
<tr>
<th>Selling Industry</th>
<th>Extraction</th>
<th>Construction</th>
<th>Manufacturing</th>
<th>Trade</th>
<th>Services</th>
<th>Households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraction</td>
<td>1.1446</td>
<td>0.0377</td>
<td>0.0657</td>
<td>0.0222</td>
<td>0.0287</td>
<td>0.0314</td>
</tr>
<tr>
<td>Construction</td>
<td>0.0230</td>
<td>1.0142</td>
<td>0.0144</td>
<td>0.0192</td>
<td>0.0435</td>
<td>0.0213</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.2252</td>
<td>0.2900</td>
<td>1.2041</td>
<td>0.1629</td>
<td>0.1725</td>
<td>0.2263</td>
</tr>
<tr>
<td>Trade</td>
<td>0.2254</td>
<td>0.2598</td>
<td>0.1836</td>
<td>1.2322</td>
<td>0.2315</td>
<td>0.3675</td>
</tr>
<tr>
<td>Services</td>
<td>0.4691</td>
<td>0.4581</td>
<td>0.3728</td>
<td>0.5766</td>
<td>1.6279</td>
<td>0.7462</td>
</tr>
<tr>
<td>Households</td>
<td>0.7799</td>
<td>0.6767</td>
<td>0.5884</td>
<td>0.9065</td>
<td>0.8487</td>
<td>1.5734</td>
</tr>
</tbody>
</table>

Source: (Schaffer, 1999)
Input-Output models estimate three effects: direct, indirect, and induced effects. Direct effects refer to the initial change in expenditures in the industry in question. Indirect effects are the additional industry effects due to interlinkages between industrial sectors in the economy. Induced effects are the additional output effects due to household spending. Finally, the sum of the direct, indirect, and induced effects is best known as the total effects (Kenton, 2020). For example, if one were to commercialize alligator skins and hides, we would require inputs to be paid such as feed, utilities, labor, hatchlings, and other inputs. Purchasing these inputs is considered the first round of spending, or our direct effect. The indirect effects would be due to the suppliers of the inputs hiring workers to meet demand. The induced effects would result from the personal consumption of workers of these suppliers purchasing more goods and services, or household spending.

Schaffer (1999) mentions in his book of regional science that a regional Input-Output model also presents a set of economic multipliers. These multipliers track the effects of changes in demand on economic activity in the specific region analyzed. The traditional multipliers possible in an Input-Output system are Output multipliers, Employment multipliers, and Income multipliers. For a given local industry, the Output Multiplier is the foundation from where all the rest of the multipliers are calculated. This multiplier measures the combined effect of a $1 change in a single sector’s demand on the output of all local industries. The labor income multiplier measures the total change in income from a one-dollar income change. Additionally, value added multipliers define the total amount of value added produced resulting from a one dollar of value added in a specific industry. Likewise, employment multipliers describe the total

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1 Historically, input output scholars in textbooks would distinguish in modern times is referred to as the direct effect into separate initial effects and direct effects. The initial effect would be the one dollar change in demand for the products of the industry. The direct effect would represent the first-round spending effect with the region required to replenish the inventory of the product demanded. The term initial effect has been lost as it was not adopted in the language by the Input-Output software developers.
jobs generated in the entire region as a result of an initial one job change in the target industry. All multipliers help measure the strength of backward linkages and the rates of change for different variables (IMPLAN, 2019c; Schaffer, 1999).

In Input-Output analysis, the production function used to represent the relationship between inputs and outputs is the Leontief Production Function. The Leontief Production Function consists of output being a function of capital and labor. This relationship entails that capital and labor are fixed quantities. In other words, they are perfect complements, and their relationship is locked. Hence, increasing inputs on one side will only lead to a proportional increase in outputs on the other side (Clouse, 2019). Equation 3.13 illustrates this relationship.

\[ Q = \min(aK, bL) \]  

(3.13.)

where \( Q \) represents output, \( K \) is capital and \( L \) represents labor. The term \( \min \) refers to the minimum values for Capital and Labor. Other assumptions of Input-Output analysis are that the distribution of purchases and sales is fixed as well as the fact that there are no constraints on resources (production resources are readily available when demanded), and local resources are efficiently and fully employed (Schaffer et al., 2004).

3.3. Ready-Made Models and IMPLAN

In regional economics, there are historical approaches that can be used when estimating the economic contribution of an industry including Input-Output modeling, Social Accounting Matrices (SAM), and Computable General Equilibrium models (CGE). According to Compton et al. (2015), historically, the most widely adopted tool for estimating contributions, impacts, interindustry linkages, and structural decomposition analysis is the Input-Output model. Until the 1990s, constructing Input-Output models was a complex and expensive task undertaken only by highly trained economists. However, this situation has recently changed with the development and refinement of ready-made secondary data based Input-Output modeling.
software such as IMPLAN, RIMS II (Regional Input-Output Modeling System (Bureau of Economic Analysis, 2018)), and REMI (Regional Economic Modeling Inc.(REMI, 2019)) (Crompton, Jeong, & Dudensing, 2015).

RIMS II, currently maintained by the Bureau of Economic Analysis of the U.S. Department of Commerce, and REMI have benefits that make them appropriate for certain scenarios. For example, RIMS II is considered to be the simplest and cheapest of all the modeling software. However, one of its disadvantages is that it fails to provide a breakdown of impacts by industry and it requires the economist performing the analysis to manually apply the different sets of multipliers in order to determine the indirect and induced effects. REMI, on the other hand, is a much more sophisticated model that includes complex econometric features that have elements of Computable General Equilibrium modeling as well as conjoined Input-Output econometric modeling. Its drawbacks include the fact that it requires an extensive amount of data and this sophistication often makes the explanation of multipliers more difficult for readers. Additionally, REMI provides less ability to make measurable changes to the model including editing of production functions and exporting source data outside the software (Crompton et al., 2015). For this research, it will be necessary to evaluate a breakdown of the contributions by industry and to be able to edit the production functions to incorporate improvement strategies. One of IMPLAN’s most significant advantages is its flexibility. IMPLAN allows the user to enhance any of the data within the model to more precisely account for regional relationships. Therefore, IMPLAN has been chosen as the proper modeling software for this research due to its customizability, accessibility, and ease of interpretation, at a relatively low cost for its feature set.

As noted, IMPLAN is a software package that consists of procedures for estimating local Input-Output models and associated databases. IMPLAN (acronym for Impact Analyses and Planning) was originally developed in 1976 by the U.S. Forest Service (USFS) in
cooperation with the Federal Emergency Management Agency and the U.S. Department of Interior’s Bureau of Land Management to assist in land and resource management planning. By 1985, the USFS partnered with the University of Minnesota to expand and update IMPLAN’s database and software. Due to a growing demand for regional models from private organizations, IMPLAN was established as an independent corporation (Minnesota IMPLAN Group, MIG Inc.) for the purpose of developing and selling future IMPLAN databases and software. In 1988, IMPLAN was used outside of the federal government for the very first time and in 1991 it undertook its first commercial order. By 1999, MIG released version 2.0 of the IMPLAN software, which implemented the newly developed social accounting matrix (SAM), which is now the standard used in all versions of IMPLAN\(^2\). Nine years later, MIG released version 3.0, which added Multi-Regional Input-Output capabilities in the software. By 2013, the independent corporation changed its name to IMPLAN and relocated to Huntersville, North Carolina where they later released a new IMPLAN web-based application five years later. Currently, there are hundreds of licensed users in the United States including universities, government agencies, and private companies (IMPLAN, 2020b; Mulkey & Hodges, 2004).

IMPLAN merges two components: a set of extensive databases and software that both use the regional datasets to calculate a regional Leontief Inverse matrix as well as create a user interface from which contribution and impact scenarios can be coded and applied to the Leontief Inverse. The software performs the calculations and the databases, which are updated annually, provide the basic information needed to create the IMPLAN Input-Output models. IMPLAN’s databases originate from the system of national accounts for the United States based on data collected by the U.S. Department of Commerce, the U.S. Bureau of Labor Statistics, and other federal and state government agencies. The data collected provides information for 536 custom

\(^2\) This thesis adopts the popular terminology of describing IMPLAN and its modeling approach as Input-Output modeling despite technically most users leverage the distributional effects of institutional sectors that make IMPLAN a Social Accounting Matrix.
industrial sectors, based on source information following NAICS (North American Industry Classification System) and accounting conventions used by the U.S. Bureau of Economic Analysis. As previously noted, the databases are available at the county, state, and national levels (or any mutual exclusive geographic combination) and can also be customized and made available at the ZIP-code level. As a result, an Input-Output model can be defined for any section of a city, county, state, or the entire United States (Crompton et al., 2015). For a basic analysis, the analyst needs the industry or institution in which a change in demand is occurring, the year of the change, and one of the following: industry sales, employment, employee compensation, or proprietor income. With this information and the local economic database available, it’s possible to estimate the rest of the information needed for the analysis (French, 2018).

The way IMPLAN estimates the Leontief Inverse Matrix and presents its results is through its multiplier report. Since IMPLAN includes a set of databases including all 536 sectors of the economy, one can consider it an extensive “spreadsheet”. These databases help IMPLAN calculate the rounds of spending resulting from all the sectors of the economy to recreate the Leontief Inverse Matrix. IMPLAN’s multiplier report presents the Type I Multiplier and a Type SAM Multiplier. The Type I Multiplier is computed by first adding the direct effects (the final demand change that the researcher inputs into IMPLAN) plus the indirect effects divided by the direct effects. This multiplier looks only at business-to-business purchases and does not include the effects of local household spending. Since the denominator for this multiplier is always 1.0, this multiplier reflects the Direct Effect and the Indirect Effects. On the other hand, the Type SAM (Social Accounting Matrix) Multiplier does include the impact of household spending (induced effect). It is calculated as the sum of the direct, indirect, and induced effects, divided by the direct effect. One example of the results presented by the Type SAM Multiplier is that it illustrates the total output generated in the specific region due to a one
dollar change in final demand for a sector’s output. The results of the Type SAM Multiplier are a full transactions table that present the proportion of what all industries need to spend on inputs to produce a unit of output, as well as the value of labor, taxes, profits, and household income purchases. The combination of all these elements allows the software to define the necessary quantity of a commodity needed to satisfy the change in production of the industry analyzed and how much of this can be acquired from the local region. After multiple rounds of spending, the resulting quantities spent locally on each commodity can be all added to estimate the total purchasing needs for that specific commodity in dollars and cents (IMPLAN, 2019c).

3.4. Research on Economic Contribution and Impact Analyses

In this section, I review selected articles that highlight various topics in regional economic impacts and contributions to Agriculture and Natural Resources. This review includes a focus on strategies applied in performing these analyses. The challenges and aspects of impact analysis are discussed primarily by a great number of journal articles and theses in which a specific event, policy, or industry is analyzed in terms of its contribution or impact to a specific regional economy.

Research studies such as Deller et al. (2009), examined the impact that collective cooperative businesses had on the U.S. economy. It described the legal and economic characteristics that were used to define cooperative firms and how they measured cooperative activity across all sectors of the U.S. economy through census and survey data. Additionally, another study by Schmit et al. (2013) investigated the substantial increase of food hubs in New York State. They suggested that two alternative impact assessment models be constructed; one that incorporates additional data collected from farms that sell to food hubs and one that does not. The first model included collecting detailed farmer information on sales and other variables, while the second model collected data from customer surveys. Thirty farmers agreed
to participate in in-person interviews where farm-level information was collected. On the other hand, customers were surveyed using an online survey to better understand the demand for locally grown farm products. Both models utilize the data collected from a food hub operation that purchases and markets food products from farms and agribusinesses in New York State. By collecting detailed expenditure and sales information from this food hub, the economic impact assessment was conducted. This estimated the multiplier effects of a change in final demand for local food hub products. By using the data originating from farms supplying the food hub, the authors managed to provide more accurate assessments than using secondary data. Through this approach, they were able to better understand the extent to which additional data collection from farms selling to food hubs was necessary to perform a more accurate evaluation (Schmit, Jablonski, & Kay, 2013).

These studies provided components that have contributed data collection strategies and the elaboration of the methodology such as standardized survey instruments, uniform sampling methodology, and incorporation of redefined sectors into an input output framework. Other studies have evaluated the economic activity of an already existing industry, event, or policy in a given regional economy, also called economic contributions (Watson & Thilmany, 2007). Roche et al. (2016) discussed how the economic contribution of local food purchasing by schools add to the economy of the state of Vermont. To do this, the authors established a baseline estimate of the contribution of the 2014 local food purchases by Vermont schools on the Vermont economy. By assessing the total value-added measures, which includes wages, rents, interests, profits, and dividends, the authors reached a more accurate and conservative measure of the economic contribution. Among their findings, they discovered that local food purchases by schools generated a total $1.4 million in economic activity, including $915,000 in sales in the farm and food processing sectors. With the multiplier effect, they found that for every dollar contributed in value added in the farm and food processing sectors, (such as
wages), profits add an additional $1.20 to the economy of the state. With this being the first statewide assessment of the contribution of the Farm to School program in Vermont, the authors expected to find a modest economic contribution.

Moreover, there is a significant number of economic impact and contribution studies using IMPLAN. Many of them have been used in Louisiana in the past two decades, among these include Fannin et al. (2007). In this paper, the authors measured the contribution of the food and fiber system to the Louisiana economy. Their methodology consisted of obtaining estimates for final demand of the food and fiber products and services from the Louisiana dataset generated by IMPLAN. Also, they included additional final demands from federal, state, and local governments as well as capital expenses to calculate for the gross commodity demand for food products. This total final demand was then applied to IMPLAN’s Input-Output model of the state’s economy to estimate the direct and indirect demands for goods from the food and fiber sectors. Their results indicated that the total value of the food and fiber products supplied in Louisiana surpassed $25.1 billion in 2005, from which $8.27 billion contributed dollars in value-added to the regional economy. Even though value added grew in Louisiana over the years, employment declined over a four-year period. The authors revealed that total jobs decreased from 249,674 to 246,512, corresponding for a 1.27 percent reduction. They conclude their study by affirming that Louisiana has been following the U.S. average growth rates in terms of the development of the food and fiber industry (Fannin & Henderson, 2007).

