THESIS

THE CONTRIBUTIONS AND FUTURE OUTLOOK FOR COLORADO'S POTATO ECONOMY: MODELING VALUE-ADDED MARKET SCENARIOS

Submitted by

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ABSTRACT

THE CONTRIBUTIONS AND FUTURE OUTLOOK FOR COLORADO'S POTATO ECONOMY: MODELING VALUE-ADDED MARKET SCENARIOS

The potato industry plays an important role in Colorado's economy, with the San Luis Valley as the leading production region in the state. The first paper in this thesis will share a 2022 baseline economic contribution analysis of Colorado's potato industry at both the San Luis Valley (SLV) regional and state levels, highlighting employment, labor income, and overall economic activity. To explore how various strategic changes that might be considered within potato supply chains may affect economic activity, the second paper will examine potential value-added market scenarios. Catalyzed by changes in consumer demand emerging in market trends, the first market scenario will model how changes to decrease potato packaging size could change how the potato industry contributes to the SLV regional economy. The second market scenario takes a relatively small niche of the potato industry, organic supply chains, and increases its relative production in the SLV region. Although the organic potato sector makes up only 3% of the potato production in Colorado, the aim of this analysis is to understand what implications would result from increasing the share of organic potato production. By assessing both scenarios, the paper will provide insights into how value-added potato production could shape the future economic contribution of Colorado's potato industry.

The results of the 2022 baseline economic contribution analysis show that potato farming in Colorado supported over 3,100 jobs and created $165 million in economic activity. The San

Luis Valley region had a total economic output of $328 million and supports over 2,200 jobs through the potato farming industry. The value-added market scenarios also produced positive outcomes. The results showed that increasing the market share of small packages of potatoes increased the farm-gate value of production, employment, and the economic output of the potato industry. Finally, the analysis results from increasing organic potato production show a positive effect on the SLV economy, despite yield loss. Although these scenarios represent estimates of various strategies being considered by potato producers, they provide guidance to sector leadership on how such initiatives more broadly impact regional economic activity.

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First and foremost, I would like to thank my thesis committee for their guidance, support, and valuable insights throughout this process. Their expertise and encouragement have been instrumental in shaping this research.

I am also grateful to my friends for their encouragement and support. Their occasional distraction kept me motivated and made this journey much more enjoyable.

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Thank you all.

DEDICATION

This thesis is dedicated to Thomas Kluck and Dr. Thomas Goerke.

TABLE OF CONTENTS

CHAPTER 1: THESIS INTRODUCTION

1.1 Introduction

1.1.1 Potato Background

Located in the U.S. Mountain region, Colorado, is home to a diverse agricultural landscape, ranging from cattle ranching to wheat farming. Among its most economically important crop sectors is the potato farming industry. In 2023, the potato farming industry in Colorado made over $170 million in sales and produced 21 million cwt of potatoes (U.S. Department of Agriculture [USDA], n.d.). Colorado was ranked 7th for the number of potatoes produced in 2023, behind top producers such as Idaho and Washington. Often overlooked as a smaller producer in the U.S., Colorado's potato industry stands out because of one unique characteristic. About 95% of the potatoes produced in Colorado are marketed as fresh potatoes and it ranks as the second largest shipper of fresh potatoes in the U.S. (Ehrlich, 2020).

It should be noted that potatoes sold in the fresh market are held to a higher quality standard than their processed counterparts. As a result of careful and precise farming methods, the majority of Colorado's potatoes meet these quality standards. This unique attribute of the Colorado potato farming industry makes it an important focal point for research on the role of agriculture, particularly in the San Luis Valley. Beyond the profits that the industry makes, the industry also contributes to the economy through business transactions, employment, and wages for employees and owners. These contributions are often overlooked, as research tends to focus on industry performance and profits, with less concern about broader contributions.

In this thesis, we will share a 2022 baseline economic contribution analysis of the Colorado potato farming industry at both the San Luis Valley (SLV) region and state levels. The contribution analysis will highlight employment, labor income, and economic activity.

1.1.2 The San Luis Valley

While potato production happens across the state, the vast majority of potato production happens in the San Luis Valley. The Valley is a 6-county region located in the southern portion of Colorado where roughly 90% of potato production in the state takes place. Optimal climate and soil conditions make the region an ideal location for potato production (Colorado Potatoes, n.d.). The concentration of potato production in SLV makes it an important region for research, with a Colorado State University Ag Experiment Station focused on breeding and pest management: one example of broader economic contributions the sector has on that region's economy.

Beyond the region's role in potato production, it is important to consider the broader economic landscape of the San Luis Valley. The region faces persistent challenges with poverty, making the agricultural sector especially vital to the region's economic well-being. According to the 2022 San Luis Valley Statistical Profile, the median household income in the SLV was $40,360.00, well under Colorado's median household income of $75,231.00. In addition to median household income this report also presents poverty rates and indicates that 14.9-26.6% of people in the 6 counties face poverty, compared to an average of 9.8% in Colorado (San Luis Valley Development Resources Group and Council of Governments [SLVDRGCG], 2022). Agribusiness is a primary source of employment and income in the valley, employing 4,760 people; accounting for 21% of the region's workforce (SLVDRGCG, 2022). In areas like the SLV, where economic opportunities are limited, the success and resilience of primary industries such as agriculture is important in addressing poverty and promoting stability.

Paired with the 2022 baseline economic contribution analysis in Essay 1, this thesis will discuss the role of the potato industry in the SLV as it pertains to employment, labor wages, and economic activity. In addition to the economic role the industry already plays, this research will explore ways the San Luis Valley potato industry could boost its value to producers, and subsequently, the overall economic contribution to the SLV region in Essay 2. Research into the economic contribution of the potato industry in the SLV aims to inform rural development by exploring the broader implications of market opportunities to enhance value-added potato production in the region.

1.1.3 Market Trends

Discussions with potato industry professionals and research into market trends led to the value-added market scenarios analyzed in Essay 2. In July 2022, a meeting with Jim Ehrlich, former executive director of the Colorado Potato Administrative Committee, revealed that Jim was interested in ways the value of the potato industry could be increased. We discussed different fresh potato products, as well as processed potato products that may have potential to promote growth in the potato industry (J. Ehrlich, personal communication, July 2024). From this initial interview, three more interviews were conducted with industry professionals Nancy Meraz, Sheldon Rockey, and Sarah Jones.

Nancy Meraz, the director of retail sales at Farm Fresh Direct, LLC. discussed trends she had noticed in the retail sales of fresh potatoes. She noted that large retailers were requesting smaller potato packaging sizes (N. Meraz, personal communication, January 2025). Further research into this trend revealed that as family sizes in the U.S. shrink the demand for smaller packaged goods is increasing (Hatt, 2017). The upward trend in demand for smaller packaging

sizes presents an opportunity for potato producers to pack more potatoes in small bags and create a product that is highly valued by its consumers.

Sheldon Rockey, owner of White Rock Specialties, LLC shared insight on potato packing sheds (S. Rockey, personal communication, January 2025). This helped us understand the function of a pack shed and how changing packaging sizes may have an effect on the potato production supply chain and the economy. Further research and more data from N. Meraz indicate that smaller packages of potatoes are more expensive to produce. In this research the increase in cost for potato packaging is absorbed throughout the economy. A more in-depth explanation of how this increase in cost affects the economy is discussed in Section 3.2.4. It is assumed that the increase in packaging cost is matched with an increase in the value of the smaller package of potatoes.

Sarah Jones is part of the family-operated agribusiness, Jones Farms Organics. The interview with Sarah was very insightful and helped us to understand a clearer picture of organic potato farming. We discussed a lot in our interview, including the benefits of organic production and market trends. From the interview it was learned that organic farming does not require any more water than conventional farming and sometimes less. We also discussed issues of yield loss and how they can be compensated through an increase in sale prices. Finally, we discussed where Sarah thought the market was going, capturing her outlook on organic potato production (S. Jones, personal communication, January 2025). More independent research revealed that consumer demand for organic produce, which includes potatoes, is steadily increasing. Some research suggests that the demand for organic fruits and vegetables is growing at a faster rate than the production of organic produce (Skorbiansky et al., 2023), and this supply gap may be

exacerbated in an era when tariffs may be elevated. This trend suggests there is an opening for farmers to enter the organic produce market and have an opportunity to be successful.

The combined research and interview process informed market-based scenarios in which the supply chain distributes more potatoes in small package sizes and scenarios where organic potato production accounts for a larger proportion of potato production. The goal of creating these scenarios is to assess the value the market innovations may add to the economy of the San Luis Valley, in which the agriculture sector is so important.

1.1.4 Production Issues

Addressing changes to the supply chain to support rural development and economic success of agriculture in the San Luis Valley is vital, but in doing so we must also consider challenges involved in crop production.

The first challenge faced by potato producers in the valley is water shortages. Once an area with what seemed like endless water supply, is in recent years facing major water shortage threats (Bailey, 2023). The SLV is known for producing two prominent crops, alfalfa and potatoes. These two crops happen to be water heavy crops that rely on moist soils to grow successfully and plentifully. As stated previously, the valley relies heavily on the agricultural sector to drive its economy, so keeping the production of these two crops is important. This puts producers in a situation where they must inform policy makers of the economic benefits of maintaining water in the region for potato and alfalfa production.

It should be noted that potatoes and alfalfa are often paired in crop rotations. This is done to mitigate potato pest pressures, like the Colorado Potato Beetle, and to improve crop yields by maintaining soil nutrients (Wright, 1984). It is important to note that potatoes and alfalfa are

grown on the same land as that suggests water restrictions would affect the production of both crops in the long run.

Producers in the region are also faced with land constraints. This means there is only so much land available to grow potatoes. Unfortunately, land in agricultural production has been declining, so a call for potato acre expansion is unrealistic (Zulauf, 2024). In addition to proving that using water on potatoes is valuable, we must also prove that land in potato production should stay in potato production whether it be in organic or conventional production.

Coupling decreasing water supply and tightening land constraints, it is the aim of this study to inform policy makers that potato production is already valuable to the region, and there are options that could elevate those contributions. Indicating that any water spent on growing potatoes will be met with a positive effect on the region's economy. The SLV potato industry produces much more than a profit, it supports jobs and inter-business transactions that further boost economic activity.

The following research is split into two essays. The first examines a baseline economic contribution analysis of Colorado's potato industry as it pertains to the San Luis Valley region and the whole state. The second essay explores potential value-added market scenarios, analyzing how shifts in consumer preferences could create new opportunities for potato producers. Together these essays aim to inform how the potato industry makes its contribution to regional economies.

CHAPTER 2: ESSAY 1, ECONOMIC CONTRIBUTION OF THE POTATO FARMING INDUSTRY

2.1 Introduction

2.1.1 Background

As of 2023, Colorado is the 7th largest potato producing state in the United States. The state produced 21,098,000 cwt of potatoes and grossed $194,946,000.00 in production value in 2023. Colorado provides roughly 5% of the total U.S. potato stock behind the largest potato producing states Idaho and Washington (Figure 2.1) (National Agricultural Statistics Service [NASS], 2022). Even though it is continuously in the top ten potato producing states, Colorado is often overlooked as smaller provider of potatoes to the U.S. While the state does not produce the largest potato crops, a unique attribute of Colorado's potato industry is that around 95% of potatoes are marketed as fresh. This places Colorado in the number two spot for fresh potato shipments in the U.S. (Ehrlich, 2020).

It should be noted that potatoes that are sold as fresh potatoes are held to a higher quality standard than those turned into chips, flakes, flour, and other processed potato products. Thus, the quality of potatoes that come from Colorado are a result of careful and precise farming and hauling. This unique attribute to Colorado's potato industry makes it an important potato market to understand. Colorado's potato contribution to the U.S. is evident, but it is equally important to understand the role that the potato industry plays within Colorado's boarders. Beyond the profits that the potato industry brings into the state, the industry also contributes to the economy because its producers themselves purchase inputs, provide jobs, and pay wages (both to workers and

themselves as owners/managers). These three factors, and more, are often overlooked when only focusing on the profits generated from an industry. To better understand the whole contribution of the potato industry provides for regional economies, we conduct an economic contribution analysis on the San Luis Valley and the state of Colorado as a whole.

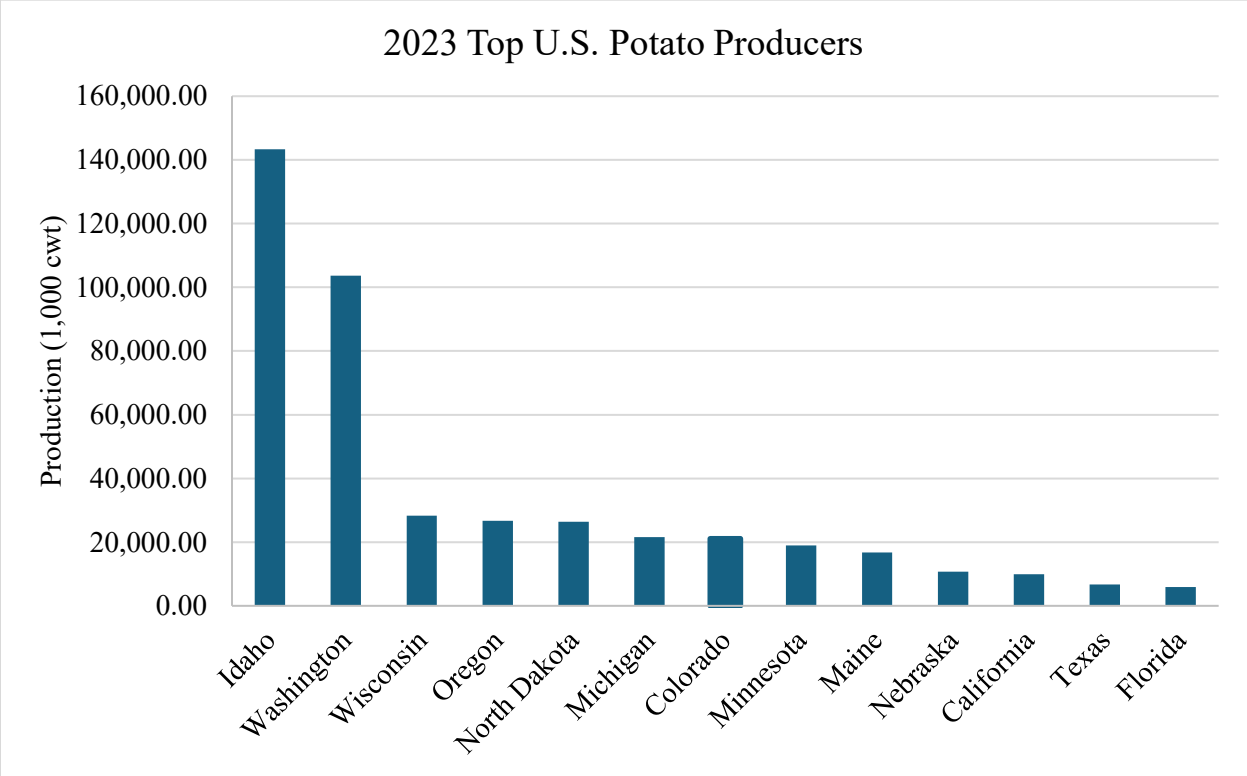

Figure 2.1: 2023 Potato Production by State

Source: USDA NASS Quick Stats, 2023

Colorado is home to a diverse agronomic landscape and is commonly sub-divided into three geographical regions – the western slope, the mountains, and the plains. Each of these regions' acreage is dominated by production of specific crops. The western slope is home to a variety of vegetables, including sweet corn and fruit trees. The mountain region is dominated by cattle and winter produce. Lastly, the plains are best suited for dryland crops like feed corn,

wheat, hay, millet, and sorghum (Walden, 2018). In this regional context, potatoes are primarily grown in the southern-mountain region of the state. This region is better known as the San Luis Valley and is made up of 6 counties – Alamosa, Conejos, Costilla, Mineral, Saguache, and Rio Grande. About 90% of Colorado potatoes are produced in these six counties (Table 2.1), depending on the year. The valley provides an ideal environment for potato growth with mineral rich soil, temperate summers, more than 300 days of sun and water from the mountain snow melt (Colorado Potatoes, n.d.). All these factors make the San Luis Valley an important region to consider for a separate focus in this larger for an economic contribution analysis of the potato industry.

Table 2.1. Potato Production: 2014-2018

Year	SLV Production (cwt)	CO Production (cwt)	Proportion of Production Occurring in SLV
2018	20,124,000.00	21,722,000.00	93%
2017	19,313,000.00	21,220,000.00	91%
2016	19,828,000.00	22,236,000.00	89%
2015	19,943,000.00	22,575,000.00	88%
2014	20,482,000.00	23,196,000.00	88%
Source: USDA NASS Quick Stats, 2014-2018			

The 10% of potatoes that are grown outside of the San Luis Valley still make important contributions to the state's economy, motivating the reason for holistic look at the whole state of Colorado. In addition to the profit from potatoes that are grown outside the SLV region, there are also economic activities that occur beyond the SLV borders, but still within Colorado, that are related to the potato industry. Capturing the economic contribution from the potato industry for

the whole state is important to understanding the full extent of the potato industry's contribution to the economy.

2.1.2 Motivation

The main motivation for this research comes from a previous economic contribution study, conducted in 2014 on the Colorado potato complex. In the 2014 report published by the Colorado Potato Administrative Committee (CPAC), Colorado's potato and potato product production contributed $595.5 million to the state economy (Informa Economics, 2016). The scope of the 2014 study is larger than the one in this paper, as it looks beyond the potato production industry, studying the downstream industries that also produce potato products. This contribution was a combination of the output from the industries and the full-time jobs they provided. The 2014 study focused on the whole state, while this research will include, in addition to the whole state analysis, a regional analysis of the contribution in the San Luis Valley. This paper seeks to update some of the statistics presented in this report and update numbers to reflect the industry's economic contribution nearly 10 years later.

The paper will begin with a Theoretical Framework that outlines the economic theory behind economic contribution analysis. This will review Wassily Leontief's Input-Output Theory and discuss the important aspects used for economic contribution analysis. Next, the Data section explains how regional economic data is customized for analysis of specific industries. The Methodology section will then explore how important values and relationships captured for the Leontief's I-O model are used to capture the value of economic activity in a region. The last three sections will conclude the paper by discussing results, limitations, and future directions of this research.

2. Theoretical Framework

2.2.1 Input-Output Theory

This study will focus on the total economic contribution from the potato industry. The framework for this study will be grounded in Input-Output (I-O) Theory developed by Wassily Leontief (Jenson, 2001; Miller & Blair, 2012). This theory explains how all industries are interconnected through supply chains. The interconnection of industries is known as linkage. Linkages can be forward or backward. A backward linkage measures the connection between an industry and the industry it buys inputs from. A forward linkage measures the connection between an industry and the industry that buys its output. Leontief's I-O theory begins with a basic accounting identity.

$$X = Z + Y$$

In this simple function, *X* represents the vector of total industry output. The Z variable represents the matrix of inter-industry transactions. The matrix of transactions displays expenditures as columns and income as rows. The final variable, *Y,* represents the vector of final demand. This simple function tells us what proportion of total output is determined by inter-industry transactions and final demand. The next step to Leontief's model is to understand what portion of output comes from each industry. To do this, each number in the column of a specific industry is divided by the total output of the corresponding industry, using only the matrix of inter-industry transactions. This results in a matrix of coefficients, *A* which describes the amount of input that is needed to produce a unit of output. Deriving this matrix creates another avenue for calculating *Z*, as shown in the function.

$$Z = AX$$

Using the new definition of *Z*, we can substitute *AX* for *Z* in the basic accounting problem. Leaving the function $X = AX + Y$, which can be rearranged using matrix algebra. This leaves us with the general form for Leontief's Input-Output Model.

$$X = (I - A)^{-1}Y$$

The dependent variable is X, which represents the vector of total output from a specific industry. As stated previously, *Y* is representative of a vector of final demand. The variable *A* now appears in the function $(I - A)^{-1}$, which represents the total output needed for one unit of final demand. In the inverse function, *I,* is the identity matrix. The identity matrix is the matrix equivalent to one. The *I* matrix is necessary for as a mathematical function and is not representative of any economic variable. The inverse function, $(I - A)^{-1}$, is also known as the matrix of output multipliers. This is because the matrix shows how, on average, a one unit increase in final demand would multiplicatively increase total output, ceteris paribus. This 1973 Nobel Prize winning model is used as the basis for many economic contribution analyses and impact studies (Remmers, 2018). The straightforward model can be modified to fit several different studies, as seen in Schmit et al. (2018) and Silk (1973). Each study may change how variables interact to explain a different outcome in the economy. This paper will use the groundwork set forth by Leontief's original model to calculate the economic contribution of the potato industry. This specific analysis will require a matrix transformation of the *Y* variable. This transformation of the Y variable will allow for a different interpretation of the dependent variable, *X*. Per Leontief's original model, the X variable is originally interpreted as the total output of an industry. After the matrix transformation of Y, the X variable is representative of a matrix of economic activity that happens in each sector. This transformation will not change the total output of the region's

economy but will only display a different way to interpret the contribution of an industry. This interpretation will become clearer in the methodology and result sections of this paper.

2.2.2 Input-Output Model Assumptions

The use of I-O modeling requires standard assumptions. (Slovachek, 2023a; Thorvaldson et al., 2006).

1. Constant returns to scale: this assumption implies that the production function for a given industry is linear. This means that a single unit of output requires the same quantity of input, regardless of how much production takes place.
2. Fixed input structure and no substitution effects: this means that the exact same set of inputs is used to create output.
3. Industry homogeneity: the model assumes that all the firms in each industry follow similar production processes.
4. No supply constraints: the model does not account for restrictions on inputs, raw materials, or employment. The assumption is that there is an appropriate number of inputs for an infinite amount of production. The researcher must decide if this assumption is appropriate for their analysis.
5. Technology assumption: this assumes that an industry's production function is a weighted average of the inputs required for its primary and by-products, based on output shares.
6. Constant byproduct coefficients: this aligns with the technology assumption and assumes that an industry will produce the same mix of goods regardless of the scale of production.
7. The model is static: the model assumes that consumer preferences, government policy, technology, and prices all remain constant.

8. Backward linkages: an I-O model traditionally uses Type 1 multipliers; this means the model only captures backward linkages. These are direct and indirect effects from an industry. If the researcher uses a different multiplier assumption, the model may account for more other linkage types.
9. Time dimension: the length of time it takes for an economy to return to equilibrium is unknown. It is up to the researcher to make this decision, and it is not explicitly in the I-O model.

Understanding each of these assumptions helps to ensure a well-informed interpretation of the results of this research.

2.2.3 Using the I-O Model for Economic Contribution Analysis

For the purposes of this research, the most important takeaway from I-O modeling is the output multipliers. Again, the multipliers inform how the output in an industry is affected by changes in final demand. Output multipliers have many different uses including how to: (1) look at how a future event may shape the economy or a specific industry (i.e., impact analysis), (2) measure economic activity in a past economy, (3) inform regional economic planning, and well as many more potential uses. We will use these multipliers to explain the economic activity that has taken place in a past economy.

2.3 Data and Preprocessing

2.3.1 Data Sources

This section describes the data that is to be used for the economic contribution analysis of potatoes in the state of Colorado, as well as the San Luis Valley region. This includes the sources and preprocessing for all data. The data for this study comes from various secondary sources.

These sources include IMPLAN, United States Department of Agriculture National Agricultural Statistics Service (USDA NASS), and the Colorado Potato Administrative Committee (CPAC). The main data sets for this analysis will come from IMPLAN. The IMPLAN data used will come from the years 2021 and 2022. The data sets from these years have the same aggregation scheme and allow for customizations. Unfortunately, the newly released 2023 IMPLAN data has a new aggregation scheme that conflicts with the customizations needed for the analysis. One set of data will be for the entire state of Colorado, while the other set will be modeling the San Luis Valley region as an aggregate of its counties. The USDA NASS data will span various years depending on the specific use. The USDA NASS data is also used for customization and used as a tool to verify some of the data in IMPLAN.

2.3.2 IMPLAN Social Accounting Matrix

From the primary data source, IMPLAN, we need to extract the social accounting matrix (SAM) for both regions. The social accounting matrix is a snapshot of an economy for a given year. It reflects many different aspects of the economy such as income, consumption, production, and trade. The SAM from IMPLAN will be set to an aggregation scheme of 546 industries. The aggregation scheme is based off the North American Industry Classification System (NAICS). The NAICS helps to organize every kind of production system into an industry category. The 546-industry data set is the most unaggregated scheme that IMPLAN has for 2022 and 2021. This aggregation scheme is the same for 2018 to 2022 (Clouse, 2017). The industry SAM will be a square matrix that is roughly 546 by 546 industries, where each value in the matrix will describe a transaction between industries.

It should be noted that not all SAMs are the full 546 industries, as some industries may have no transactions occurring in a region's economy. As stated previously, the columns in the

matrix represent the expenditures of an industry and the rows represent the industry's income. The matrix is modelled so that income is equivalent to expenditures. This state is representative of an economy in equilibrium, which means demand is equivalent supply. This state of the economy aligns with the theoretical assumption of a perfectly competitive market, in which long-run profits are zero (Hall, 2023). This assumption aligns with earlier discussed assumption of I-O modeling, such as the fixed production relationships assumption, where firms in the market do not adjust production methods in response to profit incentives. An economy in equilibrium is an essential condition for using I-O modeling.

As stated previously, IMPLAN aggregates industries based on the NAICS codes that each industry carries. IMPLAN refers to this aggregation as bridging, where industries with the same beginning to their NAICS code are put into industry groupings (Slovacheck, 2023c). The analysis in the paper focuses on the potato farming industry which has the NAICS code of 111211. In the aggregation scheme we are using in IMPLAN the potato industry will fall under the larger umbrella of the vegetable and melon farming industry. The vegetable and melon farming industry carries the NAICS code of 11121 (NAICS Association, 2023). These two industries both fall under the Agriculture, Forestry, Fishing and Hunting Industry - NAICS 11. All industries can be linked back to twenty, two-digit NAICS codes (U.S. Census Bureau, 2024).

2.3.3 IMPLAN Multipliers

Beyond the output multipliers that are found using I-O analysis, IMPLAN calculates employment multipliers, labor income multipliers, and value-added multipliers. There are numerous types of these multipliers in IMPLAN – summary, detail, and per million. For this research the 2022 summary and per million multipliers for labor income and employment will be used. The value of the multipliers differs from Colorado to the SLV as seen in Tables 2.2-2.5.

Summary multipliers correlate to the direct effects of an industry. For example, 1 direct job in the industry generates an additional 5 jobs in the local economy. In the case of that example the employment multiplier would be 6. Per million multipliers show the value or number of jobs associated with every $1 million in output (Clouse, 2019). These multipliers are also split up based on type – direct, indirect, type 1, induced, and SAM. For this research, the direct and SAM multipliers will be used. The direct multipliers are the measured number of jobs or labor income for the specific industry. The SAM multipliers follow the form below (Slovachek, 2023b).

$$\frac{Direct\ Effect + Indirect\ Effect + Induced\ Effect}{Direct\ Effect} = Type\ SAM\ Multiplier$$

The SAM multiplier captures the total effect, induced and indirect, per direct effect. Using this multiplier type for employment and income labor will help further explain the economic contribution of an industry, beyond its direct effect.

Table 2.2 Colorado Multipliers: Summary Effects

Vegetable and Melon Sector	Type
Multiplier Effect	SAM
Employment (persons)	2.074
Labor Income ($)	2.199
Source: IMPLAN, 2022	

Table 2.3 San Luis Valley Multipliers: Summary Effects

Vegetable and Melon Sector	Type
Multiplier Effect	SAM
Employment (persons)	2.576
Labor Income ($)	1.968

Source: IMPLAN, 2022

Table 2.2 Colorado Multipliers: Effects Per Million Dollars of Output

Vegetable and Melon Sector	Type	
Multiplier Effect	Direct	SAM
Output ($)	1,000,000.00	2,090,545.00
Employment (persons)	6.18	12.82
Labor Income ($)	298,223.00	656,020.00
Total Value Added ($)	272,764.00	872,374.00

Source: IMPLAN, 2022

Table 2.5 San Luis Valley Multipliers: Effects Per Million Dollars of Output

Vegetable and Melon Sector	Type	
Multiplier Effect	Direct	SAM
Output ($)	1,000,000.00	1,833,228.00
Employment (persons)	4.30	11.08
Labor Income ($)	308,393.00	607,142.00
Total Value Added ($)	272,730.00	719,311.00

Source: IMPLAN, 2022

2.3.4 Customizing IMPLAN SAM for Colorado

To do the analysis related to this paper's goals, the SAMs that are extracted from IMPLAN require customizations. Customizations will alter in the vegetable and melon farming industry row and columns, as this is where the focal industry of potato farming is located. The first set of customizations will be to correct pricing issues. The second set of customizations will allow for disaggregation of the vegetable and melon farming industry, so potato farming may be analyzed independently.

Looking at the industry SAM for Colorado, it was noted that the value associated with the vegetable and melon farming industry was much larger than previous years. The value of the vegetable and melon sector is equivalent to the farm-gate value of production for all of the vegetables and melons produced in Colorado. Further research indicated this inflated value was because of the higher-than-usual average price received for potatoes in Colorado in 2022. The average price receive for Colorado potatoes in 2022 was $17.70/cwt, up 65% from the 5-year average that preceded 2022. This spike in prices was due to high input costs, lingering effects from the supply chain disruptions due to the Covid-19 pandemic, and small crops yields due to drought (Eborn, 2022; and Harvey, 2022). The increase in prices was not unique to Colorado, as the average US price increased from $10.20/cwt in 2021 to $12.90 in 2022. 2022 also happened to be an agriculture census year. Since IMPLAN relies heavily on census data, the 2022 and 2023 SAM for Colorado reflected these inflated prices.

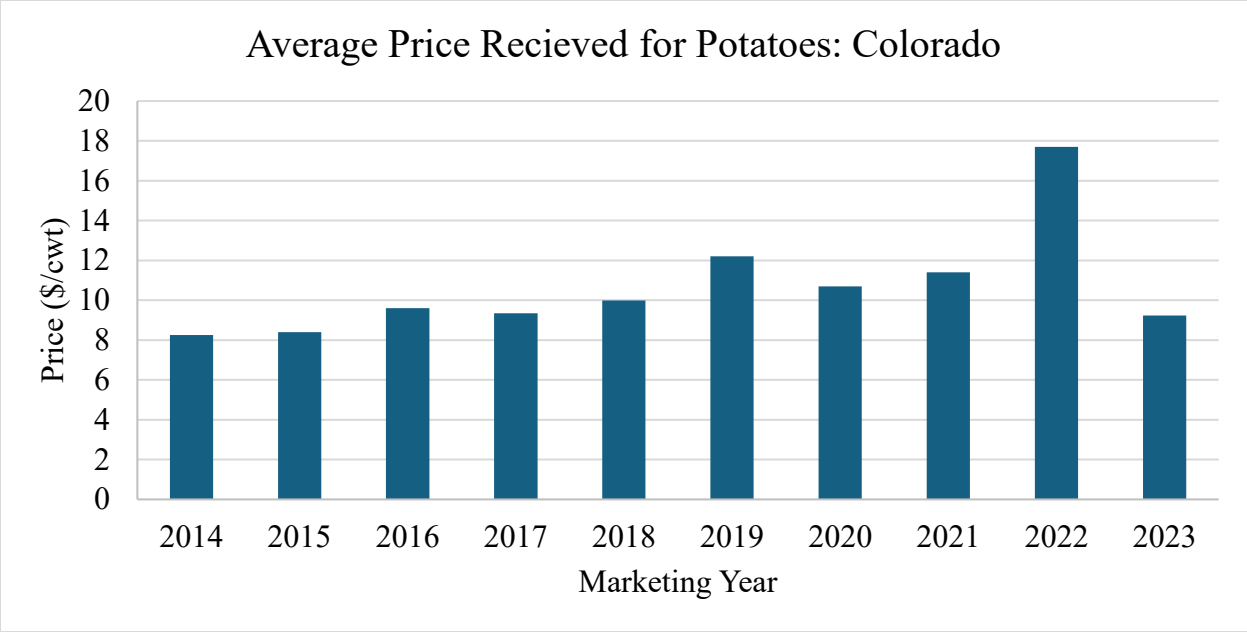

Figure 2.2: Average Price Received for Potatoes

Source: USDA NASS Quick Stats, 2014-2023

If these inflated prices are used in analysis, it would skew results and could lead to making false inferences about the potato farming industry. To reflect a more accurate representation of the economy for the vegetable and melon farming industry and ultimately the potato farming industry, values were adjusted. To deflate the record high potato prices from 2022, we replaced the vegetable and melon farming industry row and column from the 2022 industry SAM with the 2021 row and column of the same industry. This essentially deflated the industry and reflected a more normal market year for the potato farming industry. In this method of deflation, we are assuming all other vegetables and melons included in the industry did not realize any large price fluctuations between 2021 and 2022. An issue that arose from the replacement of data, was that the matrix of economic relationships was thrown out of equilibrium. To restore equilibrium to the matrix, the RAS method was employed. This method is an iterative method of bi-proportional adjustment (Fofana et al., 2005). To use this method on the industry SAM for Colorado, R

programming software is used. The first step is to read the now unbalanced, industry SAM into R. This is known as the A matrix and represents the 'A' in RAS. We then prompt R to calculate the row and column totals for the entire matrix. For the matrix to balance, R must be prompted with the desired row and column totals. The new row totals, R, and the new column totals, S, are representative of the 'R' and 'S' in RAS. For this research, the desired row and column totals were to be equal to the row totals after the vegetable and melon row and column were replaced. This is a stylistic choice and depends on the researcher. With the desired row and column totals in the program, R will begin an iteration process to get to the new equilibrium. The iteration process involves every row value in the matrix being multiplied by a row factor. The row factor, r_i , is calculated as follows.

$$r_i = \frac{R_i}{\Sigma_j A_{ij}}$$

Where R_i is the desired row total for a specific industry i and $\Sigma_j A_{ij}$ is the sum of the row of the same industry, i, from the unbalanced matrix, A. In addition to the row factors, there are column factors. These factors, s_i, are calculated in the same way only using column values.

$$s_j = \frac{S_j}{\Sigma_i A'_{ij}}$$

Where S_j is the new column total for industry j and $\Sigma_i A'_{ij}$ is the sum of the column for industry j after the row factor adjustment. The process of multiplying the unbalanced matrix by the row and column factors is iterated until the matrix is balanced. For this re-balancing, the R program was restricted to 100 iterations, as to not change the matrix values significantly. The matrix met convergence in under 100 iterations. Since only one column and row had new data, there were no significant changes to the matrix (see Table A2 in Appendix A).

The focus industry of this paper is potato farming, which falls under the vegetable and melon farming industry (i.e. NAICS 11121). Unfortunately, IMPLAN does not have an industry that is explicitly for potato farming, so we must extract the potato farming industry from the vegetable and melon farming industry row and column in the SAM. As discussed earlier, since the potato farming industry bridges to the vegetable and melon farming industry, we disaggregate the vegetable and melon farming industry. To do this, we simply pulled our estimated values assigned to the potato industry out of the existing vegetable and melon farming industry. This disaggregation method started with gathering the farm-gate value of the potato farming industry. This value comes from USDA NASS 2021 survey data and is $244,918,000.00. We took the farm-gate value of potatoes and divided it by the farm-gate value of the vegetable and melon farming industry from IMPLAN, $319,293,394.00. This value says that the potato industry is roughly 77% of the value of the entire vegetable and melon farming industry in Colorado. We divided each column value by the column total and each row value by the row total to express each value as a proportion of the overall totals. These proportions then allowed for the calculation of the new row and column for the potato farming industry.

$$(1)\ r_p = \$319{,}293{,}395.00 * 77\% * x_r$$

$$(2)\ s_p = \$319{,}293{,}395.00 * 77\% * x_s$$

Equation 1 represents the new row values, r_p, for the potato industry. Where x_r represents the vegetable and melon row value as a proportion of the row total. The sum of all the new row values for the potato industry will return the farm-gate value of potatoes, $244,918,000.00. Equation 2 represents the new column values, s_p, for the potato industry whereas x_s represents the vegetable and melon column value as a proportion of the column total. Similar to the row equation, the sum of all the new column values from equation 2 returns the same farm-gate

value. With the new row and column values for the potato farming industry, the last step to restore the matrix's balance is to subtract the value of the potato farming industry row and column from the vegetable and melon farming industry's row and column. The result is a row and column that represents the potato farming industry and a row and column that represents all other vegetable and melon farming (excluding potatoes). The value of the entire economy has not been changed; instead, the disaggregation just allows for analysis to be done on an industry that otherwise is not explicitly in IMPLAN. The Colorado SAM now includes a potato farming industry and is structured to allow for a more focused economic contribution analysis on the potato sector.

2.3.5 Customizing IMPLAN SAM for the San Luis Valley

To first extract the industry SAM for the San Luis Valley (SLV), we need to compose a region in IMPLAN. The SLV region is made-up of six counties – Alamosa, Saguache, Costilla, Conejos, Rio Grande, and Mineral. IMPLAN will do the aggregation of the six counties by combining the regional economies of each county into a larger regional economy. The industry SAM from this region looks very similar to the entire state's industry SAM, however there are more industries that do not exist in this smaller regional economy. This makes the matrix smaller as there are fewer rows and columns. The matrix still follows the 546-industry aggregation scheme, but IMPLAN automatically deletes industries that have a zero value for both the row and the column totals.

Like the industry SAM for Colorado, customizations need to be made to the matrix before it is ready for analysis. For the SLV region, only one set of customizations is necessary. The customization will be for the same pricing issue that the whole state industry SAM had. The pricing issue that was discussed previously still exists in this matrix; primarily, 2022 prices are

similarly inflating the value of the vegetable and melon farming sector, so the same row and column replacement process is done. Taking the 2022 row and column values for the vegetable and melon sector and swapping them with the 2021 row and column values. This gives a more accurate account of the vegetable and melon sector. As with the Colorado matrix, this matrix was unbalanced after the vegetable and melon farming industry row and column were replaced. Similarly, the RAS method is used in the exact same way to re-balance the matrix. There were also no notable changes in the row and column values, due to only a small amount of data being changed (see Table A1 in Appendix A).

Fortunately, the San Luis Valley industry SAM does not need the addition of a custom industry for the potato farming industry. This is the case because the potato farming industry makes up majority of the vegetable and melon farming industry in the SLV. The portion of the total value that is not from potato farming is so small that it is negligible for the analysis in this paper. Thus, for the purposes of this paper, we will assume that the vegetable and melon farming industry is equivalent to the potato farming industry for the San Luis Valley.

After all the customizations were made for both matrices, it was verified that the matrices were still in equilibrium. As mentioned in the Theoretical Framework, the equilibrium requirement is important for I-O modeling.

2.4 Methodology

The goal of the economic contribution analysis is to estimate the economic activity that is generated by an industry. Economic activity generated by an industry captures more than the value of the industry's production. Like Leontief's model intends, this analysis captures the transaction between industries and how one industries' activity may affect another's. Analyzing

only the value of an industry's production would significantly discount the value of that industry. For example, a potato farm not only produces and sells potatoes, but they also purchase inputs like labor and fertilizer. Informing research with only the potato production would leave out all the positive economic activity from input purchases that more broadly contribute to the community surrounding potato farms. Additionally, the hired labor on the potato farm will take their paycheck to the grocery store, creating another layer of economic activity. Missing these inter-industry connections could significantly underestimate the roll of an industry in a regional economy. We do the economic contribution analysis to capture more than the value of production. This paper will include two economic contribution analyses. The first analysis will aid in the understanding of the economic contribution of the potato industry to the state of Colorado. The second analysis will focus on the region of the San Luis Valley. Both analyses will follow the same structure and yield the same result structure. The results from each analysis will be discussed in the Results sections.

2.4.1 Output Multipliers

In the Theoretical framework section, an overview of I-O modeling is discussed. A key factor in the I-O equation is $(I - A)^{-1}$, which we also referred to as an output multiplier. As previously stated, an output multiplier measures the amount of output needed to meet final demand. The multipliers can also be interpreted as the increase in output due to a $1.00 increase in new dollar spending in an industry (i.e. exogenous final demand). This interpretation assumes that the economy stays static as only exogenous final demand changes. The output multipliers are an important variable in economic contribution analysis and are the basis for the analysis in this paper.

To capture the output multipliers, we first created the *A* matrix as Leontief's model demands (P. Watson, personal communication, 2025). The A matrix will be made up of endogenous industries. These industries are ones that we know to be interdependent on the economy. The endogenous sectors are impacted by changes in demand and will reflect a multiplier effect. For this analysis, we determined that all producing industries and households are endogenous. Producing industries are any industry that bridge to a specific NAICS code. The choice of which industries are endogenous or exogenous may fluctuate depending on the analysis and commonly left to the interpretation of the researcher. To create the A matrix, we took every endogenous industry in a column and divided each industry by the columns total. The columns total still includes the exogenous industries.

It should also be noted that there are positive and negative values in the columns; a positive value denotes expenditure, while a negative value can be interpreted as a subsidy or money given to the industry. This calculation gave us the proportion of an industry's expenditure that comes from the endogenous industries they purchase from. The output matrix will be an endogenous industry by endogenous industry, square matrix. The transactions represented in the matrix contribute to the output multiplier effect. The *A* matrix is also known as the matrix of technical coefficients. In addition to the *A* matrix, an identity matrix was created. The identity matrix is the matrix equivalent to 1 and is necessary for matrix algebra. It appears as a matrix where all the diagonal values are 1 and the off-diagonal values are 0. In the case of this paper, the 1 represents a place in the matrix where the row industry matches the column industry; this also denotes an area where an industry makes a purchase from itself. With the *I* and *A* matrix created, the next step in the methodology can be completed; subtracting the *A* matrix from the *I* matrix. The output from this calculation does not have an economic interpretation, it is merely an

algebraic step in the methodology. Taking the inverse of the $I - A$ matrix will output the matrix of output multipliers. The diagonal cells in the matrix show the direct and indirect output effect within the same sector and the cells on the off-diagonal indicate how much output in one industry is necessary to meet a single unit of final demand in another industry. A higher output multiplier indicates a stronger interdependence between industries, while a low multiplier value indicates weak linkages. Summing the column of multiplier effects for an industry gives us the total output multiplier, which measures the total output required across all sectors to meet a unit of final demand for the industry. This value captures the direct effect, which is how much output the industry requires from itself as well as the indirect effect of the output needed from other industries that supply inputs. The total output multiplier can be interpreted the same as the individual multipliers, where a high total output multiplier indicates the industry is highly interconnected to the regional economy, and conversely, a low total output multiplier indicates a more independent industry that relies less on other industries for production.

2.4.2 Economic Contribution

The economic contribution is a value estimated through relationships among the output multipliers and the level of exogenous final demand. The next step, after finding the output multipliers, is to find exogenous final demand. Exogenous final demand is calculated from the original industry matrix. For this research, the original matrices are those that were customized for the SLV and Colorado. Including both the endogenous and exogenous industries. Taking this matrix and focusing on the endogenous rows, we sum across all the exogenous columns. These summed rows give us the income from each industry that is exogenous. This is known as exogenous final demand because it is all the demand that is independent of the regional economy, meaning it is not generated by the activities that occur within the regional economy.

Only focusing on demand generated within the economy would measure the recycling of money and not economic growth. So, instead of focusing on demand that only currently exists inside the regional economy, an update including exogenous final demand shows how new or outside dollars expand the region's economy. To calculate how the exogenous final demand affects output, a transformation of the values is executed. When the exogenous industry row values are summed, what is left is an endogenous industry by 1 column vector of total exogenous final demand. This column vector needs to be transformed into a square matrix, the same size as the *A* matrix. To do this, the exogenous final demand is placed on the diagonal and the off diagonal is made-up of 0s. We then take the matrix of output multipliers and multiply it by the diagonalized matrix of total exogenous final demand. The resulting matrix is a matrix of economic output. Each cell in the matrix can be interpreted as the economic activity generated by new or outside dollars. To calculate the total economic output of an industry we sum down the column for a specific industry, including only producing industry rows. This value is the total economic output, also known as base output. This value tells us how much economic activity is generated in an industry from exogenous final demand. This value also reveals how much the industry is contributing to the regional economy, beyond the direct output of the industry. From the matrix of economic output, gross output can also be calculated. It is the row sum of an industry and is equivalent to the value of production. Gross output can be used as a comparison to the base output of an industry. When the base value is larger than the gross value, it means that the industry has a high amount of export activity, meaning the product that is produced in that industry leaves the region. On the flip side, an industry with a base value lower than the gross value retains a lot of their production, meaning that the region's economy consumes most of what is produced. The calculation of economic output of an industry does not change the value of

the region's economy, it merely changes the perspective. This claim can be checked by comparing the total sum of the gross value to the sum of the base value through the producing industries. The values, if the methodology is done properly, should be equivalent. These values are equivalent to the region's total value of output, which is listed in IMPLAN's region details.

2.4.3 Other Contribution Indicators

As mentioned in section 2.3.3, IMPLAN calculates labor income and employment multipliers (see Tables 2.2-2.5). We will use these multipliers to help further visualize the economic contribution of the potato industry in Colorado and the SLV. The first set of multipliers, summary multipliers, are given in IMPLAN and do not require any further calculations. The second set of multipliers, per million effects, requires simple algebra to understand the contribution. For employment, the per million effect shows how many jobs are held for every $1 million dollars of output in an industry. Using the farm-gate value of the potato industry, it is divided by $1 million and multiplied by the per million multiplier effect. The output using the SAM multiplier is the direct, indirect, and induced jobs that the potato farming industry supports whereas the results using the direct multiplier is only jobs directly tied to the potato farming industry.

2.5 Results

The methodology explained allows for an overview of an existing economy. This research has used two years of past data to compile an industry SAM for the San Luis Valley and Colorado. For the purposes of this paper, we will assume that the customized matrices for the two regions best represent an approximation of the year 2022. However, as discussed in the data section, 2021 data was used to represent the potato farming industry due to inflated prices in

2022. The following section will discuss the results of the 2022 economic contribution analysis on two regions, using the previously discussed methodology.

2.5.1 Colorado Economic Contribution

Table 2.6 2022 Economic Contribution of the Potato Farming Industry: Colorado

Effect	Farm-gate Value of Production ($)	Economic Output ($)	Employment (persons)	Labor Income ($)
Direct	244,917,600.00	-	1,514	73,040,025.00
Indirect & Induced	-	165,655,220.00	1,626	87,630,937.00
Total	244,917,600.00	165,655,220.00	3,140	160,670,962.00

Sources: USDA NASS Quick Stats, 2021; IMPLAN, 2022 & 2021

The greater Colorado regional economy gained $165.7 million in economic output from the potato farming industry. This value is how much economic activity the potato farming industry created from the new dollars contributed to the Colorado economy in 2022. As stated in Section 2.1.2 the economic output is evaluated based on exogenous final demand and the output multiplier. For Colorado's potato farming industry, exogenous final demand is $81,765,534.00 and the output multiplier is 2.026. So, for every $1 in exogenous final demand the potato industry produces 2.026 units of output. For the whole state of Colorado, the economic output is smaller than the value of production, $244.9 million, indicating that the state retains a lot of its potato production rather than capturing export income, a point that may be important in the current climate of uncertain trade. This can be interpreted as most of the potatoes produced in Colorado are consumed inside Colorado's borders. There are still potatoes that leave the state, indicated by the positive domestic trade income in the potato farming sector row in the SAM

industry for Colorado, $53,815,778.00. So, for Colorado the direct effect of the production of potatoes is larger than the economic activity the industry produces.

Still, the economic contribution from Colorado's potato farming industry consists of more than just the output from the industry. Other large contributors are employment and labor income. The per million employment multipliers for 2022, Table 2.4, indicate that the Colorado potato farming industry directly employs about 1,514 full-time equivalent workers. These are workers that are directly working in potato production. In addition to the 1,514 potato production workers, the Colorado potato farming industry also supports 1,626 jobs outside of direct employment. These jobs could range widely across economic sectors, from potato packers to toothbrush manufacturing, so long as the industry links back to the Colorado potato farming industry. The ratio of direct employment to indirect and induced employment is about 1 to 1, indicating that for every 1 direct potato farming job there is 1 job that is supported by the potato farming industry (see Table 2.2). The employees of the potato farming industry, including both workers and owners, are paid an income. The direct labor income paid to employees of the Colorado potato farming industry has a total value of $73,040,025.00. The additional labor income paid to the indirect and induced labor is valued at $87,630,939.00. The labor income paid to employees plays an additional role in spurring the economic contributions from the potato farming industry through the additional spending from potato employees. An employee takes their paycheck home and then spends it on various things – groceries, bills, recreation, etc. These spending activities then link back to the potato industry and create economic output.

The results from the economic contribution analysis were verified using the method discussed in Section 2.1.2. The total value of output in Colorado calculated from the approximated 2022 matrix is $861.7 billion, which is nearly identical to the actual total value of

output listed by IMPLAN for 2022. The sum of the all the production values, or gross output, for producing industries is equivalent to the sum of all the economic output for all endogenous industries. This indicates that the value of the economy is not changed through economic contribution analysis, it only changes the way the economy is divided.

2.5.2 San Luis Valley Economic Contribution

Table 2.7 2022 Economic Contribution of the Potato Farming Industry: San Luis Valley

Effect	Farm-gate Value of Production ($)	Economic Output ($)	Employment (persons)	Labor Income ($)
Direct	202,143,536.00	-	869	62,339,668.00
Indirect &Induced	-	327,977,203.00	1,371	60,390,149.00
Total	202,143,536.00	327,977,203.00	2,240	122,729,817.00

Sources: USDA NASS Quick Stats, 2021; IMPLAN, 2022 & 2021

The potato industry within the San Luis Valley contributed $443 million to the region's economy. The large economic output value is due, in part, to the amount of export activity the region participates in, some of which simply flows to other parts of Colorado (as discussed above). As discussed in the introduction, the SLV produces about 90% of the potatoes in Colorado, but the region does not consume that proportion of potatoes. According to the 2020 census the population size of the six-county region is 41,114 (U.S. Census Bureau, 2025). This is only 0.7% of the state of Colorado's population. With such a large potato production supply, but such a small population, it would make sense that a significant amount of the potatoes produced in the region leave the region. This is shown by the fact that the value of production, $202,143,536.00, is smaller than the economic output. The exogenous final demand, which includes the export market for the SLV, is $191,145,750.00. This is a large portion of the total

production value of potatoes in the SLV, again indicating that a large portion of the demand for potatoes is external to the region. Since exogenous final demand is a determinant part of the calculation for economic output, having such a large exogenous final demand increases the economic output value. The output multiplier for the SLV potato farming industry is 1.716, smaller than Colorado.