Correspondingly, Fannin et al. (2008) evaluated the economic impact of a switch of 295,000 acres of cotton production to corn production. This study attempted to evaluate the tradeoffs from switching cotton production to corn production by studying production budgets for both commodities in 2007. As expected by the authors, the input costs for ginning an acre of cotton were more expensive than drying an acre of corn. Similar to this study, they created new present-year production functions for corn, cotton, and the processing sector outside the
IMPLAN model. These production levels were then combined with the production functions’ data to create alternative final demand scenarios, which were applied to the multipliers in the IMPLAN model. In their results, the authors found that the switch from cotton to corn expected to increase total output by $700,000 (0.57 percent greater than if cotton was planted). The other indicators specified that value added was expected to decrease by more than $650,000 (decrease of 0.89 percent) and a loss of $1.97 million was to be expected in labor income. These effects were expected to affect negatively and positively different sectors of the economy of the state. The largest sectors positively affected were health and social services, wholesale trade, and transportation and warehousing, while the most negatively affected were retail trade, manufacturing, and agriculture, forestry, and fishing sector (Fannin, Paxton, & Barreca, 2008).

Studies like these demonstrate their value in the decision-making of major leaders and stakeholders when presented with short-term and long-term challenges.

Other studies have discussed economic base social accounting analysis\(^3\) conducted simultaneously across all sectors of the regional economy. This method also allows for non-traditional components of economic base to be accounted for in a consistent manner and can be performed with readily available and commonly used data tools. Due to the customizability of IMPLAN’s social accounting matrix, this type of method is flexible and easily implemented and can also help reduce misleading estimates (Watson, Cooke, Kay, & Alward, 2015).

\(^3\) IMPLAN Group, LLC has developed methodologies for creating local (county) area SAM data that is consistent with Bureau of Economic Analysis. Like Input-Output (I-O) tables, a SAM is a double-entry bookkeeping system capable of tracing monetary flows between industries through inflows and outflows. SAMs extend traditional I-O accounts by also providing information on non-market financial flows - i.e., industry-institution transfers and inter-institution transfers (IMPLAN, 2020a).
3.5. Limitations and Abuses of Input Output Analysis for Economic Impact

Throughout its history, economic impact and contribution studies have received substantial criticism due to their political role in informing both elected officials and taxpayers of the economic contributions of an event, industry, or policy. Crompton (2006) discussed specific problematic procedures of impact and contribution studies including inappropriate aggregation, abuse of multipliers, ignoring opportunity costs, expanding the project scope and more. In his review, he stated that these studies are usually driven by a desire to demonstrate their sponsors a positive contribution to the economic prosperity of their jurisdiction (Crompton, 2006; J. Crompton, 2019). However, it is important to recognize that in some cases, these problematic practices are not the result of ignorance and unintentionality, but often are deliberately intended to mislead.

Similar research, however, such as Hughes (2003) discussed several issues that should be considered in the interpretation of multiplier-based studies. In his review, he focused on the influence these issues may have on multiplier limitations and the policy analyst’s decision making. The issues can be summarized in the following: project feasibility, employment impacts, effects on current residents, considerations about capital, impacts on local government, and accounting stance (Hughes, 2003). Equally important are the reviews performed by Partridge (2018) where he argued that impact and contribution analyses and multiplier effects are extremely valuable for a distressed rural area. However, he claimed that one main issue of commercial software like IMPLAN and REMI is their “false precision” in which they produce exact employment or income estimates by detailed sector, hence ignoring indication of large standard errors due to strict structure of local economies (Partridge, 2018; Tsvetkova, 2016).

Jeong et al. (2016), identified eight troublesome practices as “hidden” in normal economic impact analyses in the tourism sector. The authors claim these troublesome practices are not easily identifiable since researchers tend to fail to mention in their reports. Nevertheless,
these practices still have the potential to distort decision makers with their economic impact estimates. The eight decisions are divided into two categories: potentially malignant decisions and those potentially benign, with the malignant being defined by whether there’s another obvious correct way to proceed and whether they are meant to distort. In the potentially malignant category, the authors identified 1) aggregating per person expenditures by group weighting rather than by individual weighting, 2) omitting a measure of the extent to which visiting a park was the exclusive trip purpose, 3) retaining outlier values, and 4) aggregating different visitor segments. On the potentially benign category, the authors included 1) convenience or probability samples, 2) manager’s estimates, 3) treating nonresponses as missing data, or as zero expenditures, and 4) sector selection for assignment of government expenditures (Jeong, 2016). The authors claim that in order to avoid compromising the integrity of an economic contribution analysis, researchers must mitigate these practices mentioned in Crompton (2006).

Moreover, Crompton et al. (2015) offer a detailed technical critique of Input-Output models in their research article. The authors stated that IMPLAN possesses four primary limitations regarding its Input-Output models. Their first critique mentions that the models assume that the economy is fully stretched (producing at full capacity), allowing no time for slack in the local economy. They state that employees are not fully occupied and consequently, this does not represent an increase in the amount of labor or labor hours. Their second critique alludes to the fact that IMPLAN models assume prices and purchasing patterns remain constant. In a stretched economy, prices are likely to increase in the short term as additional demand increases. In the long run, these prices will eventually stabilize, but the authors claim that IMPLAN assumes the prices will always remain unchanged. The third criticism suggests that IMPLAN’s Input-Output models assume there are no resource constraints or resource substitutions, in other words, resources of land, labor or capital will always be available. One
example that represents this criticism is if an alligator facility is built, the Input-Output model in IMPLAN assumes that construction and labor is readily available in the economy. Finally, their last review proposes that the model does not specify the time it will take for new inflow of money to generate the additional income and jobs (Crompton et al., 2015).

When performing a contribution or impact analysis in IMPLAN software, the timing of the impacts is not specific, in other words, they occur in multiple time periods (particularly indirect/induced effects); therefore, it becomes difficult to evaluate whether any type of impact analysis through IMPLAN is fully incorporated in any single time period. As mentioned before, input output contributions to input-output methods have included many authors highlighting the flaws of this methodology throughout time. On the other hand, researchers working in input output analyses have incorporated strategies to limit some of these criticisms, and at the same time, improve the credibility of model results to decision makers. This study will attempt to understand how sensitive the improvement strategies will be as primary data is embedded more deeply into the model (IMPLAN, 2013a).

3.6. Overview of Model Improvement Strategies in IMPLAN

This section presents the definition of the modeling improvement strategies: Production Functions, Regional Purchase Coefficients (RPCs), and Analysis-by-Parts. In addition, it reviews previous academic works in which these methods have been successfully executed, besides just applying IMPLAN’s baseline Input-Output model to a single industry’s final demand. It describes the purpose of including these methods and will also illustrate the process of executing these techniques.

3.6.1. Production Functions

The first strategy for improving the accuracy of contribution and impact analysis using Input-Output is the editing of the production functions. Schmit et al. (2017) defined it as the
function that demonstrates where an industry spends, and in what percentages, it generates a dollar of output (Schmit & Jablonski, 2017). Of all the types of production functions, the Leontief Production Function is the one used in IMPLAN to dictate the ratio of inputs needed by each industry to produce a unit of output (in terms of a dollar value). The Leontief Production Function of one sector in IMPLAN determines how each sector will distribute the value of its output sold to various intermediate inputs and value-added outlays. While IMPLAN is based on the Leontief Production Function technology, it is possible to change this production function, hence making changes to industry and value-added relationships.

Platas et al. (2002) attempted to develop five different modified versions of the default IMPLAN production functions in 1998. The authors used a default set of production functions derived from purchases that the pork industry makes from other industries for every $1 in output the industry produces and sells. Additionally, they used Regional Purchase Coefficients (RPCs) from local swine operations assuming the residual spending was from outside the state of Minnesota. (This thesis mentions that when an IMPLAN scenario is applied to a constructed model in IMPLAN, the production functions and regional purchase coefficients are all positive and fixed; therefore, the model's final results are always in the same direction and proportional to the initial change entered. One example is if there is a positive economic shock in the size of the alligator industry, this increase results in greater total regional employment.) To solve this issue, the authors replaced the default IMPLAN pork industry with sets of production functions and RPCs customized to the specific types and sizes of operations of interest to their study. These production functions were used in separate IMPLAN models to trace through the impacts and the aggregation on the rest of the region’s economy. The functions were derived by translating expense categories to the closest IMPLAN industry classification. After entering all the input expenses into IMPLAN, the authors summarized the production functions for all pork operations per input into a table. They discovered that both small and large swine operations
had most of their input’s expenses concentrated in premixes from soybean mills for farrow-finish. In the finish operation, most of the inputs were focused on purchasing nursery pigs with a coefficient of 0.384 per $1 of output in small operations (Lazarus, Platas, Morse, & Guess-Murphy, 2002). This paper helped display a solid application of this methodology to display the ripple effects through consumer spending to final demand.

One fundamental reason for wanting to reassess the modeling software's production functions is the limitation in how IMPLAN creates its production functions. IMPLAN does not use primary data from detailed industries to determine total intermediate input usage in a sector. Instead, it uses national BEA benchmark Input-Output account inputs based on aggregated industries to determine which and at what proportions inputs are used. IMPLAN uses these national averages and applies them to individual regional Input-Output models. This is not problematic for very homogenous sectors across the United States (e.g., gas stations). However, for very heterogeneous sectors, whose production functions are very different based on their region of production, using default IMPLAN production functions can be problematic. For example, sugar production intermediate inputs in IMPLAN are a weighted national average of sugarcane production and sugar beet production. Using the national average IMPLAN sector data can reduce the accuracy of contribution/impact analysis. The improvement strategy of this thesis is based on the customization of the Leontief Production Function in IMPLAN, and it will aim to compare IMPLAN's default production functions to the ones that will be derived from the survey data (IMPLAN, 2019b).

3.6.2. Regional Purchase Coefficients

Schmit et al. (2017) define Regional Purchase Coefficients as the proportion of all local demands for a commodity that is supplied (met) by the region itself (Schmit & Jablonski, 2017). An example of the interpretation of an RPC for the state of Louisiana is the following. An RPC
of 0.6 for the commodity “alligator feed” means that local Louisiana feed manufacturers, mostly from Franklinton, Louisiana, provide 60% of the demand for alligator feed to Louisiana alligator producers. The remaining 0.4 (40%) of demand is satisfied by imports from the Rest of the World (both other states in the United States and internationally).

IMPLAN provides production function coefficients as well as Regional Purchase Coefficients for each industry based on national averages. Regional Purchase Coefficients are typically estimated either by the supply-demand pool method, econometric methods, or trade flow methods based on the data set of a specific year. The Supply-demand pool method calculate RPCs by multiplying the row coefficients of a base Input-Output model (often national model) by a scalar that represents the ratio of regional supply to regional demand. This result is an estimated row of RPCs (Robison & Miller, 1988). The supply demand pool assumes that all local supply goes to meet local demand. It does not account for cross-hauling; the process in which not all local supply meets local demand but is exported to other regions because of price considerations or differences in the attributes of the product demanded locally to the attributes of product supplied locally. The econometric approach is a model developed by IMPLAN that leverages source information from the supply pool method and attempts to accommodate for cross-hauling. The trade flow method applies product transportation statistics of source and destination of commodities in the United States and uses a gravity-type model to adjust for outliers.

It is fundamental to highlight that there has not been a lot of studies that compare and contrast these improvement strategies; which is partly due to the fact that most researchers collect their primary data and prefer it over the IMPLAN generated RPCs. Still, the literature available on this subject is extremely limited. Davis et al. (1984) used purchase and sales coefficients as alternative approaches for estimating the impacts on production resulting from supply-constraints. Their purchase coefficient model assumed a fixed pattern of inputs for each
sector analyzed. On the other hand, the sales coefficient model suggested that a fixed pattern of sales will only mean that any reduction in a sector’s output will cause the sector to reduce its sales proportionately among its various established markets. Both models were assigned to estimate the impacts on the regional economy of Kern County, California of a hypothetical reduction of state-supplied water. In their findings, the authors discovered that the models yielded different results mainly because of the differences in assumptions between the models and the difference between the strengths of the linkages of the agricultural sectors affected by the reduction of water supply. The purchase-coefficient model’s estimation was quite significant with a total $250 million impact to the economy of Kern County. The study revealed that any reduction in the output of agriculture will necessarily have marked implications in the model for petroleum sectors, which were the largest sectors in the 60-sector model in terms of output. This direct implication is due to the strong purchase links between the agricultural sectors in the County and the Petroleum production sector, which also has strong backward links. On the other hand, the sales coefficient model yielded a small impact on the economy with a total of $177 million, as a result of the reduction in gross output in the agriculture sector (Davis & Salkin, 1984). This paper successfully argued the opportunity to choose between alternative approaches by providing merits for each technique.

Lazarus et al. (1996) has been one of the sources cited when comparing the main differences between improving Input-Output methods using RPCs in relation to production functions. The authors not only provide an introduction to each of the techniques, but they also compare how econometrically derived IMPLAN default RPCs differ from RPCs obtained from survey results on hog producers. This case study was done on large farrow-to-finish hog operations in Martin County, Minnesota. To identify the differences between both types of RPCs, the authors compare them by using an econometric/survey ratio. They used 14 inputs from which they derived the RPC’s for both approaches. Among their findings, they discovered
that the survey estimates were higher than IMPLAN’s econometric RPCs used for 10 out of the 14 inputs examined. One example of this relationship is portrayed by the survey-based RPC of 80 percent of agricultural services are provided by Martin County, compared to the 33 percent that computed the econometric default RPC from IMPLAN. Table 2 in their article displays the comparisons between both types of coefficients.

In this study, the most essential component that is comparable to this research is the fact that the authors used survey results from hog producers to derive their RPCs. The authors discussed how the differences they observed in the RPCs and production functions may be related to the rapid technological and structural changes taking place in the swine industry. They also explored whether re-estimating the RPCs or the production functions cause a greater difference in the model’s estimate of value-added income. They concluded that generally, the production function changes are much more important than changes in the regional purchase coefficients. Furthermore, the RPC for a single major input can outweigh the impacts of all of the other production functions and RPCs combined (Lazarus, Platas, & Morse, 1996). However, these conclusions are not consistent for other industries. This research study aimed to use both approaches in order to improve the IMPLAN’s accuracy as well as test the hypotheses made by the authors.

3.6.3. Analysis-By-Parts (ABP)

Analysis-by-Parts is a technique by which one can analyze the contributions of an industry's production/spending through multiple sectors instead of using a single industry sector within the final demand vector (Y). Intermediate inputs and labor income spending are the key sectors of most industry contribution and impact studies. ABP is a technique by which one analyzes the impact of an industry's production/spending in separate components using multiple sectors instead of using a single industry sector to drive economic impact.
This modeling improvement strategy is often used in cases where the industry does not exist formally in the IMPLAN model or when that sector is an aggregation of many other small economic sectors into a “catch all sector.” This is why sometimes ABP is sometimes referred to as building a sector “outside the (IMPLAN) model.”