The gross economic output from the potato farming industry in the SLV is also driven by the employment and labor income created by the industry. In the San Luis Valley, there are 869 full-time equivalent jobs that are directly in the potato farming industry according to calculations from the per million multiplier effects in Table 2.5. These jobs earned a total income of $62,339,668.00 in 2022. In addition to the jobs directly in the potato farming industry there are indirect and induced jobs that totaled 1,371 full-time equivalences. These jobs earned a total income of $60,390,149.00. The summary employment multiplier for the potato farming industry in the SLV was about 3 (see Table 2.3). This means that for every 1 direct job in the potato farming industry in the SLV there were 2 jobs that were supported by the industry in the broader regional economy. The income that was earned by the laborers and owners was then spent on goods and services. The spending activity from labor income contributed to the relatively high economic contribution of the SLV potato farming industry to the broader economy. The spending activities that happen outside of the potato farming industry, by people connected to the potato farming industry, still contribute to the economic output of the industry because the industries in an economy are interconnected.

2.6 Discussion

2.6.1 Limitations

As there are in any research, there are limitations that exist in this research and methodology. The first limitation to this research is that the matrices used to represent the SLV and Colorado were customized to display a more normal year for the vegetable and melon sector so that an exceptional year (such as 2022) does not unintentionally inflate expectations of contributions in a more typical year. Both matrices were customized to deflate the potato prices in 2022, meaning the modeled economies used to analyze economic contribution are estimations and not the actual economy that occurred in 2022.

The second limitation is that IMPLAN only provides data to a certain degree of disaggregation, so if the sector that is desired does not explicitly exist in IMPLAN the researcher must do their own disaggregation. The Colorado SAM required disaggregation of the vegetable and melon industry. The disaggregation for the Colorado SAM was done assuming that the same proportions of expenditures and income applied to the potato farming industry as the entire vegetable and melon sector. This assumption may have caused some cells in the matrix to be undervalued or overvalued. So, this thesis's attention to this limitation is actually one of its key contributions.

Another limitation of this research is that IMPLAN relies on a large number of sources to compile data to form the industry SAMs. A lot of data can be good, but it makes it nearly impossible to verify that all the data that IMPLAN presents is correct. In short, reliance on the IMPLAN data can lead to unbacked claims.

Lastly, the economic contribution analysis in this research produced values that seem to conflict with each other. The economic output of the potato farming industry in the San Luis Valley, a region of Colorado, is larger than the same industry's economic output in Colorado. Intuition would have most people think this is wrong or backwards. Yet, these upside-down

effects can occur when production is very concentrated in a small region, like the SLV where 90% of potato production occurs. The high concentration of production, causing economic output to be larger in a small region than the whole state, causes the regional purchase coefficients (RPC) to be higher in the small region. A high RPC means that a large amount of local demand is met by local supply and indicates a region has a low dependency on imports. The RPC for the vegetable and melon sector for the SLV is 71.84% and Colorado is 38.11%. The high coefficients often result in higher multipliers, further inflating the economic output of the region. Since the model used in this paper assumes that local demand is met first, it may underestimate leakages and overstate the local economic contribution when a high production concentration is occurring where leakages represent economic activity that leaves the regional economy, rather than circles within it. Unfortunately, the spatial modeling that is done in this paper does not do a good job of explaining why this event occurs. A method that may give way to addressing this issue is discussed below.

2.6.2 Future Research

To address and better explain the "upside-down effect" that occurs in the San Luis Valley because of the high concentration of potato production, a method known as multiregional input-output (MRIO) modeling could be used in future research projects. This method is different from the one used in this paper because it creates two regions: the San Luis Valley and the rest of Colorado. Instead of trying to compare the whole state and the region inside it, the MRIO model captures how the region interacts with the rest of the state or the larger region it lies in. The MRIO model aims to capture interregional trade flows and the economic interdependences between the two, or more, regions. The modeling method helps to address the economic output distortions by tracking trade flows between regions which can improve the accuracy of the

allocation of economic activity and improve the treatment of interregional leakages. Overall, this method will reduce the risk of overstating the economic contributions in the small region where most of the potato production is occurring.

2.7 Conclusion

This study examined the economic contribution of the potato farming industry in the San Luis Valley as well as the broader economy of Colorado. The results of this research concluded that the potato industry contributed substantially to both the SLV regional and Colorado economies through employment and output. However, the relative contribution to the SLV was notably larger than Colorado. As discussed, this large contribution most likely occurred because of the high concentration of potato production in the region. This does not discount the fact that the potato farming industry is important to the SLV. The study sought to look beyond the production output of the two regions and instead provide a broader understanding of how the potato farming industry functions within the SLV and Colorado.

Although the economic output was smaller for Colorado, the industry remains an important part of Colorado's economy supporting employment and supply chains. Regionally, the large economic output in the SLV indicates that there is a large export market for potatoes (outside the region but perhaps within Colorado), and it implies a reliance on purchases made from outside the region. Given the lower export figures at the state level, it is reasonable to assume that a significant portion of Colorado's potato production is retained and consumed within the state's borders. This internal demand highlights the importance of maintaining an efficient potato supply chain to support in-state distributors, processors, and consumers. In conclusion, the potato farming industry remains an important part of Colorado's broader

agricultural sector and a vital part of the SLV's economy. This research reinforces the importance of the potato farming industry to Colorado and the San Luis Valley.

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APPENDIX A: Matrices after RAS Adjustment

Table A1. San Luis Valley Matrix Totals Before and After RAS Adjustment

IMPLAN Industry	Pre-adjustment Column Totals	Pre-adjustment Row Totals	Post-adjustment Column and Row Totals	% Change in Column Totals After Adjustment	% Change in Row Totals After Adjustment
Oilseed farming	1,607,299.79	1,623,262.79	1,623,262.79	-0.993%	0.000%
Grain farming	30,922,780.06	30,935,538.72	30,935,538.72	-0.041%	0.000%
Vegetable and Melon Farming	202,143,536.22	202,143,536.22	202,143,536.22	0.000%	0.000%
Fruit farming	18,582.33	18,579.76	18,579.76	0.014%	0.000%
Tree nut farming	10.22	10.25	10.25	-0.222%	0.000%
Greenhouse, nursery, and floriculture production	4,244,136.53	4,244,159.42	4,244,159.42	-0.001%	0.000%
All other crop farming	101,712,445.05	101,831,476.81	101,831,476.81	-0.117%	0.000%
Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming	136,247,225.80	136,195,645.14	136,195,645.14	0.038%	0.000%
Dairy cattle and milk production	8,733,464.69	8,721,031.16	8,721,031.16	0.142%	0.000%
Poultry and egg production	2,493,112.00	2,489,360.04	2,489,360.04	0.150%	0.000%
Animal production, except cattle and poultry and eggs	10,423,860.30	10,430,949.57	10,430,949.57	-0.068%	0.000%
Forestry, forest products, and timber tract production	293,412.80	293,852.91	293,852.91	-0.150%	0.000%
Commercial logging	4,483,386.94	4,485,066.35	4,485,066.35	-0.037%	0.000%
Commercial hunting and trapping	18,305,579.02	18,306,501.80	18,306,501.80	-0.005%	0.000%

Support activities for agriculture and forestry	61,937,665.32	54,618,356.52	54,618,356.52	11.817%	0.000%
Oil and gas extraction	68,894,690.98	68,888,274.65	68,888,274.65	0.009%	0.000%
Coal mining	10,511,819.29	10,511,819.29	10,511,819.29	0.000%	0.000%
Gold ore mining	18,383,081.86	18,383,081.86	18,383,081.86	0.000%	0.000%
Silver ore mining	1,993,832.79	1,993,832.79	1,993,832.79	0.000%	0.000%
Stone mining and quarrying	6,301,195.79	6,265,647.83	6,265,647.83	0.564%	0.000%
Potash, soda, and borate mineral mining	1,780,587.87	1,775,902.46	1,775,902.46	0.263%	0.000%
Phosphate rock mining	704,195.97	703,232.64	703,232.64	0.137%	0.000%
Other chemical and fertilizer mineral mining	1,220,421.50	1,220,081.65	1,220,081.65	0.028%	0.000%
Other nonmetallic minerals	1,897,620.84	1,897,387.65	1,897,387.65	0.012%	0.000%
Drilling oil and gas wells	1,709,291.03	1,709,286.84	1,709,286.84	0.000%	0.000%
Support activities for oil and gas operations	4,717,859.88	4,717,860.81	4,717,860.81	0.000%	0.000%
Metal mining services	5,675,715.11	5,669,554.60	5,669,554.60	0.109%	0.000%
Other nonmetallic minerals services	5,501,672.31	5,501,301.25	5,501,301.25	0.007%	0.000%
Electric power generation - Hydroelectric	2,611,325.59	2,611,325.59	2,611,325.59	0.000%	0.000%
Electric power generation - Solar	6,010,333.21	6,010,333.21	6,010,333.21	0.000%	0.000%
Electric power transmission and distribution	192,571,885.40	192,485,929.78	192,485,929.78	0.045%	0.000%

Water, sewage and other systems	9,252,445.19	9,171,204.88	9,171,204.88	0.878%	0.000%
Construction of new health care structures	6,994,434.42	6,994,426.02	6,994,426.02	0.000%	0.000%
Construction of new manufacturing structures	11,227,916.41	11,227,914.67	11,227,914.67	0.000%	0.000%
Construction of new power and communication structures	18,275,097.38	18,275,091.28	18,275,091.28	0.000%	0.000%
Construction of new educational and vocational structures	15,372,578.23	15,372,546.58	15,372,546.58	0.000%	0.000%
Construction of new highways and streets	22,132,743.38	22,132,728.72	22,132,728.72	0.000%	0.000%
Construction of new commercial structures, including farm structures	25,365,240.26	25,365,184.34	25,365,184.34	0.000%	0.000%
Construction of other new nonresidential structures	17,368,891.75	17,368,855.87	17,368,855.87	0.000%	0.000%
Construction of new single-family residential structures	52,991,326.91	52,991,365.06	52,991,365.06	0.000%	0.000%
Construction of new multifamily residential structures	10,861,162.64	10,861,155.96	10,861,155.96	0.000%	0.000%
Construction of other new residential structures	45,912,048.13	45,911,980.01	45,911,980.01	0.000%	0.000%
Maintenance and repair construction of nonresidential structures	28,004,809.35	28,062,264.82	28,062,264.82	-0.205%	0.000%

Maintenance and repair construction of residential structures	12,430,214.57	12,430,205.02	12,430,205.02	0.000%	0.000%
Maintenance and repair construction of highways, streets, bridges, and tunnels	4,939,427.77	4,939,425.76	4,939,425.76	0.000%	0.000%
Other animal food manufacturing	2,280,257.27	2,280,244.67	2,280,244.67	0.001%	0.000%
Malt manufacturing	16,417,238.31	16,417,232.02	16,417,232.02	0.000%	0.000%
Dehydrated food products manufacturing	13,680,474.89	13,617,492.66	13,617,492.66	0.460%	0.000%
Frozen cakes and other pastries manufacturing	2,742,266.01	2,742,265.65	2,742,265.65	0.000%	0.000%
Animal, except poultry, slaughtering	21,229,739.02	21,229,739.33	21,229,739.33	0.000%	0.000%
Meat processed from carcasses	43,238,431.04	43,238,419.86	43,238,419.86	0.000%	0.000%
Rendering and meat byproduct processing	722,845.53	722,845.62	722,845.62	0.000%	0.000%
Bread and bakery product, except frozen, manufacturing	7,415,474.99	7,415,469.14	7,415,469.14	0.000%	0.000%
Tortilla manufacturing	2,082,806.24	2,082,806.58	2,082,806.58	0.000%	0.000%
Roasted nuts and peanut butter manufacturing	1,759,130.54	1,759,130.54	1,759,130.54	0.000%	0.000%
Other snack food manufacturing	1,977,109.73	1,977,637.00	1,977,637.00	-0.027%	0.000%
Breweries	8,558,664.10	8,558,668.52	8,558,668.52	0.000%	0.000%
Distilleries	4,226,618.62	4,226,618.62	4,226,618.62	0.000%	0.000%

Textile and fabric finishing mills	155,464.98	155,464.98	155,464.98	0.000%	0.000%
Textile bag and canvas mills	1,120,511.60	1,119,910.21	1,119,910.21	0.054%	0.000%
Other textile product mills	773,986.81	773,980.73	773,980.73	0.001%	0.000%
Men's and boys' cut and sew apparel manufacturing	955,228.77	955,228.77	955,228.77	0.000%	0.000%
Sawmills	26,938,678.19	26,928,951.13	26,928,951.13	0.036%	0.000%
Wood windows and door manufacturing	762,838.88	762,845.09	762,845.09	-0.001%	0.000%
Other millwork, including flooring	927,827.80	927,827.97	927,827.97	0.000%	0.000%
Prefabricated wood building manufacturing	4,886,577.96	4,886,595.83	4,886,595.83	0.000%	0.000%
All other miscellaneous wood product manufacturing	377,186.65	377,822.86	377,822.86	-0.169%	0.000%
Paperboard container manufacturing	3,328,461.18	3,319,570.84	3,319,570.84	0.267%	0.000%
Printing	3,019,188.35	3,019,165.83	3,019,165.83	0.001%	0.000%
Petroleum refineries	56,159,970.38	56,035,398.40	56,035,398.40	0.222%	0.000%
Fertilizer mixing	6,272,304.73	6,273,828.84	6,273,828.84	-0.024%	0.000%
Medicinal and botanical manufacturing	4,340,775.33	4,340,775.33	4,340,775.33	0.000%	0.000%
Pharmaceutical preparation manufacturing	10,306,181.58	10,306,319.20	10,306,319.20	-0.001%	0.000%
Other plastics product manufacturing	785,430.61	785,417.60	785,417.60	0.002%	0.000%
Pottery, ceramics, and plumbing fixture manufacturing	7,057,406.78	7,057,406.42	7,057,406.42	0.000%	0.000%

Ready-mix concrete manufacturing	14,067,236.76	14,065,554.78	14,065,554.78	0.012%	0.000%
Cut stone and stone product manufacturing	986,642.50	985,681.36	985,681.36	0.097%	0.000%
Iron and steel mills and ferroalloy manufacturing	14,053,714.70	14,053,752.96	14,053,752.96	0.000%	0.000%
Prefabricated metal buildings and components manufacturing	2,955,494.17	2,954,339.37	2,954,339.37	0.039%	0.000%
Sheet metal work manufacturing	1,969,357.91	1,969,360.87	1,969,360.87	0.000%	0.000%
Ornamental and architectural metal work manufacturing	3,097,988.85	3,097,842.55	3,097,842.55	0.005%	0.000%
Machine shops	2,919,547.17	2,919,596.75	2,919,596.75	-0.002%	0.000%
Farm machinery and equipment manufacturing	16,109,440.69	16,093,608.22	16,093,608.22	0.098%	0.000%
Other engine equipment manufacturing	3,888,760.76	3,888,754.17	3,888,754.17	0.000%	0.000%
Semiconductor and related device manufacturing	13,083,636.86	13,083,636.84	13,083,636.84	0.000%	0.000%
Search, detection, and navigation instruments manufacturing	1,780,037.63	1,780,037.33	1,780,037.33	0.000%	0.000%
Motor and generator manufacturing	427,158.34	427,158.10	427,158.10	0.000%	0.000%
Motor vehicle gasoline engine and engine parts manufacturing	14,231,147.24	14,229,787.66	14,229,787.66	0.010%	0.000%
Motor vehicle seating and interior trim manufacturing	689,192.87	689,186.26	689,186.26	0.001%	0.000%

Guided missile and space vehicle manufacturing	2,035,183.88	2,035,183.88	2,035,183.88	0.000%	0.000%
Wood kitchen cabinet and countertop manufacturing	1,480,342.16	1,480,340.43	1,480,340.43	0.000%	0.000%
Nonupholstered wood household furniture manufacturing	858,231.01	858,222.46	858,222.46	0.001%	0.000%
Blind and shade manufacturing	1,775,843.46	1,775,840.70	1,775,840.70	0.000%	0.000%
Surgical and medical instrument manufacturing	2,513,705.24	2,513,667.27	2,513,667.27	0.002%	0.000%
Jewelry and silverware manufacturing	1,172,575.84	1,172,564.67	1,172,564.67	0.001%	0.000%
Sporting and athletic goods manufacturing	2,884,306.14	2,884,293.17	2,884,293.17	0.000%	0.000%
All other miscellaneous manufacturing	10,437,180.18	10,437,150.09	10,437,150.09	0.000%	0.000%
Wholesale - Motor vehicle and motor vehicle parts and supplies	6,216,803.09	6,231,580.69	6,231,580.69	-0.238%	0.000%
Wholesale - Professional and commercial equipment and supplies	3,787,573.36	3,793,175.68	3,793,175.68	-0.148%	0.000%
Wholesale - Household appliances and electrical and electronic goods	5,201,586.79	5,206,007.30	5,206,007.30	-0.085%	0.000%
Wholesale - Machinery, equipment, and supplies	40,936,093.76	40,943,098.62	40,943,098.62	-0.017%	0.000%
Wholesale - Other durable goods merchant wholesalers	18,472,787.16	18,471,226.78	18,471,226.78	0.008%	0.000%

Wholesale - Drugs and druggistsâ€™ sundries	7,625,271.91	7,623,516.30	7,623,516.30	0.023%	0.000%
Wholesale - Grocery and related product wholesalers	52,332,106.41	52,079,035.07	52,079,035.07	0.484%	0.000%
Wholesale - Petroleum and petroleum products	19,728,279.77	19,718,024.07	19,718,024.07	0.052%	0.000%
Wholesale - Other nondurable goods merchant wholesalers	83,867,980.93	82,725,365.06	82,725,365.06	1.362%	0.000%
Wholesale - Wholesale electronic markets and agents and brokers	963,987.02	966,965.69	966,965.69	-0.309%	0.000%
Retail - Motor vehicle and parts dealers	13,675,475.22	13,675,472.09	13,675,472.09	0.000%	0.000%
Retail - Furniture and home furnishings stores	7,812,283.49	7,812,171.39	7,812,171.39	0.001%	0.000%
Retail - Electronics and appliance stores	7,547,899.96	7,547,761.64	7,547,761.64	0.002%	0.000%
Retail - Building material and garden equipment and supplies stores	24,441,104.92	24,439,449.66	24,439,449.66	0.007%	0.000%
Retail - Food and beverage stores	43,552,754.96	43,550,706.63	43,550,706.63	0.005%	0.000%
Retail - Health and personal care stores	9,702,787.89	9,702,787.89	9,702,787.89	0.000%	0.000%
Retail - Gasoline stores	23,031,119.17	22,943,461.82	22,943,461.82	0.381%	0.000%
Retail - Clothing and clothing accessories stores	8,615,802.30	8,615,802.30	8,615,802.30	0.000%	0.000%

Retail - Sporting goods, hobby, musical instrument and book stores	9,935,156.81	9,935,018.71	9,935,018.71	0.001%	0.000%
Retail - General merchandise stores	36,684,971.60	36,684,019.36	36,684,019.36	0.003%	0.000%
Retail - Miscellaneous store retailers	14,863,295.97	14,863,282.65	14,863,282.65	0.000%	0.000%
Retail - Nonstore retailers	76,311,671.51	76,297,947.89	76,297,947.89	0.018%	0.000%
Air transportation	10,627,102.91	10,623,342.17	10,623,342.17	0.035%	0.000%
Rail transportation	12,742,604.32	12,694,389.56	12,694,389.56	0.378%	0.000%
Water transportation	982,593.45	1,001,141.16	1,001,141.16	-1.888%	0.000%
Truck transportation	44,328,658.52	44,245,575.98	44,245,575.98	0.187%	0.000%
Transit and ground passenger transportation	2,429,456.75	2,429,456.75	2,429,456.75	0.000%	0.000%
Pipeline transportation	5,608,192.34	5,613,813.90	5,613,813.90	-0.100%	0.000%
Scenic and sightseeing transportation and support activities for transportation	3,842,822.32	3,843,367.44	3,843,367.44	-0.014%	0.000%
Couriers and messengers	12,724,499.81	12,724,625.42	12,724,625.42	-0.001%	0.000%
Warehousing and storage	6,653,686.70	6,645,121.39	6,645,121.39	0.129%	0.000%
Newspaper publishers	2,341,358.50	2,341,405.80	2,341,405.80	-0.002%	0.000%
Software publishers	7,801,402.62	7,779,627.84	7,779,627.84	0.279%	0.000%
Motion picture and video industries	11,263,336.63	11,263,404.49	11,263,404.49	-0.001%	0.000%

Sound recording industries	435,944.52	435,949.60	435,949.60	-0.001%	0.000%
Radio and television broadcasting	7,191,806.96	7,191,766.78	7,191,766.78	0.001%	0.000%
Cable and other subscription programming	28,433,971.37	28,432,692.11	28,432,692.11	0.004%	0.000%
Wired telecommunications carriers	21,232,401.55	21,223,854.36	21,223,854.36	0.040%	0.000%
Wireless telecommunications carriers (except satellite)	4,781,263.03	4,790,716.74	4,790,716.74	-0.198%	0.000%
Satellite, telecommunications resellers, and all other telecommunications	23,807,848.33	23,806,386.12	23,806,386.12	0.006%	0.000%
Data processing, hosting, and related services	22,740,297.31	22,737,564.59	22,737,564.59	0.012%	0.000%
Internet publishing and broadcasting and web search portals	10,782,639.46	10,781,954.35	10,781,954.35	0.006%	0.000%
Nondepository credit intermediation and related activities	4,712,003.85	4,716,952.88	4,716,952.88	-0.105%	0.000%
Securities and commodity contracts intermediation and brokerage	14,886,309.24	14,881,177.28	14,881,177.28	0.034%	0.000%
Monetary authorities and depository credit intermediation	92,058,946.98	91,965,152.35	91,965,152.35	0.102%	0.000%
Other financial investment activities	33,416,360.52	33,423,051.81	33,423,051.81	-0.020%	0.000%

Insurance carriers, except direct life	294,986,321.82	294,583,833.38	294,583,833.38	0.136%	0.000%
Insurance agencies, brokerages, and related activities	22,901,684.33	22,991,349.88	22,991,349.88	-0.392%	0.000%
Funds, trusts, and other financial vehicles	32,243,460.83	32,243,298.75	32,243,298.75	0.001%	0.000%
Other real estate	130,424,634.48	128,849,537.81	128,849,537.81	1.208%	0.000%
Tenant-occupied housing	41,572,949.93	41,572,928.88	41,572,928.88	0.000%	0.000%
Owner-occupied dwellings	265,004,646.76	265,004,646.76	265,004,646.76	0.000%	0.000%
Automotive equipment rental and leasing	2,991,542.59	3,016,458.25	3,016,458.25	-0.833%	0.000%
General and consumer goods rental except video tapes and discs	5,791,253.39	5,803,262.52	5,803,262.52	-0.207%	0.000%
Video tape and disc rental	2,318,281.93	2,318,281.05	2,318,281.05	0.000%	0.000%
Commercial and industrial machinery and equipment rental and leasing	21,028,959.67	20,592,298.42	20,592,298.42	2.076%	0.000%
Lessors of nonfinancial intangible assets	1,236,358.29	1,247,650.28	1,247,650.28	-0.913%	0.000%
Legal services	13,414,570.39	13,423,624.45	13,423,624.45	-0.067%	0.000%
Accounting, tax preparation, bookkeeping, and payroll services	25,476,841.00	25,431,746.49	25,431,746.49	0.177%	0.000%

Architectural, engineering, and related services	21,556,514.33	21,556,783.83	21,556,783.83	-0.001%	0.000%
Specialized design services	619,843.39	619,838.84	619,838.84	0.001%	0.000%
Custom computer programming services	10,864,582.15	10,855,233.36	10,855,233.36	0.086%	0.000%
Computer systems design services	3,372,473.71	3,374,550.07	3,374,550.07	-0.062%	0.000%
Other computer related services, including facilities management	351,363.68	347,156.51	347,156.51	1.197%	0.000%
Management consulting services	5,382,309.45	5,382,305.34	5,382,305.34	0.000%	0.000%
Environmental and other technical consulting services	6,915,031.22	6,915,221.89	6,915,221.89	-0.003%	0.000%
Scientific research and development services	36,105,515.70	36,105,846.18	36,105,846.18	-0.001%	0.000%
Advertising, public relations, and related services	5,693,918.55	5,693,574.90	5,693,574.90	0.006%	0.000%
Photographic services	156,464.64	156,461.72	156,461.72	0.002%	0.000%
Veterinary services	2,385,301.93	2,385,295.66	2,385,295.66	0.000%	0.000%
Marketing research and all other miscellaneous professional, scientific, and technical services	1,872,851.94	1,872,937.33	1,872,937.33	-0.005%	0.000%
Management of companies and enterprises	19,753,339.95	19,750,647.35	19,750,647.35	0.014%	0.000%
Office administrative services	1,174,802.82	1,173,979.97	1,173,979.97	0.070%	0.000%