To perform an ABP approach, ideally one will want to know direct employment, direct labor income, and/or direct output. However, all of these elements can be estimated from the IMPLAN Model as long as one has a budget or output value with which to initiate a scenario (Clouse, 2020). Such is the case of Schmit et al. (2017) where they applied ABP to estimate impacts based on the spending pattern data collected from local food hubs. To do this, they established activities that reflect the spending pattern of the food hub for intermediate inputs, and value added expenditures for the labor income components. In each of the activities, they defined a set of events and a scenario that included the activities. Once the scenario was analyzed, the results were displayed in IMPLAN (Schmit & Jablonski, 2017).

In a standard Input-Output model, the change in demand is employed in a single sector within the IMPLAN model. On the other hand, ABP divides the analysis into two parts: intermediate expenditures and value added impacts. In ABP methodology, the logical direct effect is the same as the direct effects specified and applied to the multipliers in the traditional industry change analysis. To highlight how ABP can generate the same contributions as the traditional Input-Output analysis, IMPLAN Group (2019), elaborated a case study where both methods yielded identical results (IMPLAN, 2019a).

The biggest difference between Analysis-by-Parts in IMPLAN and traditional baseline multiplier applications is interpreting IMPLAN results tables. When using a single multiplier in a traditional IMPLAN analysis, only the production sector \( y_i \) includes a positive value in the final demand vector \( Y \). As a result, \( y_i \) is the direct effect that shows in the IMPLAN results.
table for that single sector with all interindustry linkage effects in the indirect column and all household spending effects in the induced effect column spread across all other sectors of the economy. When using the Analysis-by-Parts Approach, the production value in the original $y_i$ is distributed across all the intermediate industry input sectors as well as value-added sectors in the final demand vector ($Y$). As a result, the first round of indirect effect spending in the traditional analysis reported by IMPLAN is transferred to the direct effects column (adjusted for local spending) in the Analysis-by-Parts Approach. The initial final demand no longer shows in IMPLAN results. Consequently, to compare the two approaches, the original final demand must be added back to the IMPLAN results table in the Analysis-by-Parts approach.

3.7. Conclusion

Learning about the foundations of Input-Output analysis, the misapplications of software-generated calculations, and the structure of the IMPLAN modeling software, suggest that alternative improvement approaches should be considered in most economic contribution/impact applications using Input-Output modeling. There is a shortage of studies that have attempted to do a more comprehensive sensitivity analysis of these modeling improvement techniques. One of the objectives of this research is to implement these strategies into an economic contribution analysis of the American alligator industry. Chapter 4 will highlight the application of these modeling improvement strategies as they relate to the economic contribution of the alligator species to the Louisiana economy.
CHAPTER 4. RESULTS

4.1. Introduction

This chapter presents the realization of each of the modeling improvement strategies and their corresponding results. It comprises of two different sections, measuring the direct contribution of the alligator farming industry to the Louisiana economy and applying modeling improvement strategies to measure the indirect and induced effects of alligator farming in the state. In addressing Objective one, the first segment introduces the hybrid approach that it is used throughout measurement of the direct effects. The combination of utilizing survey data, administrative, or secondary, data and expert opinion data is the foundation of how the direct contribution results were approached for this study.

The survey approach subsection details the specific procedure taken to acquire the necessary primary information regarding detailed expenses of an alligator establishment. Additionally, the section highlights questionnaire development, the approach against bias and the expense findings that it was able to discover. Further, the administrative data section explains the source for secondary data, and it defines the specific information that it is extracted for the estimation of the contribution. To conclude this first section, the expert opinion segment describes the required information obtained from a local state tannery regarding alligator sizes and classes for processing.

The second section of this chapter addresses the second objective of the research and includes a sensitivity analysis to modeling improvement strategies for measuring the indirect and induced effects. In this portion, the procedures for each of the modeling improvement strategies are introduced. Applying the demand for alligator skins through IMPLAN’s Sector 14 (Animal Production, except cattle and poultry and eggs) in the baseline Input-Output model is the first strategy that presents a traditional multiplier approach to calculating the indirect and induced effects. Later, the next section highlights the Analysis-by-Parts approach and how the
results compare from using IMPLAN’s RPCs against using the RPCs obtained from the questionnaire. Additionally, it highlights the aggregated sector approach when using the survey’s RPCs. Following this segment, the discussion of the edit of the production functions in IMPLAN’s Sector 14 is explained.

Finally, the last section includes a comprehensive analysis of the comparison of the tradeoffs of using each modeling improvement strategy and will comply with objective three of this study. The study progresses to explain the table highlighting the results for each modeling improvement strategy and how it harmonizes the IMPLAN Output according to the standard Input-Output methodology. Finally, this portion identifies the optimal strategy to use given contribution purposes.

4.2. Measuring Direct Contribution

4.2.1. Hybrid Approach

To begin the direct contribution segment of the presentation of results, it is vital to mention that a hybrid approach was implemented for collection of data. First a survey was performed and data from it was used to obtain the detailed expenditures by category for alligator farmers. Second, using administrative data such as the Louisiana Alligator Management Program 2019-2020 Annual Report, I was able to adjust per alligator spending to total Louisiana alligator farming spending. Finally, expert opinion was leveraged through a guided conversation⁴ with a domestic alligator tannery to obtain price information of skins by size class to estimate total revenue and after adjusting for total farm expenses, proprietor income.

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⁴ Guided Conversation: Consists of a meeting, or in this case an interview, where the interviewer, reviews the information received, analyzes the responses, explains the responses' importance, and identifies how the responses will be utilized for the research study (The Institute of Cultural Affairs (ICA), 2000).
4.2.1.1. Survey Approach for Expenses by Sector

This study required collecting primary data on input costs and related production revenue through an LSU AgCenter IRB-approved survey of alligator farmers (HE20-8). This survey was funded through a grant from the Louisiana Department of Wildlife and Fisheries (LDWF). From both a literature review and conversation with LDWF, the alligator industry had not had a significant study done since the early 1990s including any recent comprehensive surveys of revenues and expenses for alligator farmers. Consequently, to support successful data collection, the questionnaire asked relevant questions regarding costs and the structure of their operations, without missing any key elements required for measuring economic contributions. In the Fall of 2019, a guided conversation with one alligator farmer occurred regarding his operations and production process (from collecting eggs to the harvest of skins). Within this conversation, a set of questions was asked in order to formulate the necessary questions that would be needed for the survey.

From December of 2019 to January 2020, a questionnaire draft was developed, and much time was spent restructuring the questions into the proper arrangement and order. The survey begins by focusing on number of hatchlings needed, and then progresses through the production process including acquiring eggs, incubation, and growing out alligators to market sizes including for making watchstraps (alligators with belly widths 29cm or less and approximately four feet long) and handbags (alligators with belly widths greater than 29cm). In February of 2020, the questionnaire was sent to the Institutional Review Board (IRB) for approval and was pre-tested with a couple of alligator producers. At the end of February, the full IRB approval (LSU AgCenter HE20-8) was received and then proceeded to initiate the data collection in March of 2020. Due to delays caused by COVID-19 restrictions and procedural changes, the completion date was achieved by the end of the Summer 2020. A copy of the Louisiana Alligator Supply Chain Survey is located in the Appendix.
Furthermore, some approaches were implemented in order to increase participation in the survey. One of these approaches included the attendance of Dr. J. Matthew Fannin (lead principal investigator for the LDWF grant), at the Annual Louisiana Alligator Farmers and Ranchers Association Meeting in early March 2020, where it was possible to advertise the questionnaire. Similarly, in collaboration with the LA Sea Grant Extension Agent, Mark Shirley, it was possible to contact a significant number of alligator farmers and encourage participation in the survey. Likewise, considering the data's sensitivity concerns, the survey was implemented in person, at their respective alligator farms and the questions were asked orally with the answers being recorded on paper. To further maintain anonymity, the respondent's individual information was not coded in the survey so that they could not be affiliated with their completed questionnaire. For these reasons, it was believed that these approaches created sufficient trust to get the level of participation that we received.

The data collection strategy focused mainly on hatchlings as the focal point of the questionnaire. The purpose of this strategy includes two main reasons. First, the number of hatchlings an alligator farm needs determines the nature of the production process from prior to the acquisition of eggs through the raising and slaughtering of those alligators. Secondly, by focusing on hatchlings, it allowed for the creation of a baseline from which the survey results could be calculated on a per hatchling basis. This permitted to roll up the total direct contribution by multiplying per hatchling revenue and costs to the number of hatchlings grown statewide including from both the production of the farmers that were surveyed as well as those that did not participate in the survey.

The questionnaire collected detailed expenses by significant cost categories. The categories representing the biggest input expenses were divided into four major cost categories, which were defined in the interview to the alligator producer (pre-survey). The four categories comprise hatchling expenses, feed expenses, utility expenses, and labor expenses. Besides these
identified by the farmers, two more categories were included: other operating expenses and capital expenses; the latter referring to those assets that the alligator farmers purchased and used during multiple production periods. Also, alligator farmers were asked to indicate the location from where each input or service was commonly purchased. These survey responses for each of these levels of input were then used to estimate the RPCs.

Among the survey results, six alligator farmers completed the questionnaire, which due to the high concentration ratio for alligator farmers in Louisiana, represented approximately 74% of the total 499,357 hatchlings that were needed for production in the state of Louisiana in 2019 (Louisiana Department of Wildlife and Fisheries, 2019).

In this circumstance, where there is a percentage of the population that is unwilling or unable to respond to the survey, it is possible to incur a bias referred to as non-response bias. This type of bias can negatively impact the research sample's representativeness and eventually lead to skewed outcomes due to the differences between those who responded and those who did not (Horn, 2018). Working with LSU AgCenter and LSU Sea Grant Specialist Mark Shirley, his knowledge of one of the farmers that did not respond was that this farmer would have represented between 10 and 15 percent of the annual hatchlings needed for Louisiana alligator production and has a similar production process to those that completed the survey. Since this producer represents a considerable amount of the remainder of the population of hatchlings, it is likely the non-response bias will be less significant.

Another point to highlight is that certain costs identified in the questionnaire had minimal variation between alligator establishments, such as feed costs. This means that most alligator producers employed feed mill feed, and they all paid approximately the same price per ton. Consequently, the feed cost per hatchling will likely be similar for those alligator farmers that did not complete the survey. Further, there is a market price for eggs and hatchlings that falls within the very narrow price range. As a result, because eggs, hatchlings, and feed make
up a non-trivial percentage of the total cost of alligator production, I would expect this would further reduce any potential non-response bias.

Recalling Jeong et al. (2016), the authors stated that troublesome practices are not easily identifiable since researchers tend to fail to mention these in their reports. These practices were divided into potentially malignant and those potentially benign. For transparency purposes, this study identifies the benign practices that are incurred in data assumption for this analysis. One of the benign techniques identified in this study is treating nonresponses as missing data, or as zero expenditures. All six of the survey respondents provided answers for questions related to hatchlings needed, costs affiliated with acquiring eggs, purchasing other pre-collected eggs, costs of incubation and hatching, and feed and labor costs. However, one of the producers did not provide costs on utilities, other operating expenses, and most capital expenses. This non-response was not treated as zero expenses, but the weighted average cost per hatchling of the other five producers was assumed for that sixth producer. Similarly, there were a few other expense categories where the non-response was treated as actual expenses occurring, as opposed to zero expenses occurring. These categories include property taxes, and expenses for heating and cooling equipment.

Another case where it is vital to be transparent concerns expenses and assets used jointly between alligator and non-alligator operations. If an alligator farmer used items such as tractors, trailers, and related equipment as well as shared utilities with other non-alligator farming operations, only the proportion of the expense or asset used toward alligator operations should be included in the alligator contribution measurement. When this question was asked in the survey, either the responses indicated 100% of the expenses of the alligator operations' assets or over 95% were related to the alligator activities. In other words, the amounts were so infinitesimal (less than 5%) it was assumed that the investments or expenses would not have been incurred if the alligator operation did not exist; therefore, 100 percent of the expenses were
treated as expenses related to alligator operations. All the remaining questions in the survey that were not responded to were treated as zero expenses.

4.2.1.2. Administrative Data for Skin Production

The primary role of this questionnaire was to get detailed per hatchling expenses by specific spending sector. No detailed revenue information was asked from the participants; however, as a part of the in-person survey process, they were asked if they wanted to provide other additional information. Many of them did provide aggregated revenue information, such as how much money they received per watch strap alligator and handbag size alligators. To measure the direct contribution of alligator farming to the state economy, it was imperative to know the state's alligator production population. To do this, I used the data from the Louisiana Alligator Management Program 2019-2020 Annual Report to obtain the total number of alligators harvested. Then, by working backward and adjusting that number based upon the number of alligators actually harvested, I added 10% to that total based on the percent of alligators released into the wild that were raised from hatchlings. Finally, an additional 1.39% was added to account the additional hatchlings needed to cover average mortality rate highlighted by alligator farmers in the survey findings.

4.2.1.3. Expert Opinion

In this research, the primary focus of using expert opinion was on obtaining revenue price information, on size class for alligator. A guided conversation occurred with a US based tanner of alligator skins. The tanner estimated the 2019 price paid by class size range indicated. This information was complimented with the percent of total alligators harvested by size class that comes from the Louisiana Alligator Management Program 2019-2020 Annual Report. Expert opinion price data by size class was combined with additionally disclosed pricing information for skins from alligator farmers provided in additional information they provided
from oral surveys. Based on all this information, a low range and a high range of prices received by size class was identified. The revenue generated by size class based on the percent of total Louisiana skins was calculated. These revenue values were summed and then divided by the total number of hatchlings needed to generate those alligators each year to get the revenue per hatchling required.

### 4.2.1.4. Direct Contribution Results

The following section presents the direct contribution results from the input expenses collected from the survey. The categories consist of feed, utilities, labor costs, fixed costs, hatchlings, and other variable operating costs. In addition, a summary table is presented where all input levels are compared by their subtotals and the direct, fixed, and total costs are calculated. The first two columns of each table highlight the individual cost that falls into each category and is presented on a per hatchling basis. Correspondingly, the third and last column presents the percent share where each key input was purchased (either in the state of Louisiana or out-of-state).

Table 4.1 introduces the first expense category, alligator feed. This category is comprised of two key costs: Feed Mill Feed and Processed Chickens, which are incurred by alligator farmers in the state. The most significant cost encountered regarding alligator nourishment is pelleted alligator feeds with a price per hatchling of $25.59. Currently, Cargill in Franklinton, Louisiana is the main supplier of manufactured pelleted alligator feeds in Louisiana. The subtotal for all expenses in this category is of $26.27 per hatchling.

Table 4.1. Feed Expenses.

<table>
<thead>
<tr>
<th>Input/Service Category</th>
<th>Input Value</th>
<th>Percent of Inputs Purchased in Louisiana</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>($/hatchling)</td>
<td>(percent)</td>
</tr>
<tr>
<td>Feed Mill Feed</td>
<td>$25.59</td>
<td>86.80%</td>
</tr>
<tr>
<td>Poultry Processing Chickens</td>
<td>$0.68</td>
<td>100.00%</td>
</tr>
<tr>
<td>Feed Subtotal</td>
<td>$26.27</td>
<td></td>
</tr>
</tbody>
</table>
Similarly, Table 4.2 displays the utilities expense category. This input level includes all the expenses for utilities related to alligator operations. These include electricity, gas (natural gas and propane), diesel/gasoline, and water. The most considerable expense incurred in this category relates to natural gas and propane gas expenses with $4.92 per hatchling. Additionally, the second most sizable input level that can be observed below is electricity with a total of $1.60 per hatchling. The value of the rest of the input levels are below these two categories. All expenses that pertain to this category are purchased in the state of Louisiana. The subtotals for all inputs in this category is of $8.92 per hatchling.

Table 4.2. Utility Expenses.

<table>
<thead>
<tr>
<th>Input/Service Category</th>
<th>Input Value ($/hatchling)</th>
<th>Percent of Inputs Purchased in Louisiana (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>$1.60</td>
<td>100.00%</td>
</tr>
<tr>
<td>Natural Gas and Propane</td>
<td>$4.92</td>
<td>100.00%</td>
</tr>
<tr>
<td>Diesel/Gasoline</td>
<td>$1.11</td>
<td>100.00%</td>
</tr>
<tr>
<td>Purchased Water</td>
<td>$1.29</td>
<td>100.00%</td>
</tr>
<tr>
<td><strong>Utilities Subtotal</strong></td>
<td><strong>$8.92</strong></td>
<td></td>
</tr>
</tbody>
</table>

Likewise, Table 4.3 presents the labor costs expense category. This category comprises the cost of all wages and benefits to employees who are directly involved in producing the commodity. These include full-time labor and part-time labor, H-2A labor, H-2A acquisition cost, H-2A housing, and H-2A food. As identified, the most substantial expense in this category applies to the wages paid to both full-time and part-time labor costs with a total of $20.38 per hatchling. The second most considerable cost relates to the wages paid to H-2A Labor workers at $4.56 per hatchling. All expenses that relate to this category are 100% purchased, or acquired, in the state, except for H-2A Labor, which only 10% of employee compensation is assumed to be spent in Louisiana while the remaining 90% is assumed to be remitted back to the home countries of the H-2A laborers. The 10% originated from conversations in the pre-survey stage between the alligator farmer and the principal investigator about the percentage of wages the
farmers believed these employees were spending while living in Louisiana versus sending back to their countries. The subtotal for all inputs is $25.18 per hatchling produced.

Table 4.3. Labor Costs.

<table>
<thead>
<tr>
<th>Input/Service Category</th>
<th>Input Value ($)</th>
<th>Percent of Inputs Purchased in Louisiana (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-Time Labor and Part-Time Labor</td>
<td>20.38</td>
<td>100.00%</td>
</tr>
<tr>
<td>H-2A Labor</td>
<td>4.56</td>
<td>10.00%</td>
</tr>
<tr>
<td>H-2A Acquisition Cost</td>
<td>0.09</td>
<td>100.00%</td>
</tr>
<tr>
<td>H-2A Housing</td>
<td>0.15</td>
<td>100.00%</td>
</tr>
<tr>
<td>H-2A Food</td>
<td>0.07</td>
<td>100.00%</td>
</tr>
<tr>
<td><strong>Labor Costs Subtotal</strong></td>
<td><strong>25.18</strong></td>
<td></td>
</tr>
</tbody>
</table>

Moreover, Table 4.4 highlights the Fixed Costs expense category. This input group refers to those costs that do not change over time and are required for yearly production. These include Buildings, Trucks, Tractors (and other Auto-Type Equipment), Coolers and Freezers, and Water Heaters. Information on the questionnaire asked about the number of different pieces of buildings, machinery, and equipment, the replacement cost of each, and the average useful life of each asset. Total replacement cost divided by the number of years of useful life of asset was used to calculate an annual cost of operation.

From all these fixed expenses, the largest expense was Buildings with a total of $7.64 per hatchling. Following this input, the second largest expense was Tractors, Trailers and other Auto-Type Equipment with a total of $1.75 per hatchling. For this category, all expenses were 100% in-state purchases. The subtotal for all fixed inputs in this category equaled $11.41 per hatchling.
Table 4.4. Fixed Costs.

<table>
<thead>
<tr>
<th>Input/Service Category</th>
<th>Input Value</th>
<th>Percent of Inputs Purchased in Louisiana</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>($/hatchling)</td>
<td>(percent)</td>
</tr>
<tr>
<td>Buildings</td>
<td>$7.64</td>
<td>100.00%</td>
</tr>
<tr>
<td>Trucks</td>
<td>$1.10</td>
<td>100.00%</td>
</tr>
<tr>
<td>Tractors, Trailers, and other Auto-Type Equipment</td>
<td>$1.75</td>
<td>100.00%</td>
</tr>
<tr>
<td>Coolers and Freezers</td>
<td>$0.09</td>
<td>100.00%</td>
</tr>
<tr>
<td>Water Heater</td>
<td>$0.84</td>
<td>100.00%</td>
</tr>
<tr>
<td><strong>Fixed Costs Subtotal</strong></td>
<td><strong>$11.41</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.5 shows the costs of Hatchlings and the operations that include acquiring them for production. These expenses include Landowner Costs, Helicopter Rental, Helicopter Spotter, Airboat Rental, Airboats, Fuel Boat, Pre-Collected Egg Cost, Diesel and Gasoline, Employee Compensation, and the cost per pre-purchased hatchling. The expense that represents the largest percentage of the subtotal are Landowner Costs at $20.53 per hatchling. This cost represents the costs paid to landowners for collecting eggs on their property. The cost per hatchling is higher than the cost per egg collected since not all eggs collected hatch. The second most significant input relates to the cost per pre-purchased hatchling with a total of $9.89. This value is calculated as the average cost per live hatchling purchased multiplied by the percent of live hatchlings needed that are purchased from other producers that incubate eggs into live hatchlings. The rest of the input expenses seem to be minimal when compared with these two inputs. Also, all inputs in this input group are purchased in Louisiana. The subtotal for all inputs is $33.73 per hatchling, making it the category with the highest input expense.
Table 4.5. Hatchling Expenses.

<table>
<thead>
<tr>
<th>Input/Service Category</th>
<th>Input Value ($/hatchling)</th>
<th>Percent of Inputs Purchased in Louisiana (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landowner Costs</td>
<td>$20.53</td>
<td>100.00%</td>
</tr>
<tr>
<td>Helicopter Rental</td>
<td>$0.76</td>
<td>100.00%</td>
</tr>
<tr>
<td>Helicopter Spotter</td>
<td>$0.00</td>
<td>100.00%</td>
</tr>
<tr>
<td>Airboat Rental</td>
<td>$0.02</td>
<td>100.00%</td>
</tr>
<tr>
<td>Airboats</td>
<td>$0.51</td>
<td>100.00%</td>
</tr>
<tr>
<td>Fuel Boat</td>
<td>$0.79</td>
<td>100.00%</td>
</tr>
<tr>
<td>Pre-Collected Egg Cost (per Hatchling)</td>
<td>$0.75</td>
<td>100.00%</td>
</tr>
<tr>
<td>Diesel/Gasoline</td>
<td>$0.13</td>
<td>100.00%</td>
</tr>
<tr>
<td>Employee Compensation</td>
<td>$0.36</td>
<td>100.00%</td>
</tr>
<tr>
<td>Cost for pre-purchased hatchlings</td>
<td>$9.89</td>
<td>100.00%</td>
</tr>
<tr>
<td><strong>Purchased Hatching Cost (per hatchling needed)</strong></td>
<td><strong>$33.73</strong></td>
<td></td>
</tr>
</tbody>
</table>

In Table 4.6, the Other Variable Operating Costs category is presented. These expenses vary in relation to the establishment’s production volume and include some of the following: Juvenile Alligator Cost, Salt, Packaging Costs, Legal Costs, Accounting costs, Insurance costs, etc. From all these inputs, the one that represents the most significant portion refers to Government Tagging Costs with a total of $3.82 per hatchling. The second biggest cost relates to Insurance costs with a total of $3.44 per hatchling. All these expenses are 100% in-state purchases. The subtotal of this category is of $19.51.
Table 4.6. Other Variable Operating Costs

<table>
<thead>
<tr>
<th>Input/Service Category</th>
<th>Input Value ($/hatchling)</th>
<th>Percent of Inputs Purchased in Louisiana (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juvenile Alligator Cost</td>
<td>$0.47</td>
<td>100.00%</td>
</tr>
<tr>
<td>Salt</td>
<td>$0.34</td>
<td>100.00%</td>
</tr>
<tr>
<td>Packaging Costs</td>
<td>$0.07</td>
<td>100.00%</td>
</tr>
<tr>
<td>Legal</td>
<td>$0.84</td>
<td>70.28%</td>
</tr>
<tr>
<td>Accounting</td>
<td>$0.91</td>
<td>74.84%</td>
</tr>
<tr>
<td>Insurance</td>
<td>$3.44</td>
<td>100.00%</td>
</tr>
<tr>
<td>Travel</td>
<td>$0.86</td>
<td>21.65%</td>
</tr>
<tr>
<td>Building Maintenance</td>
<td>$2.43</td>
<td>99.23%</td>
</tr>
<tr>
<td>Auto Maintenance</td>
<td>$0.68</td>
<td>100.00%</td>
</tr>
<tr>
<td>Equipment Repair</td>
<td>$2.13</td>
<td>95.89%</td>
</tr>
<tr>
<td>Miscellaneous Supplies</td>
<td>$1.30</td>
<td>96.44%</td>
</tr>
<tr>
<td>Property Tax</td>
<td>$0.83</td>
<td>100.00%</td>
</tr>
<tr>
<td>Telephone</td>
<td>$0.98</td>
<td>100.00%</td>
</tr>
<tr>
<td>Charitable Giving</td>
<td>$0.21</td>
<td>100.00%</td>
</tr>
<tr>
<td>Freight</td>
<td>$0.01</td>
<td>100.00%</td>
</tr>
<tr>
<td>Garbage</td>
<td>$0.02</td>
<td>100.00%</td>
</tr>
<tr>
<td>Advertising</td>
<td>$0.05</td>
<td>100.00%</td>
</tr>
<tr>
<td>Medicine</td>
<td>$0.11</td>
<td>100.00%</td>
</tr>
<tr>
<td>Research and Development</td>
<td>$0.01</td>
<td>100.00%</td>
</tr>
<tr>
<td>Government Tagging Costs</td>
<td>$3.82</td>
<td>100.00%</td>
</tr>
<tr>
<td>Government Permits</td>
<td>$0.02</td>
<td>100.00%</td>
</tr>
<tr>
<td><strong>Total Other Variable Costs</strong></td>
<td><strong>$19.51</strong></td>
<td><strong>100.00%</strong></td>
</tr>
</tbody>
</table>

Finally, Table 4.7 presents a summary of all the subtotals for all category inputs. Here, it is possible to identify that Hatchlings is the input category that represents the biggest portion of the expense total at $33.73 per hatchling. Second, Feed comes next with a total of $26.27. The Total Variable Costs were calculated by adding all the expense categories except for Fixed Costs, which resulted in a total of $113.61 per hatchling. Finally, by adding the Total Direct Costs and the Total Fixed Costs, I obtained Total Costs of $125.02 per hatchling.
One aspect that is important to mention is that those inputs, or services, that were likely being purchased directly from a manufacturer, were not applied retail margins. Retail margins allow for expenditures to be traced through retail, wholesale, and transportation industries back to the industries who manufactured the product. Therefore, by enabling retail margins for specific sectors, I appropriately allocate each dollar’s worth of spending to the producing industries and the associated margin sectors. However, not all industries/commodities have margins. These are only applicable in Industry Output scenarios when a retail or wholesale industry has been specified (Clouse, 2018). Since that is not the case for some of the expenses in these categories, margins have only been applied to the sectors listed in Table 4.8. All other inputs were assumed to be purchased directly from the manufacturer/producer.

Table 4.8. Retail Margin Sectors

<table>
<thead>
<tr>
<th>Input/Service Category</th>
<th>Sub Total of Expense Category ($/hatchling)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel/Gasoline</td>
<td></td>
</tr>
<tr>
<td>H-2A Food</td>
<td></td>
</tr>
<tr>
<td>Trucks</td>
<td></td>
</tr>
<tr>
<td>Tractors, Trailers, and other Auto-Type Equipment</td>
<td></td>
</tr>
<tr>
<td>Coolers and Freezers</td>
<td></td>
</tr>
<tr>
<td>Water Heater</td>
<td></td>
</tr>
<tr>
<td>Airboats</td>
<td></td>
</tr>
<tr>
<td>Fuel Boat</td>
<td></td>
</tr>
<tr>
<td>Salt</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous Supplies</td>
<td></td>
</tr>
</tbody>
</table>
4.3. Measuring Indirect/Induced Effects

The Indirect and Induced Effects section completes the second objective of this research by presenting the four modeling improvement strategies used to evaluate the economic contribution of the alligator industry in Louisiana. Here, the procedures for each of the techniques are described and then highlighted by their corresponding results. For all modeling strategies, IMPLAN is used for measuring indirect and induced effects. The baseline Input-Output model is the first strategy, which presents a traditional multiplier approach to calculating the indirect and induced effects. The second strategy introduces the Analysis-by-Parts approach using IMPLAN’s default RPCs (in-state spending) and using the RPCs obtained from the questionnaire. Finally, the editing of the production functions of Sector 14 is described. Each strategy presents a series of tables that display the results obtained from IMPLAN. Additionally, the following section will include a comparison of the tradeoffs of using each method and will comply with objective three of this research.

Moreover, for all modeling strategies, an IMPLAN model for the state of Louisiana was created. The model used 2019 data from Louisiana to create economic multipliers. Also, the model used the IMPLAN National Trade Flows approach for the model resulting IMPLAN RPCs. IMPLAN calculates these RPCs from evaluating the remaining local supply of a commodity after that commodity was exported outside of Louisiana based on commodity shipping data. IMPLAN’s Trade Flows approach consists of demonstrating the movement of goods and services between counties or user-defined regions made up of counties (IMPLAN, 2020c). Finally, the model adjusted the Multiplier Specification to households, governments, and corporations, resulting in their spending being considered Induced Effects.

In the following approach strategies, the following IMPLAN terminology is used: Commodity, Sector, Industry, Scenarios, Events, and Activities. A Commodity refers to a product or service produced by one or multiple industries. The term Sector relates to the 536
institutional units that make up the total economy. These have a digit code that corresponds to a NAICS Code description (e.g., Sector 14 (Animal Production, except Cattle and Poultry and Eggs). Furthermore, Industry refers to a group of businesses involved in the same or similar types of economic activity. In addition, a Scenario is the setting where all Activities are combined into groups for further analysis. Similarly, Events specify the economic transactions occurring in the local economy being analyzed, in terms of Type, Specification and Value. Finally, the Activities term relates to the collection of one or more Events (IMPLAN).