Employment services	9,803,788.76	9,803,230.70	9,803,230.70	0.006%	0.000%
Business support services	5,021,751.84	5,021,712.86	5,021,712.86	0.001%	0.000%
Travel arrangement and reservation services	7,867,257.93	7,838,162.31	7,838,162.31	0.370%	0.000%
Services to buildings	5,113,466.72	5,137,179.24	5,137,179.24	-0.464%	0.000%
Landscape and horticultural services	5,936,733.35	5,964,422.31	5,964,422.31	-0.466%	0.000%
Other support services	7,493,400.06	7,492,275.43	7,492,275.43	0.015%	0.000%
Waste management and remediation services	10,614,196.08	10,623,765.02	10,623,765.02	-0.090%	0.000%
Junior colleges, colleges, universities, and professional schools	2,138,812.35	2,138,551.29	2,138,551.29	0.012%	0.000%
Other educational services	8,093,813.90	8,093,539.86	8,093,539.86	0.003%	0.000%
Offices of physicians	25,181,595.40	25,181,471.10	25,181,471.10	0.000%	0.000%
Offices of dentists	13,302,891.06	13,302,903.43	13,302,903.43	0.000%	0.000%
Offices of other health practitioners	12,413,028.03	12,413,052.56	12,413,052.56	0.000%	0.000%
Outpatient care centers	28,966,626.10	28,966,571.94	28,966,571.94	0.000%	0.000%
Medical and diagnostic laboratories	150,669.03	150,669.66	150,669.66	0.000%	0.000%
Home health care services	4,622,501.62	4,622,478.76	4,622,478.76	0.000%	0.000%
Other ambulatory health care services	12,064,098.61	12,064,143.67	12,064,143.67	0.000%	0.000%

Hospitals	212,600,980.87	212,601,003.59	212,601,003.59	0.000%	0.000%
Nursing and community care facilities	25,093,387.17	25,093,418.05	25,093,418.05	0.000%	0.000%
Residential intellectual disability, mental health, substance abuse and other facilities	7,118,329.65	7,118,317.46	7,118,317.46	0.000%	0.000%
Individual and family services	12,750,025.88	12,750,029.40	12,750,029.40	0.000%	0.000%
Child day care services	13,208,893.25	13,208,866.58	13,208,866.58	0.000%	0.000%
Community food, housing, and other relief services, including rehabilitation services	8,457,197.98	8,457,097.38	8,457,097.38	0.001%	0.000%
Performing arts companies	5,998,027.46	5,998,048.80	5,998,048.80	0.000%	0.000%
Commercial Sports Except Racing	4,270,916.10	4,269,892.50	4,269,892.50	0.024%	0.000%
Racing and Track Operation	48,907.96	49,460.11	49,460.11	-1.129%	0.000%
Independent artists, writers, and performers	5,838,775.71	5,838,775.71	5,838,775.71	0.000%	0.000%
Promoters of performing arts and sports and agents for public figures	3,588,270.48	3,588,376.04	3,588,376.04	-0.003%	0.000%
Amusement parks and arcades	100,533.21	100,533.03	100,533.03	0.000%	0.000%
Gambling industries (except casino hotels)	20,355,485.37	20,355,236.65	20,355,236.65	0.001%	0.000%

Other amusement and recreation industries	9,527,955.29	9,529,462.22	9,529,462.22	-0.016%	0.000%
Fitness and recreational sports centers	1,359,218.82	1,359,198.15	1,359,198.15	0.002%	0.000%
Bowling centers	428,868.04	428,862.46	428,862.46	0.001%	0.000%
Hotels and motels, including casino hotels	33,810,163.56	33,809,877.73	33,809,877.73	0.001%	0.000%
Other accommodations	13,737,496.66	13,737,416.72	13,737,416.72	0.001%	0.000%
Full-service restaurants	61,009,855.63	60,986,304.15	60,986,304.15	0.039%	0.000%
Limited-service restaurants	57,499,066.82	57,498,731.29	57,498,731.29	0.001%	0.000%
All other food and drinking places	20,034,735.46	20,033,111.35	20,033,111.35	0.008%	0.000%
Automotive repair and maintenance, except car washes	24,221,824.94	24,217,858.53	24,217,858.53	0.016%	0.000%
Car washes	11,028,129.88	11,028,114.82	11,028,114.82	0.000%	0.000%
Electronic and precision equipment repair and maintenance	1,884,119.36	1,882,169.04	1,882,169.04	0.104%	0.000%
Commercial and industrial machinery and equipment repair and maintenance	7,923,073.78	7,923,104.39	7,923,104.39	0.000%	0.000%
Personal and household goods repair and maintenance	2,215,028.38	2,215,028.38	2,215,028.38	0.000%	0.000%
Personal care services	1,882,771.51	1,882,777.12	1,882,777.12	0.000%	0.000%
Death care services	1,371,068.15	1,371,068.15	1,371,068.15	0.000%	0.000%

Dry-cleaning and laundry services	3,601,715.15	3,601,481.61	3,601,481.61	0.006%	0.000%
Other personal services	5,394,694.87	5,394,701.91	5,394,701.91	0.000%	0.000%
Religious organizations	19,372,961.48	19,373,287.20	19,373,287.20	-0.002%	0.000%
Grantmaking, giving, and social advocacy organizations	14,492,304.12	14,492,421.32	14,492,421.32	-0.001%	0.000%
Business and professional associations	827,238.27	829,197.50	829,197.50	-0.237%	0.000%
Labor and civic organizations	9,036,524.14	9,036,409.72	9,036,409.72	0.001%	0.000%
Private households	1,375,253.93	1,375,253.93	1,375,253.93	0.000%	0.000%
Postal service	8,368,753.87	8,370,426.76	8,370,426.76	-0.020%	0.000%
Other federal government enterprises	91,843.15	91,990.77	91,990.77	-0.161%	0.000%
Other local government enterprises	32,570,369.93	32,605,630.79	32,605,630.79	-0.108%	0.000%
* Employment and payroll of state govt, education	27,208,895.72	27,208,895.72	27,208,895.72	0.000%	0.000%
* Employment and payroll of state govt, hospitals and health services	4,369,484.08	4,369,484.08	4,369,484.08	0.000%	0.000%
* Employment and payroll of state govt, other services	62,648,288.21	62,648,288.21	62,648,288.21	0.000%	0.000%
* Employment and payroll of local govt, education	82,124,899.18	82,124,899.18	82,124,899.18	0.000%	0.000%
* Employment and payroll of local govt, other services	68,337,702.68	68,337,702.68	68,337,702.68	0.000%	0.000%
* Employment and payroll of federal govt, military	5,079,730.90	5,079,730.90	5,079,730.90	0.000%	0.000%

* Employment and payroll of federal govt, non-military	40,667,493.37	40,667,493.37	40,667,493.37	0.000%	0.000%
Employee Compensation	1,034,710,935.45	1,033,534,212.84	1,033,534,212.84	0.114%	0.000%
Proprietor Income	265,503,607.09	271,097,688.71	271,097,688.71	-2.107%	0.000%
Other Property Type Income	604,465,613.09	641,367,262.74	641,367,262.74	-6.105%	0.000%
Tax on Production and Imports	182,656,966.07	183,491,212.07	183,491,212.07	-0.457%	0.000%
Households LT15k	174,036,150.42	173,958,850.13	173,958,850.13	0.044%	0.000%
Households 15-30k	268,951,598.34	268,891,329.55	268,891,329.55	0.022%	0.000%
Households 30-40k	197,324,069.43	197,244,366.25	197,244,366.25	0.040%	0.000%
Households 40-50k	235,480,695.96	235,488,351.24	235,488,351.24	-0.003%	0.000%
Households 50-70k	356,276,815.55	356,262,813.85	356,262,813.85	0.004%	0.000%
Households 70-100k	411,899,112.85	411,893,908.14	411,893,908.14	0.001%	0.000%
Households 100-150k	467,575,118.79	467,609,352.40	467,609,352.40	-0.007%	0.000%
Households 150-200k	189,790,523.76	189,765,917.66	189,765,917.66	0.013%	0.000%
Households GT200k	345,476,762.48	345,534,943.09	345,534,943.09	-0.017%	0.000%
Federal Government Nondefense	727,708,052.05	727,705,447.96	727,705,447.96	0.000%	0.000%
Federal Government Defense	10,177,638.36	10,177,455.00	10,177,455.00	0.002%	0.000%
Federal Government Investment	25,458,054.18	25,458,054.18	25,458,054.18	0.000%	0.000%
State/Local Govt Other	584,353,785.92	584,343,529.43	584,343,529.43	0.002%	0.000%
State/Local Govt Education	144,190,813.51	144,189,776.49	144,189,776.49	0.001%	0.000%
State/Local Govt Hospital and Health	8,568,246.90	8,568,610.31	8,568,610.31	-0.004%	0.000%
State/Local Govt Investment	84,197,683.49	84,197,683.49	84,197,683.49	0.000%	0.000%
Enterprises (Corporations)	220,022,117.71	220,022,117.71	220,022,117.72	0.000%	0.000%
Capital	1,530,481,102.26	1,530,481,102.26	1,530,481,102.26	0.000%	0.000%

Inventory Additions/Deletions	42,593,045.64	42,643,683.83	42,643,683.83	-0.119%	0.000%
Foreign Trade	398,827,063.30	396,335,570.97	396,335,570.97	0.625%	0.000%
Domestic Trade	2,384,720,658.94	2,356,805,314.46	2,356,805,314.46	1.171%	0.000%

Sources: IMPLAN, 2022 & 2021; USDA NASS Quick Stats, 2021

Table A2. Colorado Matrix Totals Before and After RAS Adjustment

IMPLAN Industry	**Pre-adjustment Column Totals**	**Pre-adjustment Row Totals**	**Post Adjustment Row and Column Totals**	**% Change in Column Totals After Adjustment**	**% Change in Row Totals After Adjustment**
Oilseed farming	24,918,984.99	24,932,329.18	24,932,329.18	0.054%	0.000%
Grain farming	1,371,423,766.95	1,371,183,295.71	1,371,183,295.70	-0.018%	0.000%
Vegetable and Melon Farming	319,293,394.90	319,293,528.46	319,293,528.46	0.000%	0.000%
Fruit farming	27,762,126.54	27,756,093.25	27,756,093.25	-0.022%	0.000%
Tree nut farming	56,070.84	56,068.55	56,068.55	-0.004%	0.000%
Greenhouse, nursery, and floriculture production	317,957,811.80	317,971,937.32	317,971,937.32	0.004%	0.000%
Sugarcane and sugar beet farming	37,668,341.09	37,659,308.49	37,659,308.49	-0.024%	0.000%
All other crop farming	424,158,724.50	424,156,512.63	424,156,512.62	-0.001%	0.000%
Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming	4,456,160,651.92	4,456,120,947.13	4,456,120,947.12	-0.001%	0.000%

Dairy cattle and milk production	1,360,339,583.40	1,360,175,018.44	1,360,175,018.44	-0.012%	0.000%
Poultry and egg production	245,942,650.29	245,904,057.11	245,904,057.11	-0.016%	0.000%
Animal production, except cattle and poultry and eggs	377,434,754.64	377,480,795.39	377,480,795.39	0.012%	0.000%
Forestry, forest products, and timber tract production	32,128,755.41	32,125,209.39	32,125,209.39	-0.011%	0.000%
Commercial logging	91,230,310.04	91,229,102.71	91,229,102.71	-0.001%	0.000%
Commercial hunting and trapping	74,548,215.13	74,547,709.37	74,547,709.37	-0.001%	0.000%
Support activities for agriculture and forestry	365,640,266.87	364,180,159.33	364,180,159.33	-0.401%	0.000%
Oil and gas extraction	24,526,448,376.70	24,526,245,190.31	24,526,245,190.30	-0.001%	0.000%
Coal mining	823,092,288.30	823,092,288.30	823,092,288.30	0.000%	0.000%
Copper, nickel, lead, and zinc mining	298,664,113.95	298,664,113.95	298,664,113.95	0.000%	0.000%
Gold ore mining	519,601,755.76	519,601,755.76	519,601,755.75	0.000%	0.000%
Silver ore mining	49,464,198.92	49,464,198.92	49,464,198.92	0.000%	0.000%
Uranium-radium-vanadium ore mining	26,327,023.12	26,327,023.12	26,327,023.12	0.000%	0.000%

Other metal ore mining	549,304,085.98	549,304,085.98	549,304,085.98	0.000%	0.000%
Stone mining and quarrying	267,761,752.46	267,684,213.97	267,684,213.97	-0.029%	0.000%
Sand and gravel mining	225,329,909.68	225,329,700.93	225,329,700.93	0.000%	0.000%
Other clay, ceramic, refractory minerals mining	2,062,588.09	2,062,588.09	2,062,588.09	0.000%	0.000%
Potash, soda, and borate mineral mining	34,568,436.42	34,568,929.54	34,568,929.54	0.001%	0.000%
Phosphate rock mining	12,833,384.26	12,832,011.26	12,832,011.26	-0.011%	0.000%
Other chemical and fertilizer mineral mining	22,150,719.97	22,147,550.38	22,147,550.38	-0.014%	0.000%
Other nonmetallic minerals	33,205,818.53	33,205,697.46	33,205,697.46	0.000%	0.000%
Drilling oil and gas wells	2,230,276,313.72	2,230,276,315.18	2,230,276,315.18	0.000%	0.000%
Support activities for oil and gas operations	5,309,436,919.28	5,309,436,909.29	5,309,436,909.29	0.000%	0.000%
Metal mining services	2,724,441,506.22	2,724,475,455.01	2,724,475,455.01	0.001%	0.000%
Other nonmetallic minerals services	2,483,932,761.81	2,483,929,859.37	2,483,929,859.37	0.000%	0.000%
Electric power generation - Hydroelectric	22,074,650.52	22,074,650.52	22,074,650.52	0.000%	0.000%

Electric power generation - Fossil fuel	851,409,527.44	851,409,527.44	851,409,527.43	0.000%	0.000%
Electric power generation - Solar	263,425,073.89	263,425,073.89	263,425,073.89	0.000%	0.000%
Electric power generation - Wind	961,831,085.38	961,831,085.38	961,831,085.38	0.000%	0.000%
Electric power generation - Biomass	26,625,006.39	26,625,006.39	26,625,006.39	0.000%	0.000%
Electric power generation - All other	656,306.18	656,306.18	656,306.18	0.000%	0.000%
Electric power transmission and distribution	10,101,780,580.50	10,101,773,956.46	10,101,773,956.44	0.000%	0.000%
Natural gas distribution	1,649,436,524.61	1,649,459,955.72	1,649,459,955.72	0.001%	0.000%
Water, sewage and other systems	311,410,638.03	311,413,190.07	311,413,190.07	0.001%	0.000%
Construction of new health care structures	1,399,381,474.06	1,399,381,449.26	1,399,381,449.26	0.000%	0.000%
Construction of new manufacturing structures	2,219,585,886.02	2,219,585,878.70	2,219,585,878.70	0.000%	0.000%
Construction of new power and communication structures	3,757,275,659.30	3,757,275,643.71	3,757,275,643.70	0.000%	0.000%

Construction of new educational and vocational structures	2,899,350,628.55	2,899,350,549.92	2,899,350,549.92	0.000%	0.000%
Construction of new highways and streets	4,141,332,949.57	4,141,332,905.69	4,141,332,905.69	0.000%	0.000%
Construction of new commercial structures, including farm structures	5,053,136,737.51	5,053,136,572.48	5,053,136,572.47	0.000%	0.000%
Construction of other new nonresidential structures	2,894,984,868.54	2,894,984,780.13	2,894,984,780.13	0.000%	0.000%
Construction of new single-family residential structures	11,172,921,179.43	11,172,921,253.31	11,172,921,253.30	0.000%	0.000%
Construction of new multifamily residential structures	2,522,264,297.76	2,522,264,276.29	2,522,264,276.28	0.000%	0.000%
Construction of other new residential structures	9,136,262,337.32	9,136,262,123.24	9,136,262,123.24	0.000%	0.000%
Maintenance and repair construction of nonresidential structures	5,490,244,410.35	5,490,238,952.36	5,490,238,952.35	0.000%	0.000%

Maintenance and repair construction of residential structures	2,349,390,457.81	2,349,390,430.28	2,349,390,430.27	0.000%	0.000%
Maintenance and repair construction of highways, streets, bridges, and tunnels	976,571,901.24	976,571,895.34	976,571,895.34	0.000%	0.000%
Dog and cat food manufacturing	739,714,712.42	739,714,712.42	739,714,712.41	0.000%	0.000%
Other animal food manufacturing	1,098,416,057.63	1,098,415,744.48	1,098,415,744.48	0.000%	0.000%
Flour milling	245,509,451.39	245,509,451.24	245,509,451.24	0.000%	0.000%
Malt manufacturing	44,711,034.43	44,711,034.30	44,711,034.30	0.000%	0.000%
Soybean and other oilseed processing	288,957,587.26	288,957,587.26	288,957,587.26	0.000%	0.000%
Fats and oils refining and blending	228,735,391.45	228,735,391.45	228,735,391.45	0.000%	0.000%
Breakfast cereal manufacturing	188,337,520.02	188,337,520.02	188,337,520.02	0.000%	0.000%
Beet sugar manufacturing	167,966,181.33	167,966,151.01	167,966,151.01	0.000%	0.000%
Nonchocolate confectionery manufacturing	386,988,968.14	386,988,976.17	386,988,976.17	0.000%	0.000%
Chocolate and confectionery manufacturing from cacao beans	6,130,275.11	6,130,274.69	6,130,274.69	0.000%	0.000%

Confectionery manufacturing from purchased chocolate	301,803,272.13	301,803,272.13	301,803,272.13	0.000%	0.000%
Frozen specialties manufacturing	419,187,879.50	419,333,219.40	419,333,219.40	0.035%	0.000%
Canned fruits and vegetables manufacturing	72,493,848.33	72,433,181.12	72,433,181.12	-0.084%	0.000%
Dehydrated food products manufacturing	74,741,483.82	74,683,757.01	74,683,757.01	-0.077%	0.000%
Cheese manufacturing	1,655,714,971.11	1,655,714,971.11	1,655,714,971.11	0.000%	0.000%
Dry, condensed, and evaporated dairy product manufacturing	171,010,414.84	171,010,414.84	171,010,414.84	0.000%	0.000%
Fluid milk manufacturing	636,918,162.02	636,918,155.92	636,918,155.92	0.000%	0.000%
Ice cream and frozen dessert manufacturing	162,822,457.93	162,822,457.93	162,822,457.93	0.000%	0.000%
Frozen cakes and other pastries manufacturing	391,734,753.96	391,734,753.65	391,734,753.65	0.000%	0.000%
Animal, except poultry, slaughtering	5,277,343,314.98	5,277,343,318.59	5,277,343,318.59	0.000%	0.000%
Meat processed from carcasses	941,296,809.22	941,296,806.20	941,296,806.20	0.000%	0.000%

Rendering and meat byproduct processing	84,162,248.84	84,162,249.08	84,162,249.08	0.000%	0.000%
Seafood product preparation and packaging	46,970,206.09	46,970,206.09	46,970,206.09	0.000%	0.000%
Bread and bakery product, except frozen, manufacturing	1,216,347,069.88	1,216,347,070.38	1,216,347,070.38	0.000%	0.000%
Cookie and cracker manufacturing	6,181,594.15	6,181,594.06	6,181,594.06	0.000%	0.000%
Dry pasta, mixes, and dough manufacturing	328,120,959.89	328,122,114.81	328,122,114.81	0.000%	0.000%
Tortilla manufacturing	188,398,940.45	188,398,940.78	188,398,940.77	0.000%	0.000%
Roasted nuts and peanut butter manufacturing	186,690,949.22	186,690,949.22	186,690,949.22	0.000%	0.000%
Other snack food manufacturing	596,093,464.23	596,168,231.53	596,168,231.53	0.013%	0.000%
Coffee and tea manufacturing	555,039,655.19	555,039,655.19	555,039,655.19	0.000%	0.000%
Mayonnaise, dressing, and sauce manufacturing	249,397,307.57	249,173,616.45	249,173,616.45	-0.090%	0.000%
Spice and extract manufacturing	109,370,125.37	109,370,125.39	109,370,125.39	0.000%	0.000%
All other food manufacturing	1,411,525,881.78	1,411,529,753.75	1,411,529,753.75	0.000%	0.000%

Bottled and canned soft drinks & water	1,254,374,197.59	1,254,374,169.33	1,254,374,169.33	0.000%	0.000%
Manufactured ice	26,180,473.60	26,180,473.60	26,180,473.60	0.000%	0.000%
Breweries	2,550,356,719.69	2,550,356,718.01	2,550,356,718.01	0.000%	0.000%
Wineries	157,686,391.77	157,686,394.47	157,686,394.47	0.000%	0.000%
Distilleries	770,762,616.44	770,762,616.44	770,762,616.44	0.000%	0.000%
Tobacco product manufacturing	113,344,071.90	113,344,072.90	113,344,072.90	0.000%	0.000%
Fiber, yarn, and thread mills	877,975.27	877,975.27	877,975.27	0.000%	0.000%
Broadwoven fabric mills	1,827,127.32	1,827,127.32	1,827,127.32	0.000%	0.000%
Textile and fabric finishing mills	31,692,846.31	31,692,846.31	31,692,846.31	0.000%	0.000%
Carpet and rug mills	12,054,448.05	12,054,444.68	12,054,444.68	0.000%	0.000%
Curtain and linen mills	16,228,491.75	16,228,491.71	16,228,491.71	0.000%	0.000%
Textile bag and canvas mills	146,512,085.49	146,504,469.24	146,504,469.24	-0.005%	0.000%
Rope, cordage, twine, tire cord and tire fabric mills	36,865,576.46	36,863,605.28	36,863,605.28	-0.005%	0.000%
Other textile product mills	83,256,625.98	83,256,619.47	83,256,619.47	0.000%	0.000%
Hosiery and sock mills	5,520,923.53	5,520,923.53	5,520,923.53	0.000%	0.000%
Other apparel knitting mills	6,040,771.08	6,040,771.08	6,040,771.08	0.000%	0.000%

Cut and sew apparel contractors	24,090,326.97	24,090,326.97	24,090,326.97	0.000%	0.000%
Men's and boys' cut and sew apparel manufacturing	40,748,124.20	40,748,124.20	40,748,124.20	0.000%	0.000%
Women's and girls' cut and sew apparel manufacturing	70,897,506.07	70,897,490.31	70,897,490.31	0.000%	0.000%
Other cut and sew apparel manufacturing	25,355,932.29	25,355,932.29	25,355,932.29	0.000%	0.000%
Apparel accessories and other apparel manufacturing	60,733,080.81	60,733,080.81	60,733,080.81	0.000%	0.000%
Leather and hide tanning and finishing	8,846,738.93	8,846,738.93	8,846,738.93	0.000%	0.000%
Footwear manufacturing	3,596,420.21	3,596,420.21	3,596,420.21	0.000%	0.000%
Other leather and allied product manufacturing	34,041,678.07	34,041,678.07	34,041,678.07	0.000%	0.000%
Sawmills	205,516,212.62	205,513,105.04	205,513,105.04	-0.002%	0.000%
Wood preservation	224,413,362.85	224,413,241.68	224,413,241.68	0.000%	0.000%
Engineered wood member and truss manufacturing	380,031,571.95	380,031,584.76	380,031,584.76	0.000%	0.000%
Reconstituted wood product manufacturing	60,495,637.27	60,495,638.32	60,495,638.32	0.000%	0.000%

Wood windows and door manufacturing	292,105,264.45	292,105,267.18	292,105,267.18	0.000%	0.000%
Cut stock, resawing lumber, and planing	25,061,066.29	25,061,058.99	25,061,058.99	0.000%	0.000%
Other millwork, including flooring	199,659,962.53	199,659,966.39	199,659,966.38	0.000%	0.000%
Wood container and pallet manufacturing	121,356,549.57	121,103,451.37	121,103,451.37	-0.209%	0.000%
Prefabricated wood building manufacturing	209,767,895.65	209,767,913.32	209,767,913.31	0.000%	0.000%
All other miscellaneous wood product manufacturing	54,410,389.82	54,410,530.64	54,410,530.64	0.000%	0.000%
Paper mills	18,144,440.70	18,144,427.21	18,144,427.21	0.000%	0.000%
Paperboard container manufacturing	671,639,091.08	671,608,919.13	671,608,919.12	-0.004%	0.000%
Paper bag and coated and treated paper manufacturing	47,346,178.85	47,342,831.89	47,342,831.89	-0.007%	0.000%
Stationery product manufacturing	4,419,847.99	4,419,841.48	4,419,841.48	0.000%	0.000%
All other converted paper product manufacturing	23,598,867.51	23,598,843.62	23,598,843.62	0.000%	0.000%
Printing	1,157,567,199.34	1,157,565,973.69	1,157,565,973.68	0.000%	0.000%