4.3.1. Approach Strategies

4.3.1.1. Baseline Single Sector (Multiplier Approach)

The most commonly used measure of economic contributions/impacts for an individual agricultural commodity is the Baseline Single Sector Approach. This approach consisted of applying the production value of the industry in a given year obtained from different administrative sources into the industry identified within the IMPLAN model. For alligators, IMPLAN’s Sector 14 (Animal Production, except Cattle and Poultry and Eggs), is the sector that includes alligator production. The procedure for calculating the direct contributions was estimated by multiplying the revenue per hatchling times the number of skins demanded/sold. Specifically, I use the Low and High Revenue per hatchling multiplied by the number of skins harvested for 2019 in the state of Louisiana. The procedures to obtain each of these parameters are explained below.

For the year 2019, the Louisiana Alligator Management Program 2019-2020 Annual Report showed that 438,575 alligator skins were harvested in the state of Louisiana. represent the most accurate number of alligators hatchlings raised, this study adjusted this number by the percentage of total juvenile alligators released back to the wild (10% of total alligators harvested) and the mortality rate (1.39%) (Louisiana Department of Wildlife and Fisheries,
The resulting number of live hatchlings in 2019 was estimated at 488,531 alligator skins, which is the number used in all modeling improvement strategies.

The two ranges known in this study as the “Low” and “High” were derived from analyzing skin prices. For this research, specific revenue information was not specifically asked in the questionnaire; however, some revenue information that was provided as additional information that the alligator producers decided to provide in the survey. Several of them provided prices that they were receiving for watch strap alligators and handbag sized alligators. In addition, data from expert opinion of a domestic tanner was also used to get price estimates for alligator skins. Estimates for prices by size class from information provided by farmers and the domestic tanner were compared. The lower price of the two estimates in each size class become the price for the low revenue estimate and the higher price the high revenue estimate.

Alligator skin prices were based on two factors: belly width and grade. Since average prices were based on a belly width range, (ranges are identified in the LDWF Alligator Management), to account for the estimation of average belly width of the alligator skin, this study identified the midpoint within each range of belly width range in number of centimeters. Also, it is important to take into consideration that the estimated price of skins had to be adjusted by the percent of skins that fall into the Grade 1 and Grade 2 category, since these are the skins tanneries commonly purchase and what almost all alligators sourced from Louisiana alligator farms grade. Grade 2 skins were adjusted downward 15% from the Grade 1 skin price based on a guided conversation with a domestic tanner of exotic skins. The average percent of skins that graded Grade 1 and Grade 2 in each size class were also identified from the guided conversation with the domestic tanner. After adjusting for the percent of skins that corresponded to the correct belly width range and grade, it was possible to estimate a low price and a high price. These results presented a Low Revenue per Hatchling of $164.17 and a High Revenue per Hatchling of $205.08. These prices proceeded to be adjusted for the total number of alligator
skins demanded (488,531). The Low Revenue per Hatchling multiplied by the number of skins resulted in a total of $80.2 million. The High Revenue per Hatchling adjusted by the number of skins resulted in approximately $100.2 million in total revenue.

After obtaining these necessary estimates, I proceeded to construct the two baseline models in IMPLAN. To import the necessary data into IMPLAN, the first step consisted of inputting the event values into the appropriate activity template Excel spreadsheet. (Templates allow for the creation and replication of model scenarios and create efficiencies in application of scenarios across multiple modeling improvement strategies.) The first model built was the Low Revenue approach and in the Industry Change tab, Sector 14 (Animal Production, except cattle and poultry and eggs) was the one inputted for the proper sector. Then, the Low Revenue per Hatchling of $164.17 was inputted as the Event Value. Finally, the Event Year is 2019 and the RP was chosen at 100% since the amount of alligator skins demanded corresponds to Louisiana only. Also, no Retail Margins were applied since the skins are being purchased directly from the farmer.

The second step involved creating the scenario where the contributions were analyzed. Once all parameters had been entered into the template spreadsheet it is imported as an “Activity” into IMPLAN’s model. Here, the Activity that was just created imports all the information that was inputted before in the spreadsheet. Subsequently, the procedure progressed to create a scenario titled “Baseline – Low Revenue Approach” where the Activity that was created was selected. The third and final step consisted of analyzing the selected Activity and the same process applied to the High Revenue approach. The results of the analyses are presented below.

Table 4.9 indicates the total economic contributions of growing 488,531 alligators 2019, for the state of Louisiana. The direct output was the starting point for this analysis. These contributions are the result of implementing the low and high revenue value for the Baseline
Single Sector Approach. Alligator farming in Louisiana generated a direct economic contribution of $80.2 million in farm revenue when using the Low Revenue per Hatchling approach. The business-to-business transactions resulting from local input purchases by the alligator industry resulted in an additional $12.8 million of output represented by the indirect effects. Furthermore, $48.9 million of induced output is supported by the spending of incomes and profits earned by employees and owners respectively. When analyzing the contributions with the High Revenue per Hatchling approach, farm level sales exceeded $100 million in output, equivalent to the revenue for the year of 2019. Additionally, the direct business to business spending in the supply chain generated a total of $16 million in indirect output. Finally, $61.2 million of induced output accounts for workers of suppliers purchasing more goods and services, or household spending.

Table 4.9. Summary of Output Contributions of the Baseline Single Sector Approach for Low and High Revenues.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Direct</th>
<th>Indirect</th>
<th>Induced</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline (Low Revenue Approach)</td>
<td>$80,201,270</td>
<td>$12,832,777</td>
<td>$48,998,791</td>
<td>$142,032,838</td>
</tr>
<tr>
<td>Baseline (High Revenue Approach)</td>
<td>$100,189,697</td>
<td>$16,031,068</td>
<td>$61,210,677</td>
<td>$177,431,443</td>
</tr>
</tbody>
</table>

4.3.1.2. Analysis-by-Parts (ABP – IMPLAN RPCs)

The ABP – IMPLAN RPCs approach consists of analyzing the contributions of an industry's spending (outlays) through multiple sectors when using IMPLAN’s default RPCs (in-state spending). For ABP, key sectors used for measuring this industry’s contribution were divided into the following categories: intermediate inputs, employee compensation, proprietor income, and household income spending. The approach is used when there is not a specific sector in IMPLAN dedicated to the industry that you are modeling. In the previous baseline
approach, Sector 14 represents an aggregation of several small agricultural commodities which results in IMPLAN’s default spending pattern not representing accurately any of the individual commodities in that sector due to aggregation bias. By including all the detailed spending allocation of revenue received to input purchases, employee wages, and farm profits, the ABP approach has also received the phrase “building a sector outside the model.” The multiple sectors that comprise the spending profile are the following: Feed, Utilities, Labor Costs, Fixed Costs, Hatchlings, Other Variable Operating Costs, and Proprietor Income. Additionally, it is important to mention that all contributions were adjusted for the Low and High Revenue approaches.

The elaboration of this ABP approach required having the available data of direct spending for each sector. Recalling the Direct Contribution section, the subtotal costs for each expense category were provided in Table 4.1 through Table 4.6. Using the spending pattern from each expense category helped to more accurately reflect the outlays of the alligator industry compared to the aggregate outlays from the baseline IMPLAN Sector 14. Additionally, it is crucial for this technique to mention that the proprietor income was added as one of the multiple sectors. Recall in Table 4.7 where the total cost for producing one hatchling was $125.53. The proprietor income was calculated by subtracting the total cost per hatchling from the Low and High Revenues per Hatchling. This resulted in a Low Net Margin of $39.91 per hatchling and a High Net Margin of $80.82 per hatchling. This sector represented the excess revenue over explicit production cost of the owner-operated businesses.

Another aspect to take into consideration with this approach was using IMPLAN’s default RPCs. When constructing each individual activity per expense category in the software, IMPLAN provides the option to change the Local Purchase Percentage (LPP) to either the default SAM Model Value, to 100%, or to use the user’s Regional Purchase Coefficient. The Local Purchase Percentage indicates to the software what portion of the input is spent locally.
and affects the local region and should be applied to the multipliers. IMPLAN’s default SAM Model Value (default RPCs) is typically used when local spending for an input is unknown. IMPLAN uses information about in-state commodity production controlled for the percentage of commodities that are shipped outside the state to meet out-of-state demand. For this research, two modeling improvement strategies were incorporated with two scenarios: 1) applying IMPLAN’s default model RPCs to alligator outlays, and 2) applying alligator farmer survey-derived RPCs to alligator outlays.

The following discussion will explain the procedure of how the models were constructed in IMPLAN. After acquiring all the necessary information to construct the analyses, the procedure advances to set up the activities that reflect the spending pattern of alligator farming for intermediate inputs, employee compensation, and household income spending. First, intermediate input purchases are entered using the commodity change type of activity in its corresponding activity template spreadsheet. For each input category, an individual activity template was constructed. In the template spreadsheet, I proceeded to add the corresponding IMPLAN commodity sector code for each input within the expense category. A bridge table identifying each detailed survey sector and the corresponding IMPLAN sector is provided in the Appendix. Next, the individual cost for each input was recorded in the event value cell, and 2019 was computed for the event year. For the inputs corresponding to employee compensation and household income spending, the procedure for recording the input levels remain the same but in the activity template, they must be entered in the Labor Income Change activity type and Household Income Change activity type, respectively.

Once importing the template into IMPLAN, a new activity was created corresponding to the data inputted and it was proceeded to change the LPP for all inputs to IMPLAN’s default SAM model value, which adjusted the purchase coefficients to IMPLAN-derived local spending percentages based on the trade flow approach. For those commodities listed more than
once, or that pertained to the same commodity sector code, the expense values were combined into one event. Additionally, since the proprietor income was adjusted for the Low and High Revenue per Hatchling, the results are presented as Total Low Revenue Effects and Total High Revenue Effects.

Furthermore, to analyze each expense category individually, it was necessary to create a scenario for each. A new scenario was named corresponding to the expense level and the relevant activities were selected. The final step involved clicking on “Analyze Single Region” and the results were computed and displayed in IMPLAN. Table 4.10 highlights the results for the economic contributions of alligator farming in the state of Louisiana using an Analysis-by-Parts method with IMPLAN’s default Regional Purchase Coefficients. The direct output was the starting point for this analysis.

Using the ABP – IMPLAN’s RPCs approach, alligator farming in Louisiana generated a total economic contribution of $98.8 million to the Louisiana economy under the Low Revenue assumption. When analyzing contributions with the High Revenue assumption, the alligator industry generated $120 million to the Louisiana economy including indirect and induced effects. The direct output contributed $41 million in revenue when aggregating all sectors that comprise the industry and using the Low Revenue proprietor income. The direct contribution when using the High Revenue proprietor income generated $53.4 million in output sales to the industry. Not surprisingly, the proprietor income for both the Low and High Revenue approach were the categories that generated the highest contributions in all effects except for the indirect effects.

Of the total expense categories, the subsectors that generated the highest direct contribution to the alligator industry output were Hatchlings and Other Variable Operating Costs with $11.7 million and $5.8 million respectively. Additionally, representing the indirect
effects, the two sectors that produced the highest contribution in business-to-business transactions from local input purchases were also Hatchlings and Other Variable Operating Costs with $6.4 million and $3.4 million respectively. Finally, the two sectors that represent the highest input share for household spending were Labor Costs and Hatchlings with $16.1 million and $6.9 million respectively.

Table 4.10. Summary of Output Contributions per Expense Category using IMPLAN’s default RPCs.

<table>
<thead>
<tr>
<th>Expense Category</th>
<th>Direct</th>
<th>Indirect</th>
<th>Induced</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td>$4,728,852</td>
<td>$2,105,105</td>
<td>$1,177,101</td>
<td>$8,011,058</td>
</tr>
<tr>
<td>Utilities</td>
<td>$2,469,418</td>
<td>$1,247,632</td>
<td>$1,432,002</td>
<td>$5,149,052</td>
</tr>
<tr>
<td>Labor Costs</td>
<td>$111,338</td>
<td>$25,465</td>
<td>$16,167,281</td>
<td>$16,304,084</td>
</tr>
<tr>
<td>Fixed Costs</td>
<td>$4,077,906</td>
<td>$1,210,352</td>
<td>$3,525,894</td>
<td>$8,814,151</td>
</tr>
<tr>
<td>Hatchlings</td>
<td>$11,776,069</td>
<td>$6,407,218</td>
<td>$6,930,819</td>
<td>$25,114,106</td>
</tr>
<tr>
<td>Other Variable Operating Costs</td>
<td>$5,838,047</td>
<td>$3,497,632</td>
<td>$4,754,574</td>
<td>$14,090,254</td>
</tr>
<tr>
<td>Proprietor Income (Low Revenue Approach)</td>
<td>$12,092,277</td>
<td>$1,934,851</td>
<td>$7,387,750</td>
<td>$21,414,878</td>
</tr>
<tr>
<td><strong>Total Low Revenue Effects</strong></td>
<td><strong>$41,093,906</strong></td>
<td><strong>$16,428,255</strong></td>
<td><strong>$41,375,422</strong></td>
<td><strong>$98,897,582</strong></td>
</tr>
<tr>
<td>Proprietor Income (High Revenue Approach)</td>
<td>$24,490,519</td>
<td>$3,918,658</td>
<td>$14,962,429</td>
<td>$43,371,607</td>
</tr>
<tr>
<td><strong>Total High Revenue Effects</strong></td>
<td><strong>$53,492,148</strong></td>
<td><strong>$18,412,062</strong></td>
<td><strong>$48,950,101</strong></td>
<td><strong>$120,854,311</strong></td>
</tr>
</tbody>
</table>

4.3.1.3. Analysis-by-Parts – Survey RPCs

The ABP – Survey RPCs approach consists of replicating the same process as the previous ABP approach using default IMPLAN RPCs. The only difference in the procedures occurs when changing the Local Purchase Percentage (LPP) to the user’s Regional Purchase Coefficients. In the Direct Contribution Results section, Table 4.1 through Table 4.6 display the RPCs as the “Percent of Inputs Purchased in Louisiana” obtained from the questionnaire. Table 4.11 demonstrates the results for the economic contributions of alligator farming in the
state of Louisiana using an Analysis-by-Parts method with the survey-derived RPCs. The direct output remained the starting point for this analysis.

The approach identified that alligator farming generated a total economic contribution of $137 million to the Louisiana economy when implementing the Low Revenue approach. When analyzing contributions with the High Revenue approach, it was revealed that the industry had produced a total economic contribution of $172 million to the Louisiana economy including indirect and induced effects. The direct output contributed $63.3 million in revenue, when aggregating for the Low Revenue proprietor income. When using the High Revenue proprietor income, output sales contributed $83.3 million in revenue to the alligator farming industry. In this approach, the proprietor income remained the most significant input for the direct effects in both the Low and High Revenue approaches. However, the indirect and induced effects illustrate different results. Hatchlings was the subsector that contributed the most significant amount of dollars to local input spending with $8.2 million represented by the indirect effects. Following, the Proprietor Income, using the high prices, represented a total $6.3 million of the total inter-industry purchases of the alligator industry. In the induced effects, the Proprietor Income (High Revenue approach) provided the most considerable contribution to the alligator industry with $24.1 million in income to owners. Additionally, Labor Costs represented the second most substantial contribution to the industry with $13.3 million supported by employee’s personal consumption.
Table 4.11. Summary of Output Contributions per Expense Category using the Survey obtained RPCs.

<table>
<thead>
<tr>
<th>Expense Category</th>
<th>Direct</th>
<th>Indirect</th>
<th>Induced</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td>$11,184,789</td>
<td>$4,988,333</td>
<td>$2,802,546</td>
<td>$18,975,669</td>
</tr>
<tr>
<td>Utilities</td>
<td>$4,345,645</td>
<td>$2,092,935</td>
<td>$2,499,965</td>
<td>$8,938,545</td>
</tr>
<tr>
<td>Labor Costs</td>
<td>$128,745</td>
<td>$28,258</td>
<td>$13,300,956</td>
<td>$13,457,959</td>
</tr>
<tr>
<td>Fixed Costs</td>
<td>$4,324,652</td>
<td>$1,287,088</td>
<td>$3,662,328</td>
<td>$9,274,068</td>
</tr>
<tr>
<td>Hatchlings</td>
<td>$15,828,338</td>
<td>$8,220,762</td>
<td>$9,225,740</td>
<td>$33,274,840</td>
</tr>
<tr>
<td>Other Variable Operating Costs</td>
<td>$8,013,520</td>
<td>$4,480,086</td>
<td>$6,321,864</td>
<td>$18,815,471</td>
</tr>
<tr>
<td>Proprietor Income (Low Revenue Approach)</td>
<td>$19,495,151</td>
<td>$3,119,364</td>
<td>$11,910,519</td>
<td>$34,525,034</td>
</tr>
<tr>
<td><strong>Total Low Revenue Effects</strong></td>
<td><strong>$63,320,840</strong></td>
<td><strong>$24,216,827</strong></td>
<td><strong>$49,723,919</strong></td>
<td><strong>$137,261,585</strong></td>
</tr>
<tr>
<td>Proprietor Income (High Revenue Approach)</td>
<td>$39,483,578</td>
<td>$6,317,655</td>
<td>$24,122,406</td>
<td>$69,923,638</td>
</tr>
<tr>
<td><strong>Total High Revenue Effects</strong></td>
<td><strong>$83,309,267</strong></td>
<td><strong>$27,415,118</strong></td>
<td><strong>$61,935,805</strong></td>
<td><strong>$172,660,190</strong></td>
</tr>
</tbody>
</table>

4.3.1.4. Production Function Editing

The following section introduces a discussion of the procedure used for editing the production functions of IMPLAN’s Sector 14 (Animal Production, except Cattle and Poultry and Eggs). The production function editing approach consists of customizing an existing IMPLAN industry where the intermediate input purchases from the original sector are removed, or in this case disaggregated, and replaced with this study's corresponding inputs. The total output value was then applied to the aggregated sector in IMPLAN that represented exclusively alligator production (similar to the baseline multiplier approach). Likewise, two models were created to represent both the Low and High Revenue approaches.

The process for editing the productions functions can be summarized in the following five steps: 1) customizing Study Area Data, 2) modifying Commodity Production, 3) editing the Industry Production, 4) setting up the Activities, and finally 5) running the Scenarios. The
key elements required to operate this process consist of having the following available information: Total Employment, Total Output, Employee Compensation, Proprietor Income, Property Taxes, and Intermediate Inputs. The process for this approach remained consistent for both the Low and High Revenue approaches.

Before initiating the creation of the new industry, it is important to mention that the model construction options within IMPLAN’s User Preferences tab should be set to “Build model through Social Accounts.” This allows for rebalancing of the model (industry production equals industry outlays for all sectors) before calculating multipliers. To begin with, the first step consists of locating the Customize bar and selecting the Study Area Data option, which will open a screen with three main windows: Industry List, Employment and Output, Value Added. The Industry List column comprises the list of all 536 sectors that can be modeled in IMPLAN, from which Sector 14 (Animal Production, except Cattle and Poultry and Eggs) is the one that must be selected and renamed to “Alligator Production.” Next, the option “Zero Out Industry” is selected which will delete the previous information for the aggregate levels of Sector 14. This eliminates all the IMPLAN economic data from Region 14 in the model. (However, it is important to observe that this option does not delete the previous inter-industry relationships of Sector 14, but this will be addressed in step three.) It should be noted that the “Edit Totals” option was selected in order to input the primary data for totals since the data calculated for the alligator industry was in total dollar value and not in per-person value.

The second portion of the screen shows the Employment section. This section refers to the total number of jobs provided by the industry sector to the Study Area, which for the Alligator industry was identified to have from the survey 243 total Full-Time and Part-Time workers. After entering this information, available primary data for Output, Employee Compensation, Proprietor Income, and Tax on Production and Imports was entered based on the respective. Total Output was defined in the Baseline approach for both the Low and High
Revenue approaches. For the Low Revenue model, the value of production entered was of $80,201,270 (original baseline). The next value to be entered was Employee compensation with a total of $11,954,567. This was calculated using the Low Revenue per Hatchling ($164.17) and subtracting the Low Net Margin per hatchling ($39.91) minus the property taxes per hatchling ($0.84) and the total of all intermediate inputs ($98.96) resulting for a total of $24.47, which adjusted for the total number of skins demanded (488,531) resulted in $11,954,567 in benefits to employees. Furthermore, the Proprietor Income value for the Low Revenue approach was entered with a total of $19,495,150, which was defined in the ABP – Survey RPCs approach. Finally, the last component to enter was the Property Taxes with a total of $405,856, which was calculated by multiplying the property taxes per hatchling ($0.83) by the total number of skins.

For the High Revenue model, the Output value entered was $100,189,701, previously estimated in the Baseline approach. Proprietor Income value for the High Revenue approach was entered with a total of $39,483,579, which was defined in the ABP – Survey RPCs approach. All other categories were the same with the low revenue approach. One important aspect that must be highlighted is that after each step, the model must be rebuilt through all the steps of the social accounts since the changes to the production functions unbalance the Regional Transactions Tables within IMPLAN. In other words, the rows (industry production value) are not equal to the columns (industry outlays); therefore, by reconstructing, the model is re-balanced and further edits can be performed.

The second step of the production functions editing refers to the modification of Commodity Production. This portion of the procedure comprises locating once again the Customize bar and selecting the Commodity Production option, which will open a screen with the Industry List column. By selecting Sector 14 from the list, it is possible to identify the commodities that are produced by Sector 14 making it possible to alter the resulting production
commodity mix. Some industries produce multiple commodities. IMPLAN’s default commodity mix includes the following commodities: Animals Products (Except Cattle and Poultry and Eggs), Forest, Timber, and Forest Nursery Products, Support Activities for Agriculture and Forestry, and finally Other Amusement and Recreation. Since alligator production falls under the Animal products (Except Cattle and Poultry and Eggs) commodity, I proceeded to adjust the default commodity mix. This means that those commodities produced by the Animal Products sector are in fact reflecting Alligator Production. After completing this part, I reconstructed the model once again and repeated the same process when adjusting the commodity mix for the High Revenue model.

The third step of the process entails editing Industry Production. This step initiates by locating the Customize bar and selecting the Industry Production option, which opens the Industry list. In this column, the Alligator Production industry is selected, and all the intermediate inputs of the previous Sector 14 (Animal Production, except Cattle and Poultry and Eggs) are shown. To adjust these intermediate inputs to the Alligator Production sector, the existing inputs in IMPLAN that are not included in the alligator survey have their coefficient changed to zero.

Furthermore, to define the production function for the alligator industry, it was necessary to calculate the Gross Absorption Coefficients (GACs) for each of the intermediate inputs and the Total Gross Absorption. The GACs represent the percentage of output that is distributed to the purchase of a specific commodity in an industry’s production function. On the other hand, the Total Gross Absorption is the percentage of output that is spent on all intermediate inputs for the industry (IMPLAN, 2013b). Total Gross Absorption value is calculated by dividing the total intermediate inputs ($48,345,698) by the Total Low Revenue ($80,201,273) resulting in a coefficient of 0.602 for the Low Revenue approach. GACs were calculated by first dividing the individual cost of that input by the intermediate inputs per
hatchling ($98.96). The percentage resulting from this calculation was then multiplied by the coefficient of Total Gross Absorption (0.602) to provide for the coefficient of each specific input. For the High Revenue approach, the procedure was consistent and the coefficient for Total Absorption Value remained the same. After obtaining coefficients for all inputs, the procedure progressed to edit the existing commodities to correspond with the correct commodity sector and proper GAC from the study’s intermediate inputs. For the High Revenue model, the procedure remained the same using the same GACs and respective commodity sectors.

The last two steps of the production function editing approach included setting up the activities and running the scenarios. When setting up the activities, the process from the previous strategies remained the same; however, in this case, the direct contributions were inputted directly into the activity. Once the new activity was created, it was proceeded to select the new Sector 14 (Alligator Production). In the industry sales portion, the direct contribution of the Low Revenue approach was applied ($80,201,273) and the event year remained 2019. Additionally, the LPP was set to 100% since the demand of skins was exclusive to Louisiana. In the fifth and final step, the scenario was created and the activity representing the Low Revenue approach with based on the editing of the production function was selected to be analyzed. Moreover, the results were computed and displayed in IMPLAN. Table 4.12 demonstrates the results for the economic contributions of alligator farming in the state of Louisiana using the production function editing approach. The direct output remained the starting point for this analysis.
Table 4.12. Summary of Output Contributions using the production functions editing approach.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Direct</th>
<th>Indirect</th>
<th>Induced</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Revenue per Hatchling</td>
<td>$80,201,273</td>
<td>$43,430,944</td>
<td>$57,857,288</td>
<td>$181,489,506</td>
</tr>
<tr>
<td>High Revenue per Hatchling</td>
<td>$100,189,701</td>
<td>$43,934,678</td>
<td>$82,780,150</td>
<td>$226,904,529</td>
</tr>
</tbody>
</table>

4.4. Comparison of Modeling Improvement Strategies

The following section includes a comprehensive analysis of the comparison of the tradeoffs of using each modeling improvement strategy and addresses objective three of this study. Additionally, it will address IMPLAN’s coding of the contribution results and will adjust these results for comparison using classical input-output applications of the Leontif Inverse. By implementing this approach, it was possible to provide a better explanation of how IMPLAN computes the direct, indirect, and induced effects for each modeling improvement strategy. Similarly, a sensitivity analysis is presented and will help display which strategy leverages the most available local information.

To appropriately compare these improvement strategies, one needs to harmonize the IMPLAN output according to the standard Input-Output methodology used for measuring effects within a regional economic contribution or impact. The way to do this is to look back at the Leontif Inverse represented by Equations 3.8. – 3.11. in Chapter 3. The comparison procedure consisted of approximating the Leontif Inverse matrix through the Power Series approximation which is represented by Equation 4.1.

\[ I+A+A^2+A^3+\ldots+A^n \]  

(4.1)

This approach takes the Output Effects and distributes them in the Identity Matrix, or I, which represents the Final Demand, or Initial Effects. In the case of this research, the demand is for alligator skins; therefore, each dollar of alligator skins demanded represents I. In this model,
the revenue affiliated with alligator skins was identified. In the Low Revenue approach, it was a total of $80,201,270 and for the High Revenue approach it was a total of $100,189,697. In Table 4.13, it is possible to observe the Power Series approximation where I refer to the Final Demand, A represents the first round of spending in the regional economy (state of Louisiana) and the combination of the Indirect (business to business spending) and the Induced (household and other institutional spending such as governments and enterprises) Effects. Finally, the sum of the Initial, Direct, Indirect and Induced effects results in the Total Effects. The Output Multiplier is then calculated as Total Effects divided by the Final Demand, or Initial Effects (I).

It is important to realize that depending on the modeling improvement strategy that one applies to IMPLAN, it will generate results with different titles such as Direct, Indirect, Induced, and Total Effects. Now, while sometimes they are in the appropriate columns according to classical effects measurement, sometimes they are not, according to the Input-Output method. Thus, in certain cases where the data was used to create a multiplier, it is interpreted incorrectly. To correct misinterpretation, Table 4.13 takes each modeling improvement strategy and allocates each result to its appropriate effect based on traditional Input-Output methodology. In this way, it will be possible for Output Multipliers that can be compared across different modeling improvement strategies.
Table 4.13. Comparison of Results from Modeling Improvement Strategies.

<table>
<thead>
<tr>
<th>Modeling Improvement Strategies</th>
<th>I Final Demand/Initial Effects</th>
<th>A Direct Effects</th>
<th>$A^2 + A^3 + \ldots + A^n$ Indirect + Induced Effects</th>
<th>I+(A^2 + A^3 + \ldots + A^n) Total Effects</th>
<th>((I+(A^2 + A^3 + \ldots + A^n))/I) Output Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low Revenue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline Single Sector</td>
<td>$80,201,270$</td>
<td></td>
<td>$61,831,568$</td>
<td>$142,032,838$</td>
<td>1.77</td>
</tr>
<tr>
<td>ABP - IMPLAN RPCs</td>
<td>$80,201,270$</td>
<td>$41,093,906$</td>
<td>$57,803,677$</td>
<td>$179,098,853$</td>
<td>2.23</td>
</tr>
<tr>
<td>ABP - Survey RPC</td>
<td>$80,201,270$</td>
<td>$63,320,840$</td>
<td>$73,940,746$</td>
<td>$217,462,855$</td>
<td>2.71</td>
</tr>
<tr>
<td>Production Function editing</td>
<td>$80,201,273$</td>
<td></td>
<td>$101,288,232$</td>
<td>$181,489,506$</td>
<td>2.26</td>
</tr>
<tr>
<td><strong>High Revenue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline Single Sector</td>
<td>$100,189,697$</td>
<td></td>
<td>$77,241,746$</td>
<td>$177,431,443$</td>
<td>1.77</td>
</tr>
<tr>
<td>ABP - IMPLAN RPC</td>
<td>$100,189,697$</td>
<td>$53,492,148$</td>
<td>$67,362,163$</td>
<td>$221,044,009$</td>
<td>2.21</td>
</tr>
<tr>
<td>ABP - Survey RPC</td>
<td>$100,189,697$</td>
<td>$83,309,267$</td>
<td>$89,350,923$</td>
<td>$272,849,887$</td>
<td>2.71</td>
</tr>
<tr>
<td>Production Function editing</td>
<td>$100,189,701$</td>
<td></td>
<td>$126,714,828$</td>
<td>$226,904,529$</td>
<td>2.26</td>
</tr>
</tbody>
</table>

For the discussion of the following table, the Low Revenue approach will be discussed, and the interpretation will be consistent to the High Revenue approach. In the Baseline Single Sector approach, where all the demand was applied to IMPLAN’s Sector 14, if no other information was available other than the total amount of revenue that was generated in a year, it is possible to take that number and input it in IMPLAN in the same sector, and it will result in Total Effects of $142 million. When taking these Total Effects and dividing them by the Final Demand/Initial Effects, it results in an Output Multiplier of 1.77. This indicates that for every one dollar change in demand for alligator skins, there is a total change in Output across all sectors of the Louisiana economy of $1.77. This includes the original one dollar in demand for alligator skins, plus an additional $0.77 cents of spending across all other sectors in the Louisiana economy.