Support activities for printing	13,359,827.74	13,359,811.82	13,359,811.82	0.000%	0.000%
Petroleum refineries	6,978,597,140.87	6,978,599,780.74	6,978,599,780.73	0.000%	0.000%
Asphalt paving mixture and block manufacturing	151,213,796.68	151,213,805.51	151,213,805.51	0.000%	0.000%
Asphalt shingle and coating materials manufacturing	294,947,802.08	294,947,788.11	294,947,788.11	0.000%	0.000%
Petroleum lubricating oil and grease manufacturing	47,525,422.07	47,525,374.64	47,525,374.64	0.000%	0.000%
Industrial gas manufacturing	299,148,758.65	299,148,686.88	299,148,686.88	0.000%	0.000%
Synthetic dye and pigment manufacturing	6,944,252.11	6,944,249.01	6,944,249.01	0.000%	0.000%
Other basic inorganic chemical manufacturing	307,572,467.63	307,553,923.77	307,553,923.77	-0.006%	0.000%
Other basic organic chemical manufacturing	368,405,389.77	368,372,079.96	368,372,079.96	-0.009%	0.000%
Plastics material and resin manufacturing	298,637,017.94	298,631,346.02	298,631,346.02	-0.002%	0.000%
Nitrogenous fertilizer manufacturing	95,901,475.34	95,412,397.32	95,412,397.32	-0.513%	0.000%

Fertilizer mixing	99,998,402.19	100,070,758.77	100,070,758.77	0.072%	0.000%
Pesticide and other agricultural chemical manufacturing	19,562,813.52	18,994,549.55	18,994,549.55	-2.992%	0.000%
Medicinal and botanical manufacturing	1,298,444,825.76	1,298,444,825.76	1,298,444,825.76	0.000%	0.000%
Pharmaceutical preparation manufacturing	2,080,687,424.20	2,080,687,494.93	2,080,687,494.93	0.000%	0.000%
In-vitro diagnostic substance manufacturing	16,790,689.82	16,790,689.82	16,790,689.82	0.000%	0.000%
Biological product (except diagnostic) manufacturing	386,993,393.17	386,993,393.17	386,993,393.17	0.000%	0.000%
Paint and coating manufacturing	119,676,770.32	119,676,769.66	119,676,769.66	0.000%	0.000%
Adhesive manufacturing	179,423,144.43	179,423,145.22	179,423,145.22	0.000%	0.000%
Soap and other detergent manufacturing	219,588,577.27	219,588,575.35	219,588,575.35	0.000%	0.000%
Polish and other sanitation good manufacturing	81,183,727.58	81,216,928.25	81,216,928.25	0.041%	0.000%
Surface active agent manufacturing	71,038,991.84	71,038,984.76	71,038,984.76	0.000%	0.000%

Toilet preparation manufacturing	393,423,752.16	393,423,729.25	393,423,729.25	0.000%	0.000%
Printing ink manufacturing	8,838,860.96	8,838,861.01	8,838,861.01	0.000%	0.000%
Custom compounding of purchased resins	4,457,658.58	4,457,657.66	4,457,657.66	0.000%	0.000%
Photographic film and chemical manufacturing	180,742,941.72	180,742,941.98	180,742,941.98	0.000%	0.000%
Other miscellaneous chemical product manufacturing	465,109,490.68	465,089,259.35	465,089,259.35	-0.004%	0.000%
Plastics packaging materials and unlaminated film and sheet manufacturing	131,110,756.61	131,109,488.96	131,109,488.96	-0.001%	0.000%
Unlaminated plastics profile shape manufacturing	76,081,121.83	76,081,113.55	76,081,113.55	0.000%	0.000%
Plastics pipe and pipe fitting manufacturing	416,775,795.14	416,775,795.14	416,775,795.14	0.000%	0.000%
Laminated plastics plate, sheet (except packaging), and shape manufacturing	202,058,861.36	202,058,855.86	202,058,855.86	0.000%	0.000%

Polystyrene foam product manufacturing	55,577,493.17	55,577,477.53	55,577,477.53	0.000%	0.000%
Urethane and other foam product (except polystyrene) manufacturing	139,045,327.91	139,045,325.40	139,045,325.40	0.000%	0.000%
Plastics bottle manufacturing	88,468,380.80	88,468,379.56	88,468,379.56	0.000%	0.000%
Other plastics product manufacturing	1,188,953,099.74	1,188,952,854.55	1,188,952,854.55	0.000%	0.000%
Rubber and plastics hoses and belting manufacturing	215,117,787.11	215,116,445.14	215,116,445.14	-0.001%	0.000%
Other rubber product manufacturing	178,252,677.53	178,252,691.48	178,252,691.48	0.000%	0.000%
Pottery, ceramics, and plumbing fixture manufacturing	289,396,859.09	289,396,856.26	289,396,856.26	0.000%	0.000%
Brick, tile, and other structural clay product manufacturing	129,062,652.04	129,062,652.04	129,062,652.04	0.000%	0.000%
Flat glass manufacturing	59,459,840.38	59,459,842.21	59,459,842.21	0.000%	0.000%

Other pressed and blown glass and glassware manufacturing	25,630,740.13	25,630,740.32	25,630,740.32	0.000%	0.000%
Glass container manufacturing	200,443,989.59	200,443,984.33	200,443,984.33	0.000%	0.000%
Glass product manufacturing made of purchased glass	158,680,816.53	158,680,820.38	158,680,820.38	0.000%	0.000%
Cement manufacturing	260,482,324.80	260,482,315.39	260,482,315.39	0.000%	0.000%
Ready-mix concrete manufacturing	1,160,993,256.89	1,160,993,086.59	1,160,993,086.59	0.000%	0.000%
Concrete block and brick manufacturing	172,159,638.85	172,159,650.42	172,159,650.42	0.000%	0.000%
Concrete pipe manufacturing	100,926,429.74	100,926,436.14	100,926,436.14	0.000%	0.000%
Other concrete product manufacturing	379,084,125.05	379,084,040.32	379,084,040.32	0.000%	0.000%
Gypsum product manufacturing	113,340,043.59	113,340,043.59	113,340,043.59	0.000%	0.000%
Abrasive product manufacturing	11,148,027.91	11,148,037.59	11,148,037.59	0.000%	0.000%
Cut stone and stone product manufacturing	185,169,341.87	185,168,925.71	185,168,925.71	0.000%	0.000%

Mineral wool manufacturing	67,014,729.02	67,014,737.60	67,014,737.60	0.000%	0.000%
Miscellaneous nonmetallic mineral products manufacturing	61,205,081.27	61,205,108.36	61,205,108.36	0.000%	0.000%
Iron and steel mills and ferroalloy manufacturing	2,787,840,143.57	2,787,840,138.30	2,787,840,138.29	0.000%	0.000%
Iron, steel pipe and tube manufacturing from purchased steel	157,170,677.65	157,170,655.23	157,170,655.23	0.000%	0.000%
Rolled steel shape manufacturing	101,588,148.05	101,588,122.89	101,588,122.89	0.000%	0.000%
Aluminum sheet, plate, and foil manufacturing	179,656,171.30	179,656,171.24	179,656,171.24	0.000%	0.000%
Other aluminum rolling, drawing and extruding	48,703,086.54	48,703,086.65	48,703,086.65	0.000%	0.000%
Copper rolling, drawing, extruding and alloying	85,223,463.49	85,223,466.83	85,223,466.83	0.000%	0.000%
Nonferrous metal, except copper and aluminum, shaping	40,108,687.15	40,108,684.05	40,108,684.05	0.000%	0.000%
Secondary processing of other nonferrous metals	4,967,202.09	4,967,202.18	4,967,202.18	0.000%	0.000%

Ferrous metal foundries	6,232,389.79	6,232,389.93	6,232,389.93	0.000%	0.000%
Nonferrous metal foundries	58,168,026.54	58,168,028.93	58,168,028.93	0.000%	0.000%
Custom roll forming	4,412,046.36	4,412,046.06	4,412,046.06	0.000%	0.000%
Crown and closure manufacturing and metal stamping	26,475,538.95	26,475,537.96	26,475,537.96	0.000%	0.000%
Iron and steel forging	46,537,770.94	46,537,770.13	46,537,770.13	0.000%	0.000%
Nonferrous forging	95,426,030.36	95,426,027.35	95,426,027.35	0.000%	0.000%
Cutlery, utensil, pot, and pan manufacturing	140,789,503.69	140,802,569.55	140,802,569.55	0.009%	0.000%
Handtool manufacturing	14,266,846.89	14,266,484.41	14,266,484.41	-0.003%	0.000%
Prefabricated metal buildings and components manufacturing	151,472,494.69	151,467,938.18	151,467,938.18	-0.003%	0.000%
Fabricated structural metal manufacturing	679,725,293.61	679,725,153.56	679,725,153.56	0.000%	0.000%
Plate work manufacturing	48,493,449.90	48,492,846.02	48,492,846.02	-0.001%	0.000%
Metal window and door manufacturing	93,025,181.01	93,025,177.63	93,025,177.63	0.000%	0.000%
Sheet metal work manufacturing	415,653,725.62	415,653,692.38	415,653,692.37	0.000%	0.000%

Ornamental and architectural metal work manufacturing	306,335,189.39	306,334,792.47	306,334,792.46	0.000%	0.000%
Power boiler and heat exchanger manufacturing	29,815,200.82	29,815,198.61	29,815,198.61	0.000%	0.000%
Metal tank (heavy gauge) manufacturing	116,910,407.82	116,910,386.42	116,910,386.42	0.000%	0.000%
Metal cans manufacturing	863,901,172.15	863,900,657.33	863,900,657.33	0.000%	0.000%
Metal barrels, drums and pails manufacturing	92,232,268.13	92,232,179.31	92,232,179.31	0.000%	0.000%
Hardware manufacturing	344,561,965.38	344,561,012.25	344,561,012.25	0.000%	0.000%
Spring and wire product manufacturing	139,353,763.79	139,354,127.26	139,354,127.26	0.000%	0.000%
Machine shops	771,509,230.91	771,508,723.98	771,508,723.97	0.000%	0.000%
Turned product and screw, nut, and bolt manufacturing	184,404,870.70	184,404,868.04	184,404,868.04	0.000%	0.000%
Metal heat treating	9,273,411.08	9,273,411.19	9,273,411.19	0.000%	0.000%
Metal coating and nonprecious engraving	290,151,432.54	290,151,430.85	290,151,430.84	0.000%	0.000%
Electroplating, anodizing, and coloring metal	45,142,470.84	45,142,470.50	45,142,470.50	0.000%	0.000%

Valve and fittings, other than plumbing, manufacturing	198,367,728.83	198,367,729.24	198,367,729.24	0.000%	0.000%
Plumbing fixture fitting and trim manufacturing	219,817,781.95	219,817,781.95	219,817,781.95	0.000%	0.000%
Ball and roller bearing manufacturing	12,267,417.31	12,267,417.30	12,267,417.30	0.000%	0.000%
Small arms ammunition manufacturing	2,531,376.69	2,531,376.50	2,531,376.50	0.000%	0.000%
Small arms, ordnance, and accessories manufacturing	275,678,427.55	275,678,440.95	275,678,440.95	0.000%	0.000%
Fabricated pipe and pipe fitting manufacturing	27,927,483.07	27,927,480.76	27,927,480.76	0.000%	0.000%
Other fabricated metal manufacturing	203,544,953.90	203,543,467.71	203,543,467.71	-0.001%	0.000%
Farm machinery and equipment manufacturing	303,282,859.52	303,267,844.90	303,267,844.90	-0.005%	0.000%
Lawn and garden equipment manufacturing	95,403,503.33	95,403,166.57	95,403,166.57	0.000%	0.000%

Construction machinery manufacturing	75,726,421.46	75,726,419.08	75,726,419.08	0.000%	0.000%
Mining machinery and equipment manufacturing	27,347,741.98	27,347,741.36	27,347,741.36	0.000%	0.000%
Oil and gas field machinery and equipment manufacturing	56,905,399.58	56,905,405.64	56,905,405.64	0.000%	0.000%
Semiconductor machinery manufacturing	23,818,144.65	23,818,146.01	23,818,146.01	0.000%	0.000%
Food product machinery manufacturing	119,395,605.05	119,395,604.28	119,395,604.28	0.000%	0.000%
Sawmill, woodworking, and paper machinery	12,276,679.42	12,276,679.18	12,276,679.18	0.000%	0.000%
Printing machinery and equipment manufacturing	14,288,846.15	14,288,845.67	14,288,845.67	0.000%	0.000%
All other industrial machinery manufacturing	130,873,324.28	130,873,318.24	130,873,318.24	0.000%	0.000%
Optical instrument and lens manufacturing	186,972,293.31	186,972,271.72	186,972,271.72	0.000%	0.000%

Photographic and photocopying equipment manufacturing	51,876,790.10	51,876,785.19	51,876,785.19	0.000%	0.000%
Other commercial service industry machinery manufacturing	593,087,075.17	593,087,003.29	593,087,003.28	0.000%	0.000%
Air purification and ventilation equipment manufacturing	124,109,410.07	124,109,396.83	124,109,396.83	0.000%	0.000%
Heating equipment (except warm air furnaces) manufacturing	25,628,733.75	25,628,734.57	25,628,734.57	0.000%	0.000%
Air conditioning, refrigeration, and warm air heating equipment manufacturing	345,018,503.43	345,018,499.45	345,018,499.45	0.000%	0.000%
Industrial mold manufacturing	54,102,747.10	54,102,748.02	54,102,748.02	0.000%	0.000%
Special tool, die, jig, and fixture manufacturing	8,786,575.63	8,786,575.87	8,786,575.87	0.000%	0.000%
Cutting tool and machine tool accessory manufacturing	15,859,983.97	15,859,981.85	15,859,981.85	0.000%	0.000%

Machine tool manufacturing	240,432,191.02	240,432,196.93	240,432,196.93	0.000%	0.000%
Rolling mill and other metalworking machinery manufacturing	37,923,924.93	37,923,925.18	37,923,925.18	0.000%	0.000%
Turbine and turbine generator set units manufacturing	370,695,751.14	370,695,751.17	370,695,751.17	0.000%	0.000%
Speed changer, industrial high-speed drive, and gear manufacturing	4,145,264.71	4,145,264.71	4,145,264.71	0.000%	0.000%
Other engine equipment manufacturing	2,031,233,353.62	2,031,233,394.88	2,031,233,394.88	0.000%	0.000%
Pump and pumping equipment manufacturing	38,203,838.27	38,203,838.52	38,203,838.52	0.000%	0.000%
Air and gas compressor manufacturing	85,740,916.46	85,740,897.53	85,740,897.53	0.000%	0.000%
Conveyor and conveying equipment manufacturing	253,020,251.90	253,020,198.59	253,020,198.59	0.000%	0.000%
Overhead cranes, hoists, and monorail systems manufacturing	59,113,226.52	59,113,253.68	59,113,253.68	0.000%	0.000%

Industrial truck, trailer, and stacker manufacturing	56,874,377.30	56,874,259.19	56,874,259.19	0.000%	0.000%
Power-driven handtool manufacturing	65,748,702.81	65,748,622.07	65,748,622.07	0.000%	0.000%
Welding and soldering equipment manufacturing	67,430,838.57	67,430,838.91	67,430,838.91	0.000%	0.000%
Packaging machinery manufacturing	45,826,342.82	45,826,345.26	45,826,345.26	0.000%	0.000%
Industrial process furnace and oven manufacturing	2,510,351.38	2,510,351.38	2,510,351.38	0.000%	0.000%
Fluid power cylinder and actuator manufacturing	103,134,136.69	103,134,136.57	103,134,136.57	0.000%	0.000%
Fluid power pump and motor manufacturing	17,743,549.42	17,743,549.67	17,743,549.67	0.000%	0.000%
Scales, balances, and miscellaneous general purpose machinery manufacturing	83,961,650.76	83,961,648.90	83,961,648.90	0.000%	0.000%
Electronic computer manufacturing	1,224,335,994.61	1,224,335,994.61	1,224,335,994.61	0.000%	0.000%

Computer storage device manufacturing	1,426,028,219.66	1,426,028,219.66	1,426,028,219.66	0.000%	0.000%
Computer terminals and other computer peripheral equipment manufacturing	336,700,430.51	336,700,408.22	336,700,408.22	0.000%	0.000%
Telephone apparatus manufacturing	145,882,152.57	145,882,152.57	145,882,152.57	0.000%	0.000%
Broadcast and wireless communications equipment manufacturing	313,951,175.49	313,951,178.86	313,951,178.86	0.000%	0.000%
Other communications equipment manufacturing	298,486,228.04	298,486,231.23	298,486,231.23	0.000%	0.000%
Audio and video equipment manufacturing	87,814,747.63	87,814,746.70	87,814,746.70	0.000%	0.000%
Printed circuit assembly (electronic assembly) manufacturing	708,967,368.34	708,967,368.34	708,967,368.34	0.000%	0.000%
Bare printed circuit board manufacturing	145,637,448.07	145,637,448.07	145,637,448.07	0.000%	0.000%

Semiconductor and related device manufacturing	1,454,603,532.55	1,454,603,524.76	1,454,603,524.76	0.000%	0.000%
Capacitor, resistor, coil, transformer, and other inductor manufacturing	12,756,863.31	12,756,863.31	12,756,863.31	0.000%	0.000%
Electronic connector manufacturing	1,766,929.43	1,766,929.43	1,766,929.43	0.000%	0.000%
Other electronic component manufacturing	108,466,254.94	108,466,254.94	108,466,254.94	0.000%	0.000%
Electromedical and electrotherapeutic apparatus manufacturing	1,649,149,489.47	1,649,149,486.23	1,649,149,486.23	0.000%	0.000%
Search, detection, and navigation instruments manufacturing	2,848,627,706.09	2,848,627,706.14	2,848,627,706.14	0.000%	0.000%
Automatic environmental control manufacturing	15,474,840.26	15,474,840.26	15,474,840.26	0.000%	0.000%
Industrial process variable instruments manufacturing	426,232,503.57	426,232,507.01	426,232,507.01	0.000%	0.000%

Totalizing fluid meter and counting device manufacturing	73,330,333.97	73,330,333.97	73,330,333.97	0.000%	0.000%
Electricity and signal testing instruments manufacturing	586,547,377.73	586,547,377.73	586,547,377.73	0.000%	0.000%
Analytical laboratory instrument manufacturing	725,471,489.87	725,471,509.66	725,471,509.66	0.000%	0.000%
Irradiation apparatus manufacturing	14,331,820.92	14,331,820.92	14,331,820.92	0.000%	0.000%
Watch, clock, and other measuring and controlling device manufacturing	280,343,260.78	280,343,260.23	280,343,260.23	0.000%	0.000%
Blank magnetic and optical recording media manufacturing	200,078,191.40	200,077,938.05	200,077,938.05	0.000%	0.000%
Software and other prerecorded and record reproducing	118,521,297.31	118,521,297.31	118,521,297.31	0.000%	0.000%
Electric lamp bulb and part manufacturing	35,343,572.43	35,343,561.94	35,343,561.94	0.000%	0.000%
Lighting fixture manufacturing	193,260,934.44	193,260,935.86	193,260,935.86	0.000%	0.000%

Small electrical appliance manufacturing	11,630,175.04	11,630,175.22	11,630,175.22	0.000%	0.000%
Power, distribution, and specialty transformer manufacturing	18,049,564.89	18,049,564.20	18,049,564.20	0.000%	0.000%
Motor and generator manufacturing	289,134,686.30	289,134,631.03	289,134,631.03	0.000%	0.000%
Switchgear and switchboard apparatus manufacturing	241,828,576.44	241,828,576.43	241,828,576.43	0.000%	0.000%
Relay and industrial control manufacturing	18,856,053.98	18,856,053.99	18,856,053.99	0.000%	0.000%
Storage battery manufacturing	76,615,110.76	76,597,812.82	76,597,812.82	-0.023%	0.000%
Fiber optic cable manufacturing	11,208,492.91	11,208,492.91	11,208,492.91	0.000%	0.000%
Other communication and energy wire manufacturing	8,075,211.59	8,075,211.59	8,075,211.59	0.000%	0.000%
Wiring device manufacturing	32,273,805.43	32,273,780.44	32,273,780.44	0.000%	0.000%
Carbon and graphite product manufacturing	48,091,369.65	48,091,369.65	48,091,369.65	0.000%	0.000%

All other miscellaneous electrical equipment and component manufacturing	101,930,271.98	101,930,271.78	101,930,271.78	0.000%	0.000%
Motor vehicle body manufacturing	71,195,259.55	71,195,252.83	71,195,252.83	0.000%	0.000%
Truck trailer manufacturing	64,330,341.19	64,330,297.96	64,330,297.96	0.000%	0.000%
Motor home manufacturing	23,494,931.79	23,494,931.79	23,494,931.79	0.000%	0.000%
Travel trailer and camper manufacturing	240,790,460.67	240,790,413.59	240,790,413.59	0.000%	0.000%
Motor vehicle gasoline engine and engine parts manufacturing	79,832,089.16	79,831,998.15	79,831,998.15	0.000%	0.000%
Motor vehicle electrical and electronic equipment manufacturing	72,935,763.38	72,932,927.99	72,932,927.99	-0.004%	0.000%
Motor vehicle transmission and power train parts manufacturing	239,629,982.75	239,629,781.73	239,629,781.73	0.000%	0.000%
Motor vehicle seating and interior trim manufacturing	281,823,404.97	281,826,368.60	281,826,368.60	0.001%	0.000%

Motor vehicle metal stamping	10,534,762.34	10,534,758.98	10,534,758.98	0.000%	0.000%
Other motor vehicle parts manufacturing	135,574,962.17	135,572,474.99	135,572,474.99	-0.002%	0.000%
Motor vehicle steering, suspension component (except spring), and brake systems manufacturing	61,345,421.01	61,345,401.52	61,345,401.52	0.000%	0.000%
Aircraft manufacturing	526,420,972.40	526,420,978.53	526,420,978.53	0.000%	0.000%
Aircraft engine and engine parts manufacturing	1,358,118.93	1,358,118.91	1,358,118.91	0.000%	0.000%
Other aircraft parts and auxiliary equipment manufacturing	267,533,747.15	267,533,746.54	267,533,746.54	0.000%	0.000%
Guided missile and space vehicle manufacturing	3,957,316,783.94	3,957,316,783.94	3,957,316,783.94	0.000%	0.000%
Propulsion units and parts for space vehicles and guided missiles manufacturing	91,530,138.02	91,530,177.14	91,530,177.14	0.000%	0.000%
Railroad rolling stock manufacturing	17,660,688.52	17,660,686.98	17,660,686.98	0.000%	0.000%
Boat building	59,458,097.42	59,458,097.42	59,458,097.42	0.000%	0.000%

Motorcycle, bicycle, and parts manufacturing	239,649,702.98	239,649,677.94	239,649,677.94	0.000%	0.000%
All other transportation equipment manufacturing	6,454,341.25	6,454,338.52	6,454,338.52	0.000%	0.000%
Wood kitchen cabinet and countertop manufacturing	364,617,784.32	364,617,789.00	364,617,789.00	0.000%	0.000%
Upholstered household furniture manufacturing	2,138,443.08	2,138,443.09	2,138,443.09	0.000%	0.000%
Nonupholstered wood household furniture manufacturing	77,448,701.80	77,448,704.74	77,448,704.74	0.000%	0.000%
Other household nonupholstered furniture manufacturing	27,316,072.53	27,316,072.53	27,316,072.53	0.000%	0.000%
Institutional furniture manufacturing	60,369,727.68	60,369,727.33	60,369,727.33	0.000%	0.000%
Wood office furniture manufacturing	53,464,026.26	53,464,026.16	53,464,026.16	0.000%	0.000%
Custom architectural woodwork and millwork	124,680,398.92	124,680,397.28	124,680,397.28	0.000%	0.000%

Office furniture, except wood, manufacturing	12,213,346.61	12,213,345.71	12,213,345.71	0.000%	0.000%
Showcase, partition, shelving, and locker manufacturing	149,347,071.00	149,347,071.48	149,347,071.48	0.000%	0.000%
Mattress manufacturing	229,815,449.21	229,815,447.12	229,815,447.12	0.000%	0.000%
Blind and shade manufacturing	396,392,150.96	396,392,098.16	396,392,098.16	0.000%	0.000%
Surgical and medical instrument manufacturing	1,816,481,097.59	1,816,481,079.53	1,816,481,079.53	0.000%	0.000%
Surgical appliance and supplies manufacturing	965,686,265.31	965,686,194.38	965,686,194.38	0.000%	0.000%
Dental equipment and supplies manufacturing	22,155,695.30	22,155,695.30	22,155,695.30	0.000%	0.000%
Ophthalmic goods manufacturing	41,507,098.89	41,507,098.89	41,507,098.89	0.000%	0.000%
Dental laboratories	97,467,181.41	97,467,182.53	97,467,182.53	0.000%	0.000%
Jewelry and silverware manufacturing	206,145,344.43	206,145,342.98	206,145,342.98	0.000%	0.000%
Sporting and athletic goods manufacturing	392,139,465.00	392,139,460.13	392,139,460.13	0.000%	0.000%
Doll, toy, and game manufacturing	183,805,578.90	183,805,569.53	183,805,569.53	0.000%	0.000%