It is important to mention that by observing the earlier tables that correspond to IMPLAN’s software reports, it is evident that IMPLAN applies the $80.2 million over to the Direct Effects category. However, Direct Effect spending, which relates to the A matrix (Technical Coefficients Matrix), represents the detailed input spending required to reproduce
alligator skin inventories demanded from the initial effects. The purpose of collecting primary data through the questionnaire was to identify how alligators are produced including all the detailed inputs, which is what is represented by the Direct Effects. As a result, to be consistent with traditional Input-Output methodology, the $80.2 million was relocated into the Initial Effects. Also, what is reported in IMPLAN as Indirect and Induced Effects in the baseline model is actually the combination of the Direct Effects (the first round of spending in order to replicate the alligator skins) plus all the other spending throughout the economy. Finally, if this study had not received funding to collect primary data, the Output Multiplier and Total Effects would have been limited to this baseline strategy.

On the other hand, because specific information on detailed spending (feed, utilities, labor costs, fixed costs, etc.) was collected through the survey, it was possible to perform the Analysis-by-Parts approach. When using ABP, one enters the actual first round of spending, or Direct Effects. The $41,093,906 that pertain to the Direct Effects, is the sum of the spending that was calculated, as well as the proprietor income that was estimated adjusted for the amount of local spending using IMPLAN’s default RPCs. In other words, this result was correctly measured since it was reported as Direct Effects in IMPLAN. Further, the additional rounds of spending, Indirect and Induced Effects, are also correctly measured. The problem originates when IMPLAN calculates the Total Effects as the result of the sum only the Direct Effects and the Indirect and Induced Effects and failing to add the Initial Effects, or Final Demand, for the demand of skins. To be consistent with the traditional Input-Output method, the Initial Effects were added back and were added under the Initial Effects cell value for both ABP approaches (in italics). In the ABP – IMPLAN RPCs approach, after making this adjustment, the Total Effects summed to $179 million. Then, to calculate the Output Multiplier I took the Total Effects and divided it by the Initial Effects, resulting in a multiplier of 2.23. This means that for every dollar of demand for alligator skins, there is a total change in Output of $2.23 across all
sectors of the Louisiana economy. This includes the original dollar of demand for alligator skins plus an additional $1.2 of additional spending across all sectors of the Louisiana economy. This means that the additional value of having the available survey data can be appreciated when IMPLAN’s baseline underestimates the Output Effects by $0.46 cents (2.23-1.77). This represents the difference in spending effects by knowing the more accurate distribution of direct spending from the questionnaire. By realizing that the Baseline Single Sector approach uses the same RPCs as in the ABP – IMPLAN RPCs approach, the value of having just the more accurate alligator input spending from the survey is $0.46 cents per dollar of output.

The next modeling improvement strategy consists of incorporating the survey RPCs with the accurate distribution of spending to the sectors. Since this method applies to an ABP approach, the process of adding back the Initial Effects was repeated to be consistent with the traditional Input-Output method. In this improvement strategy, by using the accurate distribution of spending and the survey-based proportion of local spending, the Direct Effects increased approximately 53% from the Baseline, resulting in a total of $63,320,839, which represents the sum of the spending, as well as the proprietor income that was estimated for both Low and High Revenues. This means that when I adjust for the amount of spending that is occurring locally from our survey data, there are higher percentages than in the default IMPLAN data. As a result, the Direct Effects are much higher, which resulted in a spillover effect into a higher Indirect and Induced Effects. Consequently, that makes the Total Effects larger, using the survey RPCs as opposed to the IMPLAN RPCs. The Output Multiplier increased as well by almost half a dollar ($0.48 cents).

From this analysis, it can be observed step-by-step how the additional information impacts the Output Multiplier. Using the detailed spending patterns of alligator farmers increased the Output Multiplier of the Baseline approach by $0.46 cents. Additionally, the difference between using additional output spending effects in the multiplier based upon the
increased accuracy of local spending from our survey, compared to just using IMPLAN by default, increased the multiplier by an additional $0.48 cents (2.71-2.23).

For the production functions editing approach, the distribution of spending was changed based on the survey, just as in the ABP approaches. However, instead of doing it outside of the model as Final Demand (ABP approaches), it was re-allocated inside the model (Sector 14) and then the multipliers were re-calculated. One aspect that was not possible to perform in this approach was to edit the RPCs inside the model. This meant that it was not possible to go into this model and change the spending patterns of those sectors within the model. Instead, they were defaulted back to the IMPLAN RPCs. As a result, two corresponding errors using ABP and the production function editing approach were identified. In the ABP approach, with primary data, it is known that the Direct Effects should be $63 million, but we are only going to have $41 million in the production function editing approach. What happens is that we were able to account more accurately for the Indirect and Induced Effect spending because in succeeding rounds by spending, demanded products of the Alligator industry are going to be produced using the correct production functions. In essence, the production function is correct for ABP in the Direct Effects but defaults back to the suboptimal IMPLAN production functions in the Indirect and Induced Effects since the model was not changed. In the production function editing approach, the changes to the production functions were correct but the local spending used IMPLAN’s default RPCs since this option was not possible within IMPLAN. On the other hand, the accuracy of the production functions was improved for Sector 14 for the surrounding Indirect and Induced Effects; therefore, what should be expected is whether the relative importance of that accuracy impacts the Output Multiplier. When analyzing the multiplier, it is possible to identify this by comparing the ABP – IMPLAN RPCs, the ABP – Survey RPCs and the production function editing approaches. If the ABP – IMPLAN RPCs Multiplier is compared to the production function Multiplier, I see that when equivalent RPCs are used, there
is a slight increase using the production functions editing approach. Moreover, there is an additional increase of $0.03 cents of Indirect and Induced Effects that are added by having an accurate production function in the succeeding rounds of spending ($A^2+A^3+\ldots+A^n$). However, that is overshadowed in magnitude by having the correct RPCs at the Direct Effect stage with a 2.71 Multiplier. In other words, for the alligator production sector, the importance of getting the proportion of the Direct Effects spending that is in Louisiana accurate is more important to the size of the multiplier than getting the production function accurate for succeeding indirect and induced rounds of spending.

This can similarly be seen when reviewing the High Revenue approach. One important aspect to highlight is that in the Baseline High Revenue approach, the Multipliers need to be exactly the same since only the values for all modeling improvement strategies are changing. In the ABP – IMPLAN RPCs High Revenue approach, the Multiplier is slightly smaller than the Low Revenue, which is somewhat attributable to how IMPLAN takes the Final Demands inputted and how it handles the models and where rounding effects occur such that they could be off by a few cents. In the Survey RPCs High Revenue approach, the Multipliers are exactly the same, only the values have a difference in scale. Finally, in the production function editing approach, the same tendency was observed with the Multipliers remaining exactly the same.

In conclusion, what the comparison analysis demonstrates is that for the alligator industry, having additional information about the distribution of spending does increase the size of the multiplier by 26%. However, by combining the more accurate distribution of spending and the location of that spending, there is an increase in the Multiplier by 53%. In other words, having the survey information from the alligator farmers resulted in a 53% increase in the Output Multiplier as opposed to not having any of the information. From the state of point of the alligator industry, I measured an additional $75.4 million in Output Effects when comparing the Total Effects resulting from the Baseline to the Total Effects from the ABP – Survey RPCs.
Finally, when analyzing the production function editing approach, arranging the production functions within Section 14 provides only marginal value for the alligator industry as oppose to constructing that sector outside of the model through ABP and using default IMPLAN RPCs. In essence, the value was only $0.03 cents of additional effects for every dollar of additional alligator skin demanded.

It should be noted that part of the reason that this is so minimal is that there are not a lot of other sectors of the Louisiana economy (either businesses or households) that are going to demand alligator skins because alligator skins are not in a lot of the other business production processes in the state. Neither do households and government institutions buy many alligator skins directly. If this same approach was to be applied to a sector where there was a lot more interlinkages with other industries, or greater demand from households, a much higher multiplier would be observed for the production function editing strategy. In this case, the multiplier would narrow the gap between it and the use of local spending.
CHAPTER 5. SUMMARY

The alligator industry in Louisiana has not had a study in thirty years that has measured its economic contribution. The industry has changed structurally over that period and it produces more alligator skins concentrated in a smaller number of producers. With current threats to the industry through potential bans on alligator sales in states like California, the importance of these studies for the industry are more important now than ever.

My first objective was to measure the contributions to the alligator industry to the Louisiana economy. I constructed a questionnaire that asked alligator farmers in person about detailed spending from the acquisition of eggs through the raising and slaughtering of those alligators. I then evaluated the cost per hatchling based upon total hatchlings needed to produce the amount of skins harvested in Louisiana for 2019. I identified the direct contribution to be $80,201,270 based on a Low Revenue approach for class sizes for alligator skins. When analyzing the High Revenue approach, I identified a direct contribution of $100,189,697. The highest expense categories per hatchling included Hatchlings ($33.73), Feed ($26.27), and Labor Costs ($25.18).

In accomplishing the second objective, I evaluated three modeling improvement strategies over the baseline model that was provided in IMPLAN. I used the survey data to augment the baseline IMPLAN model. When I evaluated using all data including an improvement in the distribution of the spending patterns in the use of local in-state spending proportions provided in the survey, I found that when using the ABP – Survey RPCs Modeling Improvement Strategy, the total economic contributions ranged from $217 million to $272 million. As a result, this generated an Output Multiplier of 2.71.

For the third objective, I completed a comprehensive analysis of the comparison of the tradeoffs of using each modeling improvement strategy and adjusted IMPLAN results to the
traditional Leontief Inverse interpretation of effects. I found that for the alligator industry, having additional information about the distribution of spending increases the size of the Baseline Multiplier by 26%. However, by combining more accurate distribution of spending and the location of that spending, there is an increase from the Baseline Multiplier strategy of 53%. From the point of view of the alligator industry, I measured an additional $75.4 million in Output Effects. In the production function editing approach, the value of editing the production functions within IMPLAN was only $0.03 cents of additional effects for every dollar of alligator skin demanded.

5.1. Limitations and Next Steps

One of the limitations of this study was that it was only possible to use a one-year snapshot of data from the alligator industry. If multiple years of data would have been available, a more historical analysis would have been ideal to measure the average economic contributions. However, 2019 was the simplest year of data to collect for alligator farmers since at the time it was the most recent information for revenue and input costs. Additionally, the primary data available for the year 2019 can be considered reasonable estimates for an average year of production since 2020 presented unusual measurements for all expense categories and revenue due to demand destruction from the pandemic.

The second limitation consisted of the inability of leveraging the local spending patterns to augment the Indirect and Induced Effects of the model. While having both a correct distribution of input spending and the percentage of that spending that applied within the state of Louisiana, the existing improvement strategies could only be applied to the direct spending effects. Similarly, because of the limitations of the IMPLAN modeling software, those could not be provided in the Indirect and Induced Effects.

Another limitation that must be highlighted is that while the survey asked several detailed questions regarding costs, further detailed questions could have been asked. There was
a tradeoff of survey length to cost detail and this incurred in an inability to ask the level of detailed information that might have been required to more appropriately assign certain expense categories to additional IMPLAN sectors.

Next steps to extend the application of this model would include exporting the model out of IMPLAN. By doing this, one can attempt to build one’s own Leontief Inverse Matrix in a program like Microsoft Excel. Here, the researcher could aim to adjust the local spending proportions in the model and rebalance outside of the IMPLAN software and further calculate multipliers. This is one potential method of applying the local spending patterns to complement the Indirect and Induced Effects of the model.

Additionally, another opportunity for further research would be to include the additional parts of the alligator supply chain including meat, wild alligators, tourism, and tanning. If an additional questionnaire is implemented to obtain primary data for the rest of the components of the supply chain, it would be possible to replicate a more complete model of the industry.
APPENDIX A. Louisiana Alligator Supply Chain Survey

Conducted by the Louisiana State University Agricultural Center
Terms of Participation

**Project Title:** Economic Contribution of the Alligator System to the Louisiana Economy

**Purpose and Study Procedures:** The purpose of this survey is to measure the economic contribution that alligator farmers from egg collection through processing of skins contribute to the Louisiana economy. The researchers will collect data from Louisiana alligator farmers through this questionnaire on input levels, costs, and related production revenue of alligator farms in the state of Louisiana in order to measure the direct contribution and multiplier effects to the state economy. Those selected to participate in this study were chosen from those individuals soliciting licenses/tags through the Department of Wildlife and Fisheries. As a Louisiana alligator farmer that meets these qualifications, we invite you to participate in this research study by completing the following survey.

**Risks and Benefits:** This study will be conducted on site of individual alligator farms. The following questionnaire will require approximately 30 to 45 minutes to complete. There is no compensation for responding. The risk for your participation in this survey is expected to be minimal as a process for maintaining your anonymity in responses is being followed. No personal identifiable information will be included with responses. Further, your individual responses will be reviewed in context with all other farmer responses to evaluate if your anonymity could potentially be comprised from your responses to individual questions. The researchers will further protect anonymity by taking steps such as dropping question responses, combining data from multiple questions, and/or creating response ranges. This further processing of responses will further mitigate the risk if the researchers are legally compelled to provide individual response data.

It is expected that results from this research will benefit those responding by helping the industry measure its economic contribution for purposes of market promotion and sustainability. Copies of this survey and your completed responses will be provided to the institutional officials that will oversee this research, Dr. J. Matthew Fannin, Dr. Rex Caffey, and their approved research team only.