Office supplies (except paper) manufacturing	6,787,064.79	6,787,064.78	6,787,064.78	0.000%	0.000%
Sign manufacturing	271,591,501.55	271,591,486.52	271,591,486.52	0.000%	0.000%
Gasket, packing, and sealing device manufacturing	92,094,983.27	92,094,982.59	92,094,982.59	0.000%	0.000%
Musical instrument manufacturing	4,149,297.44	4,149,297.57	4,149,297.57	0.000%	0.000%
Fasteners, buttons, needles, and pins manufacturing	2,378,725.62	2,378,725.51	2,378,725.51	0.000%	0.000%
Broom, brush, and mop manufacturing	2,865,572.66	2,865,585.63	2,865,585.63	0.000%	0.000%
Burial casket manufacturing	2,076,943.40	2,076,943.24	2,076,943.24	0.000%	0.000%
All other miscellaneous manufacturing	316,834,123.35	316,833,727.05	316,833,727.05	0.000%	0.000%
Wholesale - Motor vehicle and motor vehicle parts and supplies	2,571,498,273.35	2,571,509,902.25	2,571,509,902.24	0.000%	0.000%
Wholesale - Professional and commercial equipment and supplies	8,354,172,787.73	8,354,171,661.06	8,354,171,661.04	0.000%	0.000%

Wholesale - Household appliances and electrical and electronic goods	6,900,446,180.48	6,900,433,378.79	6,900,433,378.77	0.000%	0.000%
Wholesale - Machinery, equipment, and supplies	4,332,643,646.65	4,332,538,742.71	4,332,538,742.70	-0.002%	0.000%
Wholesale - Other durable goods merchant wholesalers	9,171,621,774.20	9,171,593,356.56	9,171,593,356.54	0.000%	0.000%
Wholesale - Drugs and druggistsâ€™ sundries	4,661,865,975.44	4,661,862,875.24	4,661,862,875.24	0.000%	0.000%
Wholesale - Grocery and related product wholesalers	4,299,475,453.41	4,299,074,067.17	4,299,074,067.16	-0.009%	0.000%
Wholesale - Petroleum and petroleum products	2,496,199,116.71	2,496,060,449.69	2,496,060,449.69	-0.006%	0.000%
Wholesale - Other nondurable goods merchant wholesalers	7,509,552,678.12	7,507,762,043.68	7,507,762,043.66	-0.024%	0.000%
Wholesale - Wholesale electronic markets and agents and brokers	818,252,509.40	818,291,741.07	818,291,741.06	0.005%	0.000%

Retail - Motor vehicle and parts dealers	2,782,246,931.61	2,782,246,925.01	2,782,246,925.01	0.000%	0.000%
Retail - Furniture and home furnishings stores	1,623,151,753.89	1,623,151,663.47	1,623,151,663.47	0.000%	0.000%
Retail - Electronics and appliance stores	1,126,205,212.32	1,126,204,944.66	1,126,204,944.66	0.000%	0.000%
Retail - Building material and garden equipment and supplies stores	3,971,985,321.91	3,971,978,216.31	3,971,978,216.30	0.000%	0.000%
Retail - Food and beverage stores	5,033,199,295.40	5,033,196,044.49	5,033,196,044.49	0.000%	0.000%
Retail - Health and personal care stores	2,122,021,662.60	2,122,021,662.60	2,122,021,662.60	0.000%	0.000%
Retail - Gasoline stores	2,111,454,999.04	2,111,341,667.92	2,111,341,667.92	-0.005%	0.000%
Retail - Clothing and clothing accessories stores	2,681,381,046.44	2,681,381,046.44	2,681,381,046.44	0.000%	0.000%
Retail - Sporting goods, hobby, musical instrument and book stores	2,014,004,390.13	2,014,003,940.66	2,014,003,940.66	0.000%	0.000%
Retail - General merchandise stores	4,974,143,958.23	4,974,139,749.26	4,974,139,749.26	0.000%	0.000%

Retail - Miscellaneous store retailers	2,486,490,639.76	2,486,490,132.50	2,486,490,132.50	0.000%	0.000%
Retail - Nonstore retailers	9,493,505,983.12	9,493,496,228.89	9,493,496,228.89	0.000%	0.000%
Air transportation	12,019,484,186.23	12,018,685,527.62	12,018,685,527.62	-0.007%	0.000%
Rail transportation	1,462,536,300.68	1,462,515,307.68	1,462,515,307.68	-0.001%	0.000%
Water transportation	22,459,989.02	22,467,563.87	22,467,563.87	0.034%	0.000%
Truck transportation	7,105,261,992.85	7,104,962,344.63	7,104,962,344.61	-0.004%	0.000%
Transit and ground passenger transportation	1,291,334,467.06	1,291,334,467.06	1,291,334,467.05	0.000%	0.000%
Pipeline transportation	2,418,369,705.88	2,418,369,536.50	2,418,369,536.49	0.000%	0.000%
Scenic and sightseeing transportation and support activities for transportation	1,503,183,182.05	1,503,229,220.89	1,503,229,220.89	0.003%	0.000%
Couriers and messengers	2,846,451,324.84	2,846,451,481.29	2,846,451,481.28	0.000%	0.000%
Warehousing and storage	3,004,415,801.53	3,004,365,470.22	3,004,365,470.21	-0.002%	0.000%
Newspaper publishers	298,621,558.02	298,621,526.22	298,621,526.22	0.000%	0.000%
Periodical publishers	358,555,193.24	358,555,103.21	358,555,103.21	0.000%	0.000%
Book publishers	501,199,807.36	501,199,843.31	501,199,843.31	0.000%	0.000%

Directory, mailing list, and other publishers	291,360,156.52	291,360,172.66	291,360,172.66	0.000%	0.000%
Greeting card publishing	172,476,457.24	172,476,468.99	172,476,468.99	0.000%	0.000%
Software publishers	9,266,090,962.52	9,266,097,551.77	9,266,097,551.76	0.000%	0.000%
Motion picture and video industries	1,656,836,231.38	1,656,836,247.34	1,656,836,247.33	0.000%	0.000%
Sound recording industries	363,730,006.50	363,730,021.46	363,730,021.46	0.000%	0.000%
Radio and television broadcasting	2,833,321,921.36	2,833,319,983.06	2,833,319,983.05	0.000%	0.000%
Cable and other subscription programming	3,993,281,871.22	3,993,284,772.30	3,993,284,772.28	0.000%	0.000%
Wired telecommunications carriers	10,911,106,349.07	10,911,115,876.63	10,911,115,876.61	0.000%	0.000%
Wireless telecommunications carriers (except satellite)	3,935,393,467.44	3,935,401,775.83	3,935,401,775.83	0.000%	0.000%
Satellite, telecommunications resellers, and all other telecommunications	1,428,371,405.70	1,428,371,997.45	1,428,371,997.45	0.000%	0.000%
Data processing, hosting, and related services	14,836,470,032.04	14,836,466,143.24	14,836,466,143.21	0.000%	0.000%

News syndicates, libraries, archives and all other information services	451,802,824.54	451,802,823.69	451,802,823.69	0.000%	0.000%
Internet publishing and broadcasting and web search portals	3,132,073,638.22	3,132,074,767.89	3,132,074,767.88	0.000%	0.000%
Nondepository credit intermediation and related activities	5,626,448,664.35	5,626,660,601.18	5,626,660,601.16	0.004%	0.000%
Securities and commodity contracts intermediation and brokerage	4,456,010,984.05	4,456,013,870.95	4,456,013,870.94	0.000%	0.000%
Monetary authorities and depository credit intermediation	12,270,029,610.45	12,269,893,912.53	12,269,893,912.50	-0.001%	0.000%
Other financial investment activities	11,771,601,330.98	11,771,596,617.19	11,771,596,617.18	0.000%	0.000%
Direct life insurance carriers	1,462,198,223.20	1,462,197,904.44	1,462,197,904.44	0.000%	0.000%
Insurance carriers, except direct life	14,010,555,928.69	14,010,456,691.61	14,010,456,691.58	-0.001%	0.000%
Insurance agencies, brokerages, and related activities	8,112,349,959.86	8,112,285,003.09	8,112,285,003.05	-0.001%	0.000%

Funds, trusts, and other financial vehicles	5,393,900,514.32	5,393,900,459.20	5,393,900,459.20	0.000%	0.000%
Other real estate	42,992,652,428.71	42,988,538,244.38	42,988,538,244.27	-0.010%	0.000%
Tenant-occupied housing	12,809,634,514.98	12,809,634,390.44	12,809,634,390.44	0.000%	0.000%
Owner-occupied dwellings	46,110,355,723.89	46,110,355,723.89	46,110,355,723.89	0.000%	0.000%
Automotive equipment rental and leasing	1,359,200,802.19	1,359,065,682.31	1,359,065,682.31	-0.010%	0.000%
General and consumer goods rental except video tapes and discs	1,140,103,061.87	1,140,097,328.28	1,140,097,328.28	-0.001%	0.000%
Video tape and disc rental	391,886,024.36	391,886,027.11	391,886,027.11	0.000%	0.000%
Commercial and industrial machinery and equipment rental and leasing	1,917,307,666.67	1,917,450,962.64	1,917,450,962.63	0.007%	0.000%
Lessors of nonfinancial intangible assets	2,420,219,708.62	2,420,247,845.90	2,420,247,845.89	0.001%	0.000%
Legal services	6,867,930,208.32	6,867,912,631.99	6,867,912,631.97	0.000%	0.000%
Accounting, tax preparation, bookkeeping, and payroll services	5,777,509,197.11	5,777,467,170.56	5,777,467,170.54	-0.001%	0.000%

Architectural, engineering, and related services	15,621,543,535.03	15,621,544,152.20	15,621,544,152.18	0.000%	0.000%
Specialized design services	1,082,266,212.35	1,082,266,298.90	1,082,266,298.89	0.000%	0.000%
Custom computer programming services	11,756,632,956.00	11,756,608,199.06	11,756,608,199.04	0.000%	0.000%
Computer systems design services	8,910,562,658.03	8,910,529,497.84	8,910,529,497.83	0.000%	0.000%
Other computer related services, including facilities management	1,729,281,913.56	1,729,262,075.92	1,729,262,075.91	-0.001%	0.000%
Management consulting services	9,078,402,503.02	9,078,401,011.57	9,078,401,011.55	0.000%	0.000%
Environmental and other technical consulting services	2,691,756,280.87	2,691,756,709.45	2,691,756,709.44	0.000%	0.000%
Scientific research and development services	15,779,399,069.44	15,779,399,684.29	15,779,399,684.27	0.000%	0.000%
Advertising, public relations, and related services	4,406,536,086.71	4,406,534,645.65	4,406,534,645.63	0.000%	0.000%
Photographic services	402,484,357.23	402,484,353.29	402,484,353.29	0.000%	0.000%
Veterinary services	1,009,527,521.04	1,009,527,539.20	1,009,527,539.20	0.000%	0.000%

Marketing research and all other miscellaneous professional, scientific, and technical services	5,027,657,517.35	5,027,658,753.93	5,027,658,753.91	0.000%	0.000%
Management of companies and enterprises	14,413,571,843.44	14,413,567,647.02	14,413,567,646.96	0.000%	0.000%
Office administrative services	476,973,753.06	476,973,591.24	476,973,591.23	0.000%	0.000%
Facilities support services	876,394,990.04	876,395,011.49	876,395,011.49	0.000%	0.000%
Employment services	9,479,189,506.81	9,479,190,044.58	9,479,190,044.54	0.000%	0.000%
Business support services	1,960,090,490.26	1,960,090,258.32	1,960,090,258.31	0.000%	0.000%
Travel arrangement and reservation services	1,665,314,128.46	1,665,243,068.60	1,665,243,068.60	-0.004%	0.000%
Investigation and security services	1,557,875,664.32	1,557,875,428.85	1,557,875,428.85	0.000%	0.000%
Services to buildings	3,470,046,436.17	3,470,046,169.36	3,470,046,169.35	0.000%	0.000%
Landscape and horticultural services	3,075,263,932.23	3,075,254,893.38	3,075,254,893.38	0.000%	0.000%
Other support services	2,194,260,778.39	2,194,258,432.01	2,194,258,432.00	0.000%	0.000%

Waste management and remediation services	2,857,905,245.66	2,857,900,106.02	2,857,900,106.02	0.000%	0.000%
Elementary and secondary schools	401,988,209.54	402,007,019.89	402,007,019.89	0.005%	0.000%
Junior colleges, colleges, universities, and professional schools	1,832,852,894.63	1,832,861,401.17	1,832,861,401.17	0.000%	0.000%
Other educational services	3,221,052,190.27	3,221,052,381.98	3,221,052,381.98	0.000%	0.000%
Offices of physicians	8,737,865,458.07	8,737,865,189.97	8,737,865,189.97	0.000%	0.000%
Offices of dentists	2,873,960,422.25	2,873,960,453.80	2,873,960,453.80	0.000%	0.000%
Offices of other health practitioners	3,761,150,581.50	3,761,150,667.64	3,761,150,667.64	0.000%	0.000%
Outpatient care centers	3,792,545,464.94	3,792,545,442.28	3,792,545,442.28	0.000%	0.000%
Medical and diagnostic laboratories	1,199,398,264.16	1,199,398,297.93	1,199,398,297.93	0.000%	0.000%
Home health care services	1,873,541,037.28	1,873,540,961.04	1,873,540,961.04	0.000%	0.000%
Other ambulatory health care services	946,390,424.91	946,390,424.87	946,390,424.87	0.000%	0.000%
Hospitals	12,594,455,988.11	12,594,455,960.46	12,594,455,960.46	0.000%	0.000%
Nursing and community care facilities	3,312,864,512.83	3,312,864,588.01	3,312,864,588.01	0.000%	0.000%

Residential intellectual disability, mental health, substance abuse and other facilities	538,318,768.57	538,318,763.23	538,318,763.23	0.000%	0.000%
Individual and family services	2,073,363,004.51	2,073,362,981.79	2,073,362,981.79	0.000%	0.000%
Child day care services	1,487,911,644.18	1,487,911,631.38	1,487,911,631.38	0.000%	0.000%
Community food, housing, and other relief services, including rehabilitation services	1,030,632,445.41	1,030,632,167.19	1,030,632,167.19	0.000%	0.000%
Performing arts companies	458,088,919.05	458,088,932.83	458,088,932.83	0.000%	0.000%
Commercial Sports Except Racing	1,078,360,956.84	1,078,362,509.63	1,078,362,509.62	0.000%	0.000%
Racing and Track Operation	54,398,300.83	54,410,020.10	54,410,020.10	0.022%	0.000%
Independent artists, writers, and performers	803,746,009.59	803,746,009.59	803,746,009.59	0.000%	0.000%
Promoters of performing arts and sports and agents for public figures	1,496,978,983.53	1,496,979,729.55	1,496,979,729.54	0.000%	0.000%

Museums, historical sites, zoos, and parks	309,487,910.42	309,487,910.42	309,487,910.42	0.000%	0.000%
Amusement parks and arcades	146,144,975.05	146,144,973.07	146,144,973.07	0.000%	0.000%
Gambling industries (except casino hotels)	2,943,131,633.53	2,943,131,546.18	2,943,131,546.18	0.000%	0.000%
Other amusement and recreation industries	1,384,603,845.56	1,384,607,587.10	1,384,607,587.10	0.000%	0.000%
Fitness and recreational sports centers	868,062,167.57	868,059,585.64	868,059,585.64	0.000%	0.000%
Bowling centers	144,003,189.17	144,002,441.80	144,002,441.80	-0.001%	0.000%
Hotels and motels, including casino hotels	5,251,164,182.52	5,251,157,787.87	5,251,157,787.87	0.000%	0.000%
Other accommodations	667,519,848.01	667,517,754.59	667,517,754.59	0.000%	0.000%
Full-service restaurants	12,268,893,486.27	12,269,311,567.66	12,269,311,567.65	0.003%	0.000%
Limited-service restaurants	11,405,648,389.97	11,405,491,933.01	11,405,491,933.00	-0.001%	0.000%
All other food and drinking places	5,157,940,287.14	5,157,962,330.86	5,157,962,330.85	0.000%	0.000%
Automotive repair and maintenance, except car washes	4,382,117,476.81	4,382,110,850.80	4,382,110,850.80	0.000%	0.000%
Car washes	2,508,251,233.62	2,508,251,216.47	2,508,251,216.47	0.000%	0.000%

Electronic and precision equipment repair and maintenance	1,324,688,409.69	1,324,687,292.27	1,324,687,292.27	0.000%	0.000%
Commercial and industrial machinery and equipment repair and maintenance	1,055,840,478.82	1,055,839,031.48	1,055,839,031.48	0.000%	0.000%
Personal and household goods repair and maintenance	729,564,396.63	729,564,396.63	729,564,396.63	0.000%	0.000%
Personal care services	908,796,803.36	908,796,769.38	908,796,769.38	0.000%	0.000%
Death care services	112,970,893.71	112,970,893.71	112,970,893.71	0.000%	0.000%
Dry-cleaning and laundry services	296,360,281.27	296,360,240.92	296,360,240.92	0.000%	0.000%
Other personal services	1,638,957,003.82	1,638,957,022.34	1,638,957,022.34	0.000%	0.000%
Religious organizations	5,142,305,045.60	5,142,307,882.68	5,142,307,882.68	0.000%	0.000%
Grantmaking, giving, and social advocacy organizations	3,060,708,846.67	3,060,708,749.10	3,060,708,749.10	0.000%	0.000%
Business and professional associations	1,074,264,538.54	1,074,263,381.78	1,074,263,381.78	0.000%	0.000%
Labor and civic organizations	1,729,495,959.42	1,729,495,777.05	1,729,495,777.05	0.000%	0.000%

Private households	398,485,907.65	398,485,907.65	398,485,907.65	0.000%	0.000%
Postal service	1,095,514,245.81	1,095,516,283.48	1,095,516,283.48	0.000%	0.000%
Other federal government enterprises	88,206,151.67	88,205,774.36	88,205,774.36	0.000%	0.000%
Local government passenger transit	92,720,949.95	92,720,973.77	92,720,973.77	0.000%	0.000%
Local government electric utilities	2,028,465,622.78	2,028,328,138.00	2,028,328,138.00	-0.007%	0.000%
Other local government enterprises	3,429,666,200.29	3,429,683,875.20	3,429,683,875.20	0.001%	0.000%
* Employment and payroll of state govt, education	3,642,592,552.61	3,642,592,552.61	3,642,592,552.57	0.000%	0.000%
* Employment and payroll of state govt, hospitals and health services	2,279,732,796.88	2,279,732,796.88	2,279,732,796.89	0.000%	0.000%
* Employment and payroll of state govt, other services	5,157,893,635.03	5,157,893,635.03	5,157,893,635.04	0.000%	0.000%
* Employment and payroll of local govt, education	9,939,438,209.18	9,939,438,209.18	9,939,438,209.08	0.000%	0.000%
* Employment and payroll of local govt, hospitals and health services	1,381,073,148.69	1,381,073,148.69	1,381,073,148.69	0.000%	0.000%

* Employment and payroll of local govt, other services	8,844,508,927.99	8,844,508,927.99	8,844,508,928.01	0.000%	0.000%
* Employment and payroll of federal govt, military	5,577,569,436.01	5,577,569,436.01	5,577,569,436.00	0.000%	0.000%
* Employment and payroll of federal govt, non-military	9,763,745,613.41	9,763,745,613.41	9,763,745,613.46	0.000%	0.000%
Employee Compensation	265,211,746,114.24	265,211,216,499.37	265,211,216,498.21	0.000%	0.000%
Proprietor Income	40,969,809,208.22	40,983,927,021.05	40,983,927,020.88	0.034%	0.000%
Other Property Type Income	157,817,365,687.52	157,869,029,368.54	157,869,029,367.83	0.033%	0.000%
Tax on Production and Imports	29,535,154,118.17	29,536,471,842.25	29,536,471,842.12	0.004%	0.000%
Households LT15k	9,953,451,142.35	9,951,761,042.05	9,951,761,042.06	-0.017%	0.000%
Households 15-30k	16,950,341,623.85	16,948,116,648.52	16,948,116,648.57	-0.013%	0.000%
Households 30-40k	14,458,701,746.95	14,456,268,766.43	14,456,268,766.49	-0.017%	0.000%
Households 40-50k	16,368,897,666.97	16,367,022,499.75	16,367,022,499.83	-0.011%	0.000%
Households 50-70k	39,828,328,446.58	39,824,773,087.68	39,824,773,087.85	-0.009%	0.000%
Households 70-100k	59,544,852,737.92	59,539,927,315.26	59,539,927,315.56	-0.008%	0.000%
Households 100-150k	87,462,459,860.12	87,457,247,469.06	87,457,247,469.55	-0.006%	0.000%
Households 150-200k	66,197,772,974.11	66,196,581,776.31	66,196,581,776.68	-0.002%	0.000%
Households GT200k	157,182,274,791.21	157,181,670,346.17	157,181,670,347.06	0.000%	0.000%

Federal Government NonDefense	97,485,525,942.46	97,485,504,799.36	97,485,504,799.64	0.000%	0.000%
Federal Government Defense	11,174,898,080.28	11,174,895,490.21	11,174,895,490.27	0.000%	0.000%
Federal Government Investment	9,709,820,179.46	9,709,820,179.46	9,709,820,179.45	0.000%	0.000%
State/Local Govt Other	69,667,182,989.57	69,668,400,973.31	69,668,400,973.50	0.002%	0.000%
State/Local Govt Education	16,769,796,252.83	16,769,714,517.07	16,769,714,517.12	0.000%	0.000%
State/Local Govt Hospital and Health	11,029,362,668.21	11,029,390,426.36	11,029,390,426.36	0.000%	0.000%
State/Local Govt Investment	11,822,029,329.86	11,822,029,329.86	11,822,029,329.85	0.000%	0.000%
Enterprises (Corporations)	57,444,642,439.47	57,444,642,439.47	57,444,642,439.85	0.000%	0.000%
Capital	165,619,276,615.04	165,619,276,615.04	165,619,276,615.66	0.000%	0.000%
Inventory Additions/Deletions	2,702,709,201.95	2,702,815,328.57	2,702,815,328.57	0.004%	0.000%
Foreign Trade	68,863,531,257.94	68,859,596,767.65	68,859,596,767.53	-0.006%	0.000%
Domestic Trade	165,555,061,443.73	165,526,381,087.52	165,526,381,087.12	-0.017%	0.000%

Sources: IMPLAN, 2022 & 2021; USDA NASS Quick Stats, 2021

CHAPTER 3: ESSAY 2, SECTORIAL OVERVIEW AND FUTURE MARKET GROWTH

3.1 Introduction

In the previous paper, we estimated the current economic contributions of the potato sector to the San Luis Valley and Colorado. But, dynamic markets, policies and demands on natural resources (particularly water), motivate the need to assess how such contributions could be enhanced by adoption of new practices and markets (Brown et al., 2019). Increasing the value of the existing potato production acres is vital in promoting the importance of the potato production industry in the U.S. Mountain region. This paper will focus on the potato production that takes place in the San Luis Valley (SLV). The SLV is a six-county region located in the southern portion of Colorado and is home to 90% of the potato production in Colorado (see Table 3.1). Therefore, this research prioritizes analyzing the small region instead of the entire state, particularly since its persistent poverty status highlights the need to consider strategies that could bolster economic activity in the region.

Table 3.1 Potato Production: 2014-2018

Year	SLV Production (cwt)	CO Production (cwt)	Proportion of Production Occurring in SLV
2018	20,124,000.00	21,722,000.00	93%
2017	19,313,000.00	21,220,000.00	91%
2016	19,828,000.00	22,236,000.00	89%
2015	19,943,000.00	22,575,000.00	88%
2014	20,482,000.00	23,196,000.00	88%

Source: USDA NASS, 2014-2018

This paper explores two market scenarios that could help to spur potential growth in the potato industry, both connected to market dynamics playing out in food retail markets and supply chains. The first potential change to the potato industry is to increase organic potato production in the San Luis Valley (SLV). The second potential change is to adapt potato packaging sizes to accommodate consumer demands. By analyzing these market scenarios, we can better understand how changes like these could shape the future economic contribution of the San Luis Valley's potato industry. To assess these scenarios, it is important to understand the current state of the potato industry in the SLV (Table 3.1).

3.1.1 Motivation for Decreasing Pack Size

The traditional marketing supply chain route that SLV potatoes take is from a farm to a packing shed. Often the packing shed is the enterprise responsible for storing, sorting, and packing of the potatoes. The potatoes that meet industry standards for whole, fresh potatoes are then packaged in varying size packages or left in bulk bins. About 95% of the potatoes grown in the SLV will end up in the fresh market and therefore go through packing sheds. One packing option commonly used in potato supply chains are large bulk crates and sacks that weigh up to 50lbs, these potatoes are for restaurants, wholesale, and for individual potato sales (i.e. pick and bag your own potatoes). In addition to larger pack sizes, there are smaller packages such as 5- and 10-pound bags that are commonly found in most grocery stores across the nation. As of the 2023 marketing year, the most common pack sizes for potatoes in the San Luis Valley are 5 lb., 10 lb., and bulk. (J. Crawford, personal communication, 2025).

The choice to pack potatoes in specific quantities is often due to the demand from consumers. To make sales of potatoes, it is important that packaging sizes meet the demand of consumers, and such preferences may be evolving over time as households get smaller in size

(Grossman, 2023). According to the consumer attitudes and usage 2023 online study conducted by Potatoes USA, American consumers would eat more potatoes if they were in "smaller bags to minimize waste" (Potatoes USA, 2023). Thus, it can be assumed that the consumer would prefer a smaller package of potatoes to what is already commonly offered to them. Although most grocers already offer a selection of potatoes that can be picked individually, essentially letting the consumer choose their own packaging size, such choice may also contribute to food loss. In an interview with Nancy Meraz from Farm Fresh Direct she shared those "choose your own" potatoes are often stored improperly, contributing to poor appearance with less appeal to consumers which could deter purchases. An added benefit to packaging potatoes is the protection that the packaging can provide (N. Meraz, personal communication, January 2025). Meraz offered some insight into the positive aspects of potato packaging, she stated that there are packaging types that have UV protection that prevent the potato from turning green (N. Meraz, personal communication, January 2025).

In short, while there is the option to purchase individual potatoes, consumers still gravitate towards purchasing the potatoes with better appearance (more commonly in packaging). Therefore, it makes sense to continue to package the potatoes but in smaller packages as the consumer demands. It is often difficult to stray from traditional protocols, like packing 5- and 10-pound bags of potatoes, but the market appears to signal a need for packaging updates.. An aim of this paper is to understand how packing potatoes in different size packages may change how the potato sector contributes to Colorado's economy.

3.1.2 Motivation for Increasing Organic Potatoes

While many consumers have opinions on the size of the bag of potatoes, other consumers may be concerned with other aspects of the potatoes inside the bag. According to

USDA ERS the consumer demand for organic produce and other goods is on a steady incline. Organic fruits and vegetables are the most purchased category of organic retail food sales, and producers are responding (Skorbiansky et al., 2023).

Since 2000 the amount of land used for organic production has, on average, increased, reaching 4.89 million acres in 2021 (Skorbiansky et al., 2023). Another indicator of this shift to organic production is that the Federal funds allocated for the Organic Agriculture Research and Extension Initiative have increased from $3 million in 2002 to $50 million in 2023 (Skorbiansky et al., 2023). In 2021 Colorado grew 584,932 cwt of organic potatoes, making up only 2.7% of total potato production (U.S. Department of Agriculture [USDA], n.d.). According to the Colorado Potato Administrative committee, the SLV grows around the same proportion at 2.6% of the total potato production (J. Crawford, personal communication, 2025). There could be a multitude of reasons why there has been limited organic production thus far in the San Luis Valley. Some producers may have concerns with lower yield values: for example in 2021, yields dropped from an average of 410 cwt per acre for conventional farming to only 257 cwt per acre for organic farming (USDA, n.d.). With organic farming also comes an increase in labor costs and an increase in cost for some fertilizer, organic chemical, and fungicide products (but these additional purchases may ironically increase the economic activity underlying an organic sector). Putting aside the reasons for not producing organically, there is clearly a pattern of increased organic produce demand which is an opportunity for the industry to consider. In addition to demand, there also is a direct economic incentive due to price premiums. In 2021 a hundred-weight organic potatoes sold for an average of $20.75 in contrast to a hundred-weight of conventional potatoes sold, receiving $11.40. In addition, the additional management and inputs to organic production may indirectly increase its economic contributions to the region where

organic crops are grown. In this paper, a potential market scenario will explore how the contribution of the potato industry changes when the production of organic potatoes increases.

The following sections of the paper will include a discussion of data, including an explanation of how the matrices of a regional economy are customized for analysis. The next section, Methodology, will explain how a customized version of Leontief's I-O model is used to capture the economic output of a region's economy after a change. The last three sections will conclude the paper by discussing results, limitations, and future contributions of the research presented in the paper.

3.2 Data and Preprocessing

3.2.1 Data Sources

To evaluate the effects that the potential market scenarios could have on the SLV potato industry, this paper relies on multiple sources of data. Primary data comes from interviews conducted with a key industry stakeholder, such as Farm Fresh Direct. Secondary data sources include USDA NASS, USDA ERS, CPAC, and IMPLAN. This section first examines what data is used to inform the creation of new economies where the two market scenarios exist. We will then discuss how the data is used in pre-processing the industry social accounting matrices for analysis.

3.2.2 IMPLAN

To conduct an economic contribution analysis, the first tool necessary is a social accounting matrix (SAM). For this paper, the industry SAM for the San Luis Valley comes from IMPLAN. Both the 2021 and the 2022 industry SAMs are extracted for the SLV. These matrices are square matrices that include all the transactions that happen within a region's economy. The

rows represent the income of industries, and the columns represent expenditures. The matrices are in equilibrium, where the total expenditure of an income is equivalent to the total income. For the purposes of this paper it is assumed that the vegetable and melon farming industry, located in the SAM industry, is equivalent to the potato farming industry in the SLV. Any other vegetable or melon production in the region is considered negligible for the purposes of this research.

A balanced matrix is essential for the methods of evaluation in this paper. When the 2022 SLV SAM was extracted from IMPLAN it was noted that the vegetable and melon sector was valued higher than expected. This sector is where the potato farming industry is included. Upon further research, it was found that the average price for potatoes in Colorado, where the SLV is located, was $17.70 per cwt. This was a significant increase from the year prior when potatoes were $11.40 per cwt., on average. To represent a more normalized year for the potato industry, the 2022 SAM row and column of data were replaced by the 2021 SAM row and column. Without this adjustment, the value of the economic contribution of the potato industry would have been overstated, which may lead to false inferences. Unfortunately, replacing data in the 2022 industry SAM threw the matrix out of balance. To address this issue a matrix balancing method called RAS was employed. This method iterates adjustments to the rows and columns until the matrix is returned to equilibrium (Fofana et al., 2005). It only creates small changes in the value of the matrix and does not produce any significant changes to the value of the matrix. The newly balanced matrix represented an approximation for the year 2022. For the purposes of this research, the text will refer to the matrix as the estimated 2022 economy for the San Luis Valley.

3.2.3 Preprocessing Packaging Data

The first value-added market scenario analysis in this paper explores how changes to the packaging size of potatoes will affect the economic contribution of the potato farming industry and any other effects that may emanate from the change. As discussed in the introduction, harvested potatoes go to packing sheds. At the packing sheds, potatoes are sorted and put into different packages of all different sizes. The producer that grew the potatoes must pay a fee to the packing sheds for their potatoes to be packed and the fee or run charge fluctuates for different pack sizes. The total fee for all potato packing, grading, and sorting is located in the support activities for agriculture industry row in the SAM, contributing to the overall contribution of the sector to the SLV economy. The support activities for agriculture industry may reflect other expenditures, but for this research it is assumed it only represents the run charges paid by potato producers to pack sheds. This data was found from mapping NAICS codes to IMPLAN industries, using the 2022 546 industry aggregation scheme in IMPLAN (Slovachek, 2023). From Farm Fresh Direct, data was gathered on the cost premiums of different packaging sizes. As noted in the introduction, the most common pack sizes are 5 and 10 lbs. bags, so these are the sizes the premiums were based on.

Table 3.2 2022-23 Marketing Year Potato Packaging Data

Pack Type	CWT	% of Total	Cost Multiplier
WB	481,404.79	3.25%	1.00
3 lbs	174,195.63	1.17%	1.80
5 lbs	3,085,708.20	20.80%	1.00
50 lbs	1,326,731.00	8.95%	1.00
C	1,317,431.50	8.88%	1.00
8lb	442,736.96	2.99%	1.07
10lb	2,447,765.30	16.50%	1.00
15	196,047.75	1.32%	1.00
BK	5,233,583.46	35.29%	1.00
20	14,928.60	0.10%	1.00
40	33,618.00	0.23%	1.00
2.5 lbs	22,497.20	0.15%	1.80
4 lbs	17,046.64	0.11%	1.28
1.5 lbs	15,563.48	0.10%	2.20
48 lbs Crton	22,276.32	0.15%	1.00
2 lbs	147.02	0.00%	1.80

Source: Colorado Potato Administrative Committee (CPAC)

The aim of the analysis where this data is used is to understand how packing potatoes into smaller bags may affect the region's economy. Therefore, the premiums that were calculated are for bags smaller than 10 pounds. The data that will be used is for bags that are 2 to 3 pounds and bags that are smaller than 2 pounds. In the 2022-23 marketing year potatoes packed in these size bags only made-up 1.42% of total packed potatoes in the SLV. The CPAC data provided the proportion of potatoes that go into 16 different pack sizes (Table 3.2). With the total cost of packing, cost premiums, and pack proportions the estimation of the additional cost to shifting potatoes from one pack size to another was calculated. First, the base cost was calculated. The base cost refers to the total run charge incurred for any pack sizes that do not carry a premium (or translate to additional costs for extra materials and labor). For this research, it is assumed that all

pack sizes greater than 10 pounds do not have a premium as they are the standard industry pack. The following formula is used to solve the base cost.

$$X = \frac{C}{\Sigma\, p_i * a_i}$$

Where *X* represents the base cost, and *C* represents the total run charge deducted from IMPLAN. The denominator is the summation of the proportion of a pack size, p_i , multiplied by the cost multiplier associated with the pack size, a_i. The cost multiplier is 1 for all pack sizes with no cost multiplier and 1 plus the cost premium for all pack sizes (Table 3.2). For the 2022 SLV data, the total pack charge is $20,884,831.00. Doing the calculation above for the original proportions of pack sizes from CPAC, the base cost is $20,590,752.00. This means that all other costs fall on the pack sizes with a cost premium. The small difference between base cost and total cost indicates that more expensive package sizes make up a small proportion of total packs. To model an increase in the small pack sizes we need to first estimate the number of potatoes desired to be in smaller packages. For this research, we will assume that the target audience for small packages of potatoes is single individuals. This assumption is backed by the correlation of the shrinking number of persons in U.S. households and the increase in demand for smaller package sizes (Hatt, 2017; Duff, 2025). As the SLV distributes potatoes to the whole state of Colorado, indicated by a positive domestic trade value in the SAM, the share of the population that is single will be calculated for the whole state. The US Census Bureau said that the U.S. population is made of 46.6% single people (U.S. Census Bureau, 2023). Assuming Colorado has the same proportion of single people, that means that 2,714,834 single people reside in Colorado (U.S. Census Bureau, 2024). Taking the single population and multiplying it by per capita consumption of potatoes, 28.3, we get 76,829,798 pounds (Navarro, 2025). This value is the total pounds of

potatoes that single individuals in Colorado consume, on average. By dividing it by 100 we get the value in hundred-weight, 768,298 cwt.

Taking this estimation of potential demand and comparing it to the number of potatoes that CPAC indicates are already placed in small packaging sizes we get a difference of 555,895 cwt. This is how many more potatoes that could be in small packages and go to single individuals if this value-added enterprise was expanded. This increase in small pack size will change the total run charge. To model the increase in small pack sizes we will split the analysis of contributions into two. The first analysis will evaluate the increase in bags of 2 to 3 pounds and the second analysis will model an increase in 1-pound bags. Those focused on the market for 2 to 3 pounds bags packed 196,839.85 cwt in the 22/23 marketing year. That means to fill the gap and meet the needs of all single people in Colorado the SLV needs to pack an additional 359,055 cwt of potatoes into 2 to 3 pound bags. There are three types of bags that fit this size range, 3, 2.5, and 2 pounds, so the additional potatoes will be split evenly amongst the three pack choices. All the bag sizes in this range carry the same cost multiplier, 1.8, so evenly spreading the new potatoes will not impact cost differently.

For this analysis, it is assumed that the number of potatoes grown is finite. Therefore, new small packages of potatoes take potatoes out of the bulk packaging category. The bulk packaging category has a cost multiplier of 1 so lessoning its proportion will not induce any cost savings to the model. In the original model, seen in Table 3.2, the total proportion of pack sizes from 2 to 3 pounds was 1.33%. With the addition of 555,895 cwt the total proportion increased to 4.32%, and given the cost premium, will change the total run charge. To model this the following formula was used.

$$C' = C * \frac{\Sigma \, \mathrm{p_i'} * a_i}{\Sigma \, p_i * a_i}$$

Where C' is the new total charge calculated from a change in the proportions of pack sizes. C is equivalent to the total run charge found in IMPLAN, $20,884,831.00. The fraction takes the sum of the new proportion times the cost multiplier divided by the sum of the original proportion times the cost multiplier. The cost multiplier, a_i, does not fluctuate with changes in proportions. Increasing 2 to 3 pounds bags from 1.33% of packing production to 4.32% increased the total run charge to $21,502,277.00. This new total run charge is used to update and customize the SLV matrix to reflect this potential market scenario.

As stated, there is also a second analysis of package sizes that will model the change in total run charge when there is an increase in 1 pound potato bags. To calculate the new total run charge the exact same methods will be used as were used in the 2-to-3-pound bag analysis. The 1-pound bags increased from 0.10% to 3.85% of the market. This increase in proportion led to a new total run charge of $21, 810, 926.00. Same as the first analysis, this value will be used the customized SLV industry SAM.

3.2.4 Customizing Matrices for Packaging Data

With an adapted model that integrates the new total run charges needed to market smaller bags, two San Luis Valley matrices will be customized to represent the updated economic contributions where small packages of potatoes are more prevalent. The customization process for the two matrices will be the same, the only difference will be the value of the run charge. The first customized matrix will represent the SLV potato industry that chooses to pack more of its potatoes in 2 to 3 pounds bags. We now know that the new run charge for this scenario is $21,502,227.00. The difference between the original run charge and the new run charge,

$617,397.00, is the basis to how much other industry sector's expenditures and income will increase (i.e. how much the row and column totals will increase). The first step to customizing the matrix will be to change the total run charge that the potato farming industry pays to the potato packing industry, which falls under the support activities for agriculture industry category as discussed in Section 3.2.3. Changing that value will increase the income of the potato packing sector and increase the expenditure total for the potato farming sector.

To make sure the matrix stays in equilibrium further customization is undertaken to restore balance. First, we address the increase in income for the potato packing sector. Since their income increased, their expenditure must increase by the same amount. In this analysis we assume that the increase in the potato packing industry income will transfer to an increase in the wage the industry pays their employees. [1]This assumption is made because confidential industry data reveals that smaller potato packaging sizes require more labor to be used in the packing sheds, therefore increasing employee compensation. From this increase in employee compensation, the employee compensation sector will realize an increase in income or the summation of the row values. This must be matched with an increase in the expenditure for that industry. To do this, in the employee compensation column we located the final demand industries -households, government (state and federal), and trade. For this paper we will spread the value increase evenly over the household and trade sectors. Increasing these values will lead to larger income for the sectors. This increase in income will loop back to the potato farming industry, where the additional income will be spent. We assume that consumers of potatoes absorb the excess cost, as there is a lack of data to explain where the increased cost would otherwise be absorbed. As stated, the potato farming industry increased their expenditure

[1] Proprietary data on file with the author.

amount, therefore their income must change to match. To model this, we take the increase in income from the household and trade sectors and mimic the change in the expenditure of these sectors. The expenditure will be for the potato farming sector, indicating that the increase in expenditure for the potato farming sector from increasing small packages of potatoes will increase the value of the potatoes and that will lead to households and trade spending more on the potato farming industry. This final customization will increase the income for the potato farming industry and the SAM will be balanced once again. See the figure below for a step-by-step customization process.

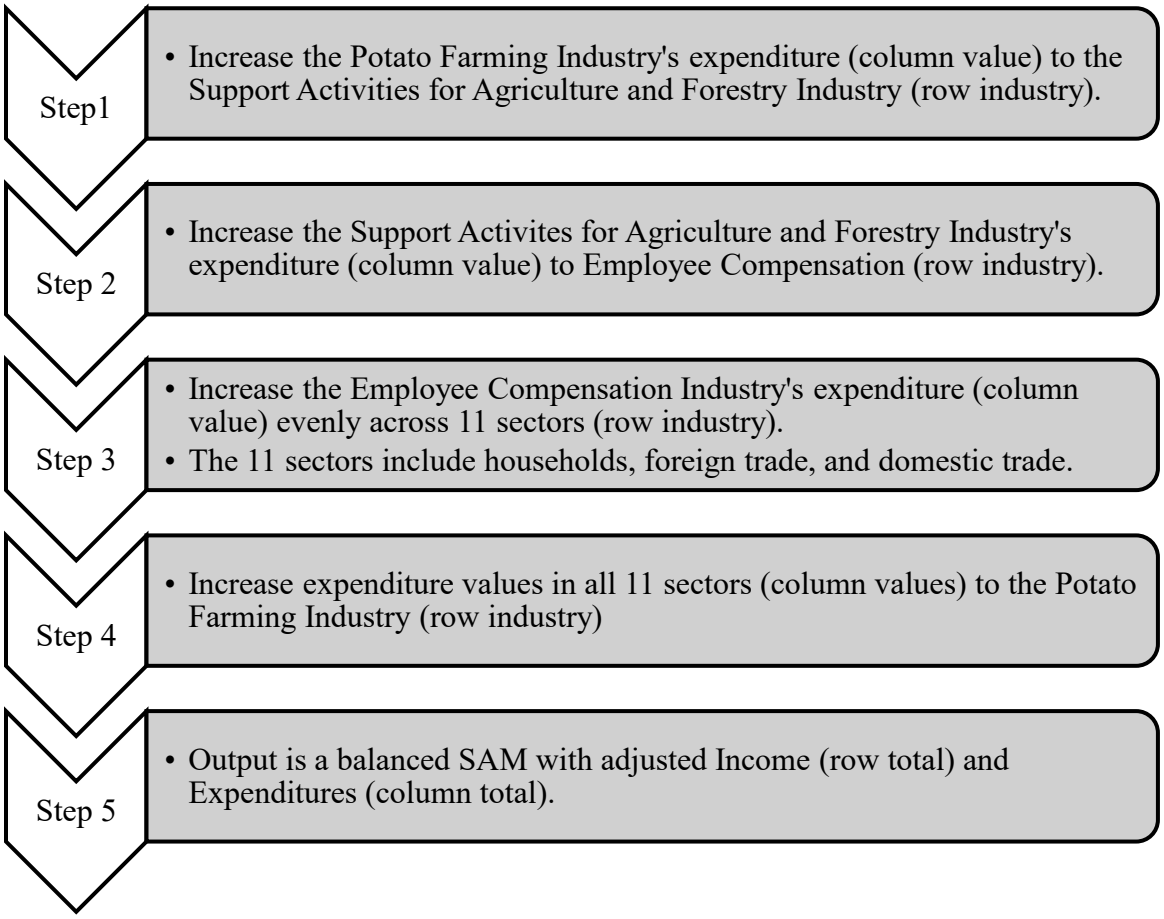

Figure 2.1: Steps to Customize Matrices for Packing Data

Customizing the SLV SAM to accommodate the price increase for packing a greater share of 1-pound bags will follow the same customization scheme as discussed for the 2 to 3 pounds bags above. The difference between the sectors will be the relative amount the value of services and income increases. The 1-pound bags have a higher cost multiplier and will increase the total run cost even more despite being a smaller proportion of the packing production. The price increase for the 1-pound packages is $926,095.00, making the new total run charge $21,810,926. This increase in value will be reflected in the employee compensation, potato packing, and potato farming industries. The two newly balanced industries are used in the analysis discussed in Section 3.3.1.

3.2.5 Preprocessing Data for Organic Potatoes

The second value-added market scenario analysis in this paper involves analyzing the economic effect of increasing the number of organic potatoes grown in the SLV. Unfortunately, there is a lack of organic market and production data for potatoes. So, different data sources were compiled and synthesized to shape what the organic potato industry looks like. To customize the SLV matrix to include an organic potato sector, section steps outlined in Section 3.2.6 were followed, but data had to be transformed. The organic potato sector does not have the exact same expenditure structure as the conventional potato sector. The three major areas where organic farms realize a difference in cost are seed cost, fertilizer and fungicide cost, and employee compensation cost (Chase, 2019). According to Finley et al. (2017) organic farming is more labor intensive. The increase in labor on an organic operation will lead to an increase in the employee compensation expenditure for the potato farming sector. According to the Dimitri (2010), the employee compensation on a conventional operation, on average, makes up 14% of the farm's total expenditure. Looking at the SLV SAM from IMPLAN we see that employee

compensation is 13.8% of the industry's total expenditure, matching the expectations from Dimitri (2010). Dimitri (2010) then goes on to state that on average organic operations report an employee compensation expenditure of 23% of their total expenditure. Subsequently for this paper, we will assume that organic potato farms in Colorado also incur employee compensation expenses that are 23% of their total expenditure. While organic operations do not implement some of the fertilizer and chemical methods that conventional farms do, they still use organic fertilizers and other organic compounds to fight pest and disease. There can be a cost savings from not buying conventional inputs, but these savings are often offset by buying organic inputs as they are more scarce and often expensive (Schahczenski, 2019). To capture a value for organic inputs like seed, fertilizer, and fungicides a few different data sources were considered. The first source to capture the difference in costs was the Colorado State University potato enterprise budget for 2021 (Colorado State University [CSU] Extension, 2021). This budget contains input costs such as seed, fertilizer, water, etc. For the purposes of this research, we assume that the only costs that differ from conventional farming to organic farming are seed, chemicals, and labor (a necessary assumption given the lack of data that exists on organic potato farming operations).

We compare the cost of seed from this budget, $347 per acre, to the average cost of seed for organic farms from the USDA 2021 Certified Organic Census (National Agricultural Statistics Service [NASS], 2024). The census data lists seed cost as a total across all organic farms, along side the number of farms that use seed. We took the total cost and divided it by the number of farms. This gave us an average seed cost per certified organic farm. Taking this average value into consideration, we multiplied it by the number of organic potato farms in Colorado in 2021, which was 14 for our reference year. We had to use the entire state's data for

this estimate, as there was no county level organic production data available. This gave us a total seed cost across all certified organic farms of $1,231,316.00. This total cost was then divided by the total acres of potatoes harvested in Colorado in 2021 and gave a seed cost of $541 per acre. The CSU enterprise budget was also on a per acre basis, comparing the values told us that organic seed cost is 56% higher than conventional seed cost, on average.

The CSU enterprise budget also gave a per acre cost for fertilizer and other chemicals. The total cost for the conventional potato fertilizer and chemical inputs was $665 per acre. Unfortunately, the 2021 organic census did not provide any data on fertilizer or chemical inputs, so data from an outside source was collected. A consultant at Cactus Hill Agricultural Consulting, LLC shared a breakdown of the typical inputs for an organic potato operation (M. ter Kuile-Miller, personal communication, 2025). Compiling the data, and further refined with communications from industry experts, it was estimated that the fertilizer and chemical inputs for an organic potato operation averaged $874 per acre, which is about 32% more expensive than conventional potatoes.

3.2.6 Customizing Matrix to Integrate Estimated Organic Data

Using the data discussed above, the SLV matrix was customized to include a new industry sector that represents the organic potato industry. The SAM pulled from IMPLAN does not include an industry that is explicitly the organic potato industry. So, to do analysis only on the potato industry, a disaggregation process of the potato farming industry sector was undertaken. This starts with understanding the value of the potato farming industry. As discussed previously, the SLV grows approximately 90% of the potatoes for the state of Colorado. Assuming this proportion is also true for organic potatoes, USDA NASS data says the entire state of Colorado produced 584,932 cwt of potatoes in 2021, therefore the SLV produced 526,439 cwt.

The average price of organic potatoes in 2021 was $20.75 per cwt, producing a total value of organic potatoes in the SLV of $10,923,605.00. Using this value of organic production, we were able to construct a new industry using proportions of expenditure for the existing potato farming industry and some of the increases in expenditures discussed in Section 3.2.6. We first addressed the column of the potato farming industry, where the expenditures of the industries are. For this column we first calculated every expenditure as a proportion of the total expenditure. Then going down the column we found the three industries where the expenditures are greater for organic potatoes than conventional potatoes using the NAICS code to IMPLAN industry mapping discussed in Section 3.2.3.

Specifically, the seed cost sector maps to the potato farming industry, the fertilizer cost maps to the wholesale sector for other nondurable goods, and labor cost maps to the employee compensation sector. For the new organic potato column, the following formula will be used for the three cells that have larger expenditures than conventional potatoes.

$$X_i = (p_i * (100 + d_i)) * V$$

Where X_i is the value of the sector – potato farming, wholesale nondurables, or employee compensation. The variable p_i represents the proportion of expenditure for the industry in the original potato farming industry column. The variable d_i is representative of the increase in the cost of organic inputs. This is added to 100 to simulate an increase by the percentage that d_i represents. Finally variable V represents the value of the organic sector, $10,923,605.00. The three new values now represent a larger proportion of the total expenditure than their counterparts did in the potato industry sector. In addition to increasing these three sectoral values, we also kept the proportion of proprietor income static from the potato farming industry column to the organic potato industry column. We maintained the same proportion due to

limited data on proprietor income differences between organic and conventional farming operations. This may undervalue the proprietor income of the organic potato farming industry, but the lack of data made this a necessary assumption.