**Voluntary Participation:** Participation is strictly voluntary, and you may voluntarily refuse to stop participating in the survey at any time.

The signature below will indicate your willingness to participate in this study. If you require additional information or have questions, please contact research investigators Dr. Matthew Fannin at (225) 578-0346 or mfannin@agcenter.lsu.edu, or Dr. Rex Caffey at (225) 578-2393 or rcaffey@agcenter.lsu.edu between 8:00am and 4:30pm Monday through Friday.

LSU AgCenter Institutional Review Board (IRB) Approval Number: HE20-8

SIGNATURES: “The study has been discussed with me and all my questions have been answered. I may direct additional questions regarding study specifics to the investigators. If I have questions about subject’s rights or other concerns, I can contact Michael Keenan, Chairman, LSU AgCenter Institutional Review Board, 209 Knapp Hall, Baton Rouge, LA 70803 (225) 578-1708, mkennan@agcenter.lsu.edu. I agree to participate in the study described
above and acknowledge the researcher’s obligation to provide me with a copy of this consent form if signed by me.”

Subject Signature: _________________________________ Date: ________
SECTION 1. HATCHLINGS

1. Over the last three years, how many hatchlings do you need for your operation in a given year? (If you answer zero, go to Question #13.)

2. What is your mortality rate on these hatchlings before your harvest/slaughter them?  
   ________

3. In your opinion, does that number reflect 100% of your capacity (actual or desired)?
   If not, what percent? ____________

4. Do you incubate eggs?
   ○ Yes
   ○ No  Go to Question 6.

5. Which method best describes the way you obtain eggs for incubation?
   ○ Collect your own eggs  Go to Question 5.1
   ○ Buy Eggs  Go to Question 5.8
   ○ Both  Go to Question 5.1

5.1. From which of these sources do you collect eggs?
   ○ Other’s property  Go to Question 5.2
   ○ Own property  Go to Question 5.4
   ○ Both  Go to Question 5.2

5.2. What do you pay per egg collected on un-owned property? $ ________

5.3. Are there any other unique costs paid to the landowner?
   ○ Yes, (Specify) ____________________
   ○ No
5.4. What equipment do you use to collect eggs?
   - Boat
   - Truck
   - Other, (Specify) ____________________

5.5. In your own words, please describe the process for locating nests.

5.6. What specific workers are involved in the collection of eggs?

5.7. In your opinion, how much time would you say it takes to collect your target number of eggs?__________________________

5.8. Briefly, please tell us about the equipment used in the process of incubation.

5.9. Of the total eggs incubated what would be the percent that hatches?_________%

5.10. Are there any other unique costs to incubation that we are not considering?
   - Yes, (Specify) ____________________
   - No

5.11. In your own words, how much time do you think is spent in labor activities?

5.12. What percent of your total eggs do you purchase pre-collected?_____%

5.13. What price or price ranges do you pay for pre-collected eggs? $________________

6. To obtain the hatchlings you need for your operations in Question #1, do you
   - Incubate hatchlings from eggs only Go to Question 7.
6.1. What percent of your total required hatchlings do you need to buy each year? ______ %

6.1.1. Can you provide a price or a price range for these hatchlings? $__________

6.1.2. What percent of these hatchlings would you say are purchased from Louisiana suppliers? ________ %

7. What percentage of hatchlings do you grow out to watch strap? ____________ %

7.1. From your opinion, what would you consider a large size watchstrap gator? _______ cm/ft

8. For your alligators that grow from hatchlings to watch strap size, how much do you spend on feed per year? _______

8.1. Can you provide an estimate of how much do you pay per ton of feed? $__________

8.2. What is your source for your feed? ________________

9. Do you keep any alligators past watch strap size?
   ○ Yes
   ○ No

9.1. Approximately what percent of your hatchlings in a given season do you grow out past watch strap size? _____________ %

9.2. How much per year do you spend on feed for alligators that you grow past watch strap size? $__________
9.3. Do you use any different type of feed for these older alligators? _____
   What type? ______________________

10. What utilities are you using to grow hatchlings?

   ○ Electricity                        Annual Expense:
     $____________________

   ○ Gas                                Annual Expense:
     $____________________

   ○ Propane                            Annual Expense:
     $____________________

   ○ Natural Gas                        Annual Expense:
     $____________________

   ○ Diesel/Gasoline                    Annual Expense:
     $____________________

10.1. Please provide what percent of your monthly bill is for growing hatchlings.

11. What would you consider other additional major costs of growing out hatchlings?
    Please list.
SECTION 2. SLAUGHTER AND PROCESSING

12. Do you slaughter and process your own alligators?
   ○ Yes  \hspace{1cm} \text{Go to Question 12.1}
   ○ No  \hspace{1cm} \text{Go to Question 14.}

12.1. Please provide an estimate of how much do you spend on salt. $ \underline{\hspace{2cm}}

12.2. What other types of supplies or other inputs that you spend in the processing and short-term storage of skins/meat?

12.3. What percent of the alligators you grow go to slaughter and process?

12.4. (Refer to question 14. If option “no” was selected) Please provide an estimate of how much do you pay to have your alligators processed?

13. Do you slaughter and process gators for other individuals?
   ○ Yes  \hspace{1cm} \text{Go to Question 13.1}
   ○ No  \hspace{1cm} \text{Go to Question 14}

13.1. On average, how many would you say you process a year over the past three years?

13.2. What percentage are other-farm raised gators? \underline{\hspace{2cm}}\% 

13.2.1. What percentage are wild? \underline{\hspace{2cm}}\%

13.3. How much do you spend on salt? $ \underline{\hspace{2cm}}$

13.4. What other types of supplies or other inputs are short-term storage of skins/meat?
   \begin{verbatim}
   \hspace{15cm} \text{___________________________________________________________________________}
   \hspace{15cm} \text{___________________________________________________________________________}
   \hspace{15cm} \text{___________________________________________________________________________}
   \end{verbatim}


SECTION 3. FIXED COSTS

14. How many tanks/buildings do you have for growing hatchlings to watch strap size? __________

15. What is the replacement cost of these buildings/tanks? __________________

16. What is the useful life of these tanks? __________________________

17. Which one of these methods do you implement in your farm?
   - O Well
   - O Surface
   - O Both

18. How much of the well/surface water is used for production? _________________

19. What equipment do you use to heat water? __________________________

20. How many of the following types of machinery and equipment categories do you use in your alligator operation?
   - O Trucks Number________ Replacement Cost $_______________
   - O Tractors Number_______ Replacement Cost $_______________
   - O Airboats Number_______ Replacement Cost $_______________
   - O Fuel Boats Number_______ Replacement Cost $_______________
   - O Trailers Number_______ Replacement Cost $_______________
   - O Bob-Tails Number_______ Replacement Cost $_______________
   - O Feed Trucks Number_______ Replacement Cost $_______________
   - O Other ________ Number_______ Replacement Cost $_____________

20.1. What percent of this equipment is dedicated to your alligator operations? ________%

21. What is the average useful life of this equipment? _______________
22. Please provide an estimate of your annual business expenses in the following areas:

<table>
<thead>
<tr>
<th>Category</th>
<th>Dollars</th>
<th>Percent Louisiana</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legal Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accounting Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insurance Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building Maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle Maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous Supplies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (Specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SECTION 4. LABOR COSTS

23. How many owners work in the alligator operation? ______________

23.1. What percent of their work week is dedicated to alligator operation? ________

23.2. Does any percent of ownership reside outside of Louisiana? ________%

   ○ Yes
   ○ No

24. How many hired full time employees work on the alligator operation?
     ______________

24.1. What percentage of their time is dedicated to the alligator operation? ________% 

25. What is the average salary including benefits that are paid to these employees?
    __________%

25.1. Do any of these employees reside outside of Louisiana?

   ○ Yes
   ○ No
25.2. How many seasonal employees do you employ? _______

25.3. What activities are they involved in?
   - Acquiring Eggs
   - Incubation
   - Growing Hatchlings
   - Slaughter and Processing

25.4. On average, how many hours per week and weeks per year do they work?

25.5. What is their average hourly wage? $_________

25.6. Do you pay for any other expenses for them beyond salary?
   - Yes, (Specify) ____________________
   - No

25.7. What percentage of these seasonal workers are H-2A? _____%

25.8. What percentage of your H-2A worker disposable income is spent in Louisiana? _________________ %

26. Do you outsource any additional labor needs to third party labor contractors?
   - Yes
   - No

27. (If option “yes” was selected, please answer this next question) How much do you spend on this type of labor?
SECTION 5. REGULATORY – COMPLIANCE: PERMITTING

28. What permits do you purchase annually that are affiliated with Alligator operations?

29. What are your annual skin tagging costs?

30. Are there any other costs associated with alligator production, processing, and distribution that come from the following departments?

<table>
<thead>
<tr>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wildlife and Fisheries</td>
</tr>
<tr>
<td>LA Department of Health</td>
</tr>
<tr>
<td>U.S. Fish and Wildlife Service</td>
</tr>
</tbody>
</table>

31. Are there any other costs that have not otherwise been covered in this questionnaire that you would like for us to include?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
## APPENDIX B. Bridge Table Identifying Detailed Survey Sector and the Corresponding IMPLAN Sector

<table>
<thead>
<tr>
<th>Survey Sector</th>
<th>IMPLAN Sector Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed Mill Feed</td>
<td>Sector 64: Other Animal Food Manufacturing</td>
</tr>
<tr>
<td>Poultry Processing Chickens</td>
<td>Sector 88: Poultry Processing</td>
</tr>
<tr>
<td>Electricity</td>
<td>Sector 47: Electric Power Transmission and Distribution</td>
</tr>
<tr>
<td>Natural Gas and Propane</td>
<td>Sector 48: Natural Gas Distribution</td>
</tr>
<tr>
<td>Diesel/Gasoline</td>
<td>Sector 154: Petroleum refineries</td>
</tr>
<tr>
<td>Purchased Water</td>
<td>Sector 49: Water, Sewage and other systems</td>
</tr>
<tr>
<td>H-2A Acquisition Cost and other legal services</td>
<td>Sector 445: Legal Services</td>
</tr>
<tr>
<td>H-2A Housing</td>
<td>Sector 448: Tenant-occupied Housing</td>
</tr>
<tr>
<td>H-2A Food</td>
<td>Sector 406: Retail - Food and Beverage Stores</td>
</tr>
<tr>
<td>Buildings</td>
<td>Sector 55: Construction of new commercial structures, including farm structures</td>
</tr>
<tr>
<td>Trucks</td>
<td>Sector 402: Retail - Motor vehicle and parts dealers</td>
</tr>
<tr>
<td>Tractors, Trailers, and other Auto-Type Equipment</td>
<td>Sector 260: Farm machinery and equipment manufacturing</td>
</tr>
<tr>
<td>Coolers and Freezers</td>
<td>Sector 275: Air conditioning, refrigeration, and warm air heating equipment manufacturing</td>
</tr>
<tr>
<td>Water Heater</td>
<td>Sector 274: Heating equipment (except warm air furnaces)</td>
</tr>
<tr>
<td>Landowner Costs</td>
<td>Sector 447: Other Real Estate</td>
</tr>
<tr>
<td>Helicopter and Airboat Rental</td>
<td>Sector 453: Commercial and industrial machinery and equipment rental and leasing</td>
</tr>
<tr>
<td>Airboats and Fuel Boat</td>
<td>Sector 361: Ship building and repairing</td>
</tr>
<tr>
<td>Pre-Collected Egg Cost (per Hatchling), Cost per Pre-Purchased hatchling, and Juvenile Alligator Cost</td>
<td>Sector 14: Animal production, except cattle and poultry and eggs</td>
</tr>
<tr>
<td>Salt</td>
<td>Sector 33: Other Chemical and Fertilizer Mineral Mining</td>
</tr>
<tr>
<td>Packaging Costs</td>
<td>Sector 186: Seafood product preparation and packaging</td>
</tr>
<tr>
<td>Accounting</td>
<td>Sector 456: Accounting</td>
</tr>
<tr>
<td>Insurance</td>
<td>Sector 445: Insurance carriers, except direct life</td>
</tr>
</tbody>
</table>
(Table Continued)

<table>
<thead>
<tr>
<th>Survey Sector</th>
<th>IMPLAN Sector Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel</td>
<td>Sector 474: Travel arrangement and reservation services</td>
</tr>
<tr>
<td>Building Maintenance</td>
<td>Sector 60: Maintenance and repair construction of nonresidential structures</td>
</tr>
<tr>
<td>Auto Maintenance</td>
<td>Sector 512: Automotive repair and maintenance, except car washes</td>
</tr>
<tr>
<td>Equipment Repair</td>
<td>Sector 515: Commercial and industrial machinery and equipment repair and maintenance</td>
</tr>
<tr>
<td>Miscellaneous Supplies</td>
<td>Sector 395: Wholesale - Machinery, equipment, and supplies</td>
</tr>
<tr>
<td>Property Tax</td>
<td>Sector 531: Other state government enterprises</td>
</tr>
<tr>
<td>Telephone</td>
<td>Sector 434: Wireless telecommunications carriers (except satellite)</td>
</tr>
<tr>
<td>Charitable Giving</td>
<td>Sector 522: Grantmaking, giving and social advocacy organizations</td>
</tr>
<tr>
<td>Freight</td>
<td>Sector 417: Truck transportation</td>
</tr>
<tr>
<td>Garbage</td>
<td>Sector 479: Waste management and remediation services</td>
</tr>
<tr>
<td>Advertising</td>
<td>Sector 465: Advertising, public relations, and related services</td>
</tr>
<tr>
<td>Medicine</td>
<td>Sector 405: Retail - Building material and garden equipment and supplies stores</td>
</tr>
<tr>
<td>Research and Development</td>
<td>Sector 464: Scientific research and development services</td>
</tr>
<tr>
<td>Tagging Costs and Government permits</td>
<td>Sector 531: Other state government enterprises</td>
</tr>
</tbody>
</table>
REFERENCES


Ilich Fernán Rosales Chiessa is a native of La Ceiba, Honduras. He attended Zamorano University in Francisco Morazán, Honduras, where he received his Bachelor of Science in Agribusiness Management in December 2018. During his last year at Zamorano, Ilich was an intern at Dole Fresh Fruit International, in Costa Rica, where he was responsible for analyzing different projects considered potential future investments. Additionally, he was also an intern at Qualitech Inc., in Chaska, Minnesota, where he assisted with market investigations of potential animal nutrition projects. After graduating Zamorano University, Ilich began his graduate career at Louisiana State University where he is expecting to receive his Master of Science in Agricultural Economics and Agribusiness in May 2021. He also began working for the university as a Research Assistant for the LSU AgCenter and the department of Agriculture Economics and Agribusiness.