Increasing three proportional expense costs and keeping the proprietor income value static meant that all the other industry proportions needed to decrease in order for the column to sum to $10,923,605.00. To do this, all the unchanged industry proportions were forced to decrease by the same proportion. To find the necessary proportional decrease we took the total value of the organic potato farming industry and subtracted the total of the changed industries discussed above – potato farming, employee compensation, wholesale nondurables, and proprietor income. This left us with the total value that needed to be filled by all the remaining, unchanged industries. This value was then divided by the sum of the unchanged industries. The sum of unchanged industry values represents the organic industry values if they were given by the same proportion as the total potato farming industry values. The output from the proportion of the value needed to be filled to the sum of the values of the unchanged industries was 79.05%. This indicated that every proportion of the unchanged values needed to be 79.05% of their original proportion. Each of these sectors now takes up a smaller proportion of the total expenditure.

Balancing the increase in expenditure proportions of three industries and one static industry with a decrease in all other industries made the new organic potato farming industry column sum to the industry farm-gate value found from USDA NASS data. The new column of organic potato farming data was then subtracted from the total potato farming sector to mitigate double counting the organic potato sector (since we assume current potato acres will be transformed to organic, rather than there being any additional acres). This leaves the matrix with

an organic potato farming sector and a conventional potato farming sector, a final step in the disaggregation process for the column vector.

The next part to disaggregating the organic potato farming industry from the total potato farming industry is to pull the value of the organic potato farming industry out of the potato farming industry row in the SLV SAM. Due to the lack of data on the sales of organic potato farming the disaggregation process for the row vector was done proportionally. Similar to the beginning step of disaggregating the column values, the value of every cell in the row vector was divided by the total of the row, which is also the income value of the potato farming industry. This gave us the proportion of income for the potato farming industry that comes from every industry it sells to. It is assumed that these proportions remain the same for the organic potato farming sector, therefore the calculated proportions are multiplied by the total value of the organic potato farming industry. This gave us a row of values that represents in the income for the organic potato farming industry. The same process is done as with the column vector, where the row values of the organic potato farming industry are subtracted from the total potato farming industry to avoid double counting. The final output is two rows, one that represents the organic potato sector and another that represents the conventional potato sector.

3.3 Methods

3.3.1 Changes to Potato Packaging Size

To model the effect of the change in packaging sizes on the economic contribution of the SLV potato farming industry a version of Leontief's Input-Output modeling is used (Miller and Blair, 2012). Leontief's model is structures as follows.

$$X = (I - A)^{-1}Y$$

Where the dependent variable *X* represents the vector of total output from a specific industry. In the case of this research the total output value is equivalent to the economic activity produced by an industry. The function $(I - A)^{-1}$ inverse represents the output multiplier of an industry. In this paper the output multiplier is interpreted as the amount of output that is produced for a dollar of exogenous final demand. The last variable, *Y*, represents exogenous final demand. Exogenous final demand is defined as all of the demand that occurs outside of the regions economy. Using this basic structure in conjunction with the two customized matrices will allow us to capture the change in the economic contribution of the potato farming industry when packaging sizes are changed.

Both analyses for the different size packages will follow the same structure. The difference will come from the total run charge discussed in Section 3.2.3. Following the steps of analysis from Watson (2025), that are rooted in Leontief's I-O model, we start the analysis by finding the A matrix (P. Watson, personal communication, 2025). The A matrix will be a square matrix where only endogenous industries are represented. In this research endogenous industries include any industry that has a NAICS code, the value-added industries, and all households. The definition of endogenous industries may differ from researcher to researcher. To create the A matrix, we divide all the endogenous cells in a column of an industry by the column total of the industry. The column total includes endogenous and exogenous industries. The next step in the evaluation is to create an identity matrix, *I*, which is the matrix equivalent to 1. Taking the I matrix, subtracting the A matrix, and inverting the entire matrix leaves us with a matrix of output multipliers.

As stated earlier, the multipliers tell us how much output is needed to meet a single unit of exogenous final demand. If we sum up the industries in the column, we get the total output

multiplier which tells us how much total output is needed to meet exogenous demand for that industry. The higher the output multipliers, the stronger its industry linkages are, signaling the industry relies on other industries and other industries rely on it. This would lead us to believe that an industry is important to the economy. The matrix of output multipliers is then multiplied by a diagonalized matrix of exogenous final demand. Exogenous final demand is the purchases made of an industry's good or service outside of the regional economy. The output from the multiplication of these two industries is the matrix of economic activity or the X in Leontief's I-O model.

By aggregating the values in an industry's column, limited to producing industries identified by NAICS codes, we capture the total economic activity that an industry generates. Economic activity is defined as the production, distribution, and consumption of goods or services. This value encapsulates all the value an industry brings to the economy that stretches beyond the production value of the product being produced. It captures direct, indirect, and induced effects from an industry's production. In Section 3.4.1 we will compare the outcome of these two analyses with an analysis that was done on the existing potato farming industry.

3.3.2 Increasing Organic Potato Production

The analysis for the increase in organic potato production will differ from the analysis done in Section 3.3.1. To analyze the potential increase in organic potato production, we will simulate two scenarios. The first scenario will increase the organic potato industry to 10% of production and the second scenario will increase the industry to 20% of total potato production. Hypothetically, increasing organic potato production will have some kind of effect on the economy. If the SLV produces 90% of Colorado's potatoes, then in 2021 the SLV produced 19,335,600 cwt of potatoes. As stated, the SLV produced an estimated 526,439 cwt of organic

potatoes. This 2021 data from USDA NASS means that organic potato production made up 2.7% of the total potato production in the San Luis Valley. The first analysis considers an increase from 2.7% to 10% organic potato production. Firstly, to get to 10% or 20% organic potato production the SLV must produce extra organic potatoes. Considering resource limitations, the increase in organic production will take land away from conventional potato production (and we assume a shift of one-to-one for acreage). To model the increase in organic potatoes and simultaneously the decrease in conventional potato production, we must calculate the value loss and gain from both industries. For organic potatoes, there will be an increase in value. This is calculated as the product of the increase in potato acres, the average yield per acre, and the price received per cwt of organic potatoes. To calculate the increase in potato acres we take the increase in organic potato production and divide it by the average yield per acre of organic potatoes, which was 275 cwt per acre in 2021 (USDA, n.d.) As for conventional potatoes, there will be a decrease in the total value of the sector. Taking the same increase in acres for organic production and using it as the decrease in acres for conventional production we calculate the total value loss as a product of the decrease in acres, average yield per acre for conventional production, 410 cwt per acre, and the price received per cwt of conventional potatoes.

Understanding the changes in economic values for organic potato production and conventional potato production we can convert our contribution analysis to an economic impact analysis, which considers how a shock will affect economic activity in the region. This analysis will help model what happens when land from conventional potatoes is moved into organic potato production. The same beginning steps from section 3.3.1 one will be used in this analysis. We created an A, I, and output multiplier matrix. Instead of taking the matrix of output multipliers and multiplying it by the diagonalized matrix of exogenous final demand, we took a

different approach. A column vector to represent the change in *Y* or final demand of a sector was multiplied by the matrix of output multipliers.

In our case, the change in value from a change in land from conventional to organic potato production is equivalent to final demand, because changing what is available in the market also shifts demand. This model will simulate how a change in final demand will affect the broader economic output and contributions of an industry sector. In other words, how a change in land utilization will affect the ripple effects to the broader economy.

3.4 Results

3.4.1 Effects of Decreasing Potato Packaging Size

Analysis focused on increasing the proportion of potatoes packed in smaller packages yielded expected results. While the total expenditure for the potato farming industry increased, the value of the potatoes also increased. The increased expenditure led to a higher value product and the economic output for the analysis with respect to both package sizes reflected the existence of the higher value product. The economic contribution from Chapter 2: Essay 1 in this Thesis reflected an approximation of the 2022 economy for the SLV (see table 3.3) where potato pack sizes were assumed to follow to proportions given by CPAC (see Table 3.2).

Table 3.3 2022 Economic Contribution of the Potato Farming Industry: San Luis Valley

Effect	Farm-gate Value of Production ($)	Economic Output ($)	Employment (persons)	Labor Income ($)
Direct	202,143,536.00	-	869	62,339,668.00
Indirect &Induced	-	327,977,203.00	1,371	60,390,149.00
Total	202,143,536.00	327,977,203.00	2,240	122,729,817.00

Source: Paper 1: Economic Contribution of the Potato Farming Industry

Comparing the outcome above to the outcome of the analysis for 2 to 3-pound packages and 1-pound packages help one to consider how increasing the proportion of small packages increased the economic contribution of the potato farming industry. In Table 3.4, the summary of the outcome from the analysis of increasing the proportion of 2 to 3-pound potato packages tells a positive story. Firstly, when compared to the analysis of the existing potato industry in Table 3.3 we see that the farm-gate value of production increased. This increase in the value of farm-gate production had a domino effect on other parts of the economic contribution of the potato farming industry. We also see that the economic output of the industry increased.

Table 3.4 Economic Contribution of the Potato Farming Industry: Value Added

Effect	Farm-gate Value of Production ($)	Economic Output ($)	Employment (persons)	Labor Income ($)
Direct	202,760,933.00	-	872	62,530,069.00
Indirect & Induced	-	328,705,862.00	1,375	60,574,596.00
Total	202,760,933.00	328,705,862.00	2,247	123,104,664.00

Note: The value added is from increasing the proportion of 2 to 3-pound potato bag production

Table 3.5 Economic Contribution of the Potato Farming Industry: Value Added

Effect	Farm-gate Value of Production ($)	Economic Output ($)	Employment (persons)	Labor Income ($)
Direct	203,069,631.00	-	873	62,625,269.00
Indirect & Induced	-	329,069,328.00	1,377	60,666,819.00
Total	203,069,631.00	329,069,328.00	2,250	123,292,089.00

Note: The value added is from increasing the proportion of 1-pound potato bag production

This means that the industry now brings in more dollars to the economy, which in turn creates additional economic activity. This is also reflected in the increase in employment. The value added to the potato industry increased the amount of people employed directly in the potato farming industry as well as the amount of jobs that are outside of the potato farming industry but are still supported by the industry's production. The increase in jobs is also reflected in an increase in labor income.

The same story is reflected in the analysis where 1-pound bags become a greater proportion of potato packing production (see Table 3.5 and 3.6). There is an even greater increase in the farm-gate value of production leading to an even higher economic output. There are also a few more jobs introduced to the market from the 1-pound package analysis and an even larger labor income contribution. Overall, increasing the proportion of small, packaged potatoes had a positive effect on the economic contribution of the potato farming industry. As far as comparing the contributions of one packaging size over the other, there is not a huge difference when comparing the economic contributions of the 2 to 3-pound and 1-pound scenarios.

Table 3.6 Comparing the Economic Contribution of Three Market Scenarios

	Scenario		
Effect	2022 Market	Increase in 2 to 3-pound Packages	Increase in 1-pound Packages
Farm-gate Value of Production ($)	202,143,536.00	202,760,933.00	203,069,631.00
Direct Employment (persons)	869.00	872.00	873.00
Indirect and Induced Employment (persons)	1,371.00	1,375.00	1,377.00
Direct Labor Income ($)	62,339,668.00	62,530,069.00	62,625,269.00
Indirect and Induced Labor Income ($)	60,390,149.00	60,574,596.00	60,666,819.00
Economic Output ($)	327,977,203.00	328,705,862.00	329,069,328.00

Source: IMPLAN, 2021 & 2022

3.4.2 Effects of Increasing Organic Potato Production

The analysis of increasing the organic potato sector was completed to model organic potatoes as either 10% or 20% of total potato production. As discussed in Section 3.3.2, increasing organic potato production would lead to a decrease in conventional potato production. For the first scenario, to make organic potatoes 10% of total production the land requirement for organic production increases by 5,475 acres. This means that 5,000+ acres of land must be removed from conventional potato farming. This creates a loss of $25,591,085.00 for conventional farming. This loss is calculated from a acreage decrease of 5,475 acres multiplied

by an average yield of 410 cwt per acre and the average price received of $11.40 per cwt. This loss is offset because the addition of land to organic production creates a gain of $29,197,873.00. The gain is calculated from the product of new acres, 5,475, the average yield of 257 cwt per acre, and the average price received of $20.75 per cwt. Inputting these values into the column vector representing a change in *Y* creates $7,071,539.84.00 of new economic output in the SLV economy. This means that increasing organic production led to a ripple effect that induced a positive effect on the SLV economy.

For the analysis where 20% of potatoes are produced organically, 12,999 acres are needed to meet the new production demand. Again, this means that 12,999 acres need to be taken out of conventional potato production. This leads to a loss of $60,756,217.00 for the conventional potato sector, but a gain of $69,319,151.00 for the organic potato farming sector. Doing the same as the 10% organic analysis, these two values are put into the column vector that represents the change in *Y*. The output is $16,788,659.00, which is a net positive increase in the economy due to an increase in organic potato production. When compared to the 10% organic scenario, the 20% scenario has a much smaller positive effect on the regional economy, most likely due to the yield decrease that comes with organic potato production.

While organic production comes with an increase in the price producers receive, there comes a point when taking land out of conventional production for organic production becomes less valuable. This exact point was not discovered in this research, but we can see that the larger increase in organic production does produce a smaller impact on the economy. Despite the smaller value of economic growth, it is still economic growth and increasing organic production is not creating a negative effect on the economy.

3.5 Limitations and Future Research

3.5.1 Potato Packaging Scenario Limitations

When it comes to the analysis of decreasing packaging sizes there were a few limitations present. The first limitation is in the data. There are no publicly available sets of data that discuss the cost to producers for potato packing. This forced us to make the assumption that the agriculture support activities sector was equivalent to the total cost of getting potatoes sorted, graded, and packed. This could have led to the over or underestimation of the cost of packing potatoes. Additionally, the only data that was available for analysis on packing prices was given as premiums above a base cost for 4 different pack size categories, the base cost being unknown. This forced us to assume that all pack sizes, that were not the 4 sizes given, had a cost equivalent to the base packaging sizes of 5 and 10 pounds. This again could lead to an over or underestimation of total packaging cost.

In addition to packaging data limitations, we also made assumptions about the demand for small bags of potatoes. There is research that supports the increase in demand for small packaging sizes, but the quantity demanded is unclear (Potatoes USA, 2023). An article from Supermarket News supports the assumption that there is an increase in demand of bagged potatoes under four pounds, saying that sales were up 17.8% in 2017 (Hatt, 2017). The issue that arises is we are unsure of total measured demand or sales amounts of the small bags of potatoes. Therefore, we assumed the pool of demand from the average per capita consumption of potatoes for the single population of Colorado. The assumption that the population of single individuals in Colorado want these small packages of potatoes could have over or underestimated demand. This estimation could lead to the packaging of potatoes that are not actually desired and end up becoming food waste. Lastly, we assume that the increase in the income of the potato farming industry comes from an evenly dispersed increase in purchases made by households and trade

industries. There is no measured data that exists on how these purchases would be distributed, therefore adding another limitation to these scenario analyses.

3.5.2 Organic Potato Scenario Limitations

There was an overwhelming limitation on organic data. The limitation of organic data was not exclusive to the potato industry but seemed to be an issue for many other sectors. Unfortunately, resources like USDA NASS often redact organic data due to there being so few organic farms and concerns about data privacy. They do not want to inadvertently reveal data about a specific farm, so when there are too few farms in a survey pool the data is not available to the public. This includes data such as input costs, and labor costs.

There was also consistently an issue that organic production was lumped in with conventional production, making it impossible to understand how organic production functioned independently. There is often a simple process to add an agricultural enterprise to an IMPLAN SAM because of the existence of enterprise budgets. The unfortunate situation for organic operations is that enterprise budgets do not often exist to assist them with production and business planning. This was the case for potatoes, which forced us to compile many different sources to make rough estimates about the cost of organic inputs.

Another large limitation to the organic production scenarios is the exclusion of transition costs. It takes a minimum of three years for a farm to be considered organic, as that is the period in which an operation cannot be using specific inputs (Agricultural Marketing Service [AMS], n.d.). Within this three-year period a farm will realize a reduction in yields that comes with organic production but will not qualify to receive the increase in sale prices that also come with organic production. This can lead to large profit losses, which are not modelled in this research.

Unfortunately, this cost that farms face is nearly impossible to estimate as every farm may experience different levels of yield loss and some transition periods can fluctuate in length.

3.5.3 *Future Research*

To address issues that limited the accuracy and scope of this research, future additions should be considered. For the potato packaging research, access to more proprietary data on run charges could better inform the scenarios. This may require the purchase of data but would overall lead to a more accurate representation of the economic output changes due to the two scenarios. Secondly, for the potato packaging research, a more detailed consumer survey about preferences for potato consumption could make for a better hypothesis about anticipated potato demand. The motivation behind changing package sizes was because consumers said they wanted smaller bags of potatoes, but the quantity of demand is unknown. The addition of a detailed consumer survey would increase the accuracy of the analysis.

For the organic scenario analysis, future research to improve the analysis would include the creation of an organic enterprise budget for potatoes. Theoretically, it would take one market-year of survey data to create an organic enterprise budget, but several years' worth of budgets would be best. This data should be gathered on farms that are already certified organic and farms that are in the transition period. Gathering this data over several years would aid in making a more accurate organic potato industry within IMPLAN and help in understanding more about the transition cost from conventional farming to organic farming.

Another improvement for the organic scenario analysis would be to find the break-even point where switching more land into organic potato production would cause a zero or negative economic effect. Tying into that same type of analysis, it may also be beneficial to do a

sensitivity analysis based on yields for organic production, as yields can be highly variable due to the lack of conventional herbicides and insecticides.

3.6 Conclusion

This study examined two different scenario analyses intended on adding value to the potato farming industry. The first analysis aimed to add value to the potato industry by meeting the changing demands of consumers. The results of this analysis yielded positive increases to the economic contribution of the potato farming industry when compared to the existing economic contribution of the 2022 potato farming industry (Table 3.6). The ripple effect from increasing the market share of small packages of potatoes increased employment numbers supported by industry and increased economic activity. While producing smaller packages does cost the producer more money, the product is a fresh potato product that has a higher value to the consumer. While potato producers do not experience the direct effect of the value increase because their income moved equally to their expenditure increase, there are positive effects from changes in the supply chain.

The second analysis focused on adding value to the SLV potato industry by modeling scenarios in which organic production is 10% and 20% of total potato production. These two scenarios were designed to reflect growing consumer demand for organic produce production and show how increasing organic production may affect the economy. Organic potatoes face lower average yields than conventional practices, but the two analyses suggest that the higher prices received for organic potatoes may offset the yield losses. This is evident, as we are forced to trade conventional acres for organic acres which may sacrifice some yield, yet the economic output from doing so is still positive. Despite the increase input and labor costs associated with

organic production and yield loss these scenarios have positive outputs. Indicating the opportunity for producers to create a higher value fresh potato product.

Overall, the set of analyses presented in this paper highlight how market adaptations within the potato farming industry can drive positive economic growth. In Chapter 1, we discuss how the value of the potato industry is important in whether farmers get access to water and land resources for growing potatoes. This research provides the potential value of the potato industry, which may secure water rights for potato producers and lead to other positive effects as the potato industry continues production. Through the exploration of two value-added market scenarios, this research demonstrates an opportunity to increase the value of the potato farming industry and support positive contribution to the SLV economy.

CHATPER 4: THESIS CONCLUSION

4.1 Conclusion

Reviewing the economic contribution of the potato industry in 2022 and the market scenarios introduced in Chapter 3: Essay 2, both sets of analysis suggest that the potato industry has a positive effect on economies of Colorado and the San Luis Valley (SLV).

4.1.1 Economic Contribution Analysis

Essay 1 captured the economic contribution of the potato industry in Colorado and the SLV as an approximation of the 2022 production season. Both analyses focused on the whole potato industry, organic and conventional potatoes, and aimed to capture the industry's contribution to the economy beyond the sale of potatoes. The contribution analysis captured backward linkages (when a sector purchases inputs from other sectors) in the economy. The total effect from these types of transactions is known as economic activity. Economic activity is the value the industry produces from exogenous demand. Furthermore, the economic contribution analysis showed how many jobs are supported by the potato industry from direct, indirect, and induced employment. The analysis also captured the labor wage paid to all jobs supported by the potato farming industry, this includes wage paid to employees and owners in the industry (see Tables 3.4 and 3.5). The wages earned are then spent throughout the economy through transactions for groceries, rent, recreation, etc. causing what we refer to as induced effects.

The results of the analyses tell two different stories in the regions. Colorado's potato industry had a production value of $244 million in 2022 but had an economic output (economic activity) value of $165 million. The production value being larger than the economic output

value tells us that the state retains a lot of its potato production within the state's borders (suggesting self-sufficiency) and does not capture a large share of sales from potato exports (exogenous demand). This is not to say the state does not export any potatoes, the value only indicates that there is not a large export income dependence for the potato industry in Colorado. The analysis for Colorado also tells us that the industry supports over 3,000 jobs and those jobs earn a sum of over $160 million in labor wages.

On the other hand, the San Luis Valley analysis shows a larger reliance on export income, which makes it contribution to the regional economy more significant. The production value of potatoes in the Valley in 2022 was $202 million and the economic output value was $328 million. These values are weighted opposite of the whole state, and this is likely because majority of the potatoes produced in the SLV leave the region. A stated numerous times, the SLV produces 90% of Colorado potatoes as the population of the Valley is not large enough to consume all of the potatoes produced so the potatoes must go elsewhere, hence the large reliance on export income. From the analysis we also see that the Valley's potato industry supports over 2,200 full-time jobs and those jobs earn $123 million in labor wages.

Despite the disparity in export income reliance in the regions, both the analyses tell a positive story. The regions both support a significant number of jobs and the employees in those jobs earn a positive income that subsequently stimulates the economy in other ways. Both regions also have positive and relatively large economic output values, determined by the interaction of the output multiplier (see Chapter 2: Essay 1 for more details) and exogenous final demand. The output multipliers for the industry in both regions was close to 2. This means for every dollar of exogenous final demand introduced into the industry roughly $2 of economic output is generated across the economy.

4.1.2 Value-added Market Scenarios

Essay 2 focused on evaluating possible value-added market scenarios in the potato industry of the San Luis Valley. 4 scenarios were created to evaluate how different approaches to add value to the potato industry would affect the broader economic contribution of the industry.

Scenario 1 and 2 focused on potato packaging size. From trends discussed in Chapter 3: Essay 2, it was determined that consumers want potatoes in smaller quantities. Scenario 1 modelled an increase in packaging sizes ranging from 2 to 3 pounds. This analysis shows a positive effect on the farm-gate value (FGV) of potato production and the economic output of the industry. It also showed an increase in employment and labor wages. Scenario 2 was very similar, instead showing an increase in producing potato packages in sizes smaller than 2 pounds. This analysis yielded an even larger increase in the FGV of production and added a few more jobs to the economy. Both scenarios addressed the potato demand of the population of single individuals in Colorado, this population pool was assumed to be the target audience for small packages of potatoes. The demand for small packages of potatoes may be smaller or larger than the assumed demand, which would affect the results of the analyses. Assuming an increase in production of small packages does appropriately address demand and finds a retail market, both analyses showed an increase in the value of potatoes and the economic output of the potato industry in the San Luis Valley.

Scenario 3 and 4 focused on organic potato production. From trends discussed in Chapter 3: Essay 2, it was determined that the demand for organic produced production is increasing in the U.S and it is increasing faster than organic production is increasing (Skorbiansky, 2023). In 2021, organic potato production accounted for only 3% of total potato production in the San Luis Valley. The analyses done addressed scenarios is which organic production was 10% and 20% of

total potato production, significant increases from 3%. Within the analyses, we consider land constraints and yield decreases. The analyses only use land for production that is already used for potato production, instead of assuming new land is introduced into production. So, the analysis substitutes conventional potato production with organic potato production. Because of this assumption of acre-to-acre substitution we also consider the reduction in yield that comes from organic production. All things considered, both analyses yield positive results. Increasing organic production to 10% of total potato production showed an increase in economic output of $7 million and increasing organic production to 20% of total potato production showed an increase in economic output of $16 million. This positive effect on the economy indicates that the value increase from organic potato production more than compensates relative to the supply reduction due to expected lower yields.

4.1.3 Addressing Issues in the San Luis Valley

As discussed in Chapter 1, the San Luis Valley faces several issues – persistent poverty, land constraints, and water shortages. The value-added market scenario analysis done in Chapter 3: Essay 2 may aid in addressing these three issues.

In Chapter 3: Essay 2, it is noted that 21% of the workforce in the SLV is employed in agribusiness. The potato industry fits into this category of employment. We also note that the San Luis Valley has a persistent poverty issue. While there are numerous ways poverty issues can be addressed, one impactful way is through employment (Custer and Enright, 2019). Therefore, adding employment opportunities for an area in persistent poverty who relies on agribusiness as an employer is vital. Scenario 1 and 2 both show an increase in employment from increasing small packaging sizes. Laying ground for an argument for why increasing packaging sizes would be good for the regional development of the San Luis Valley.

In Chapter 1, we also discuss the land limitations and water shortages that the SLV region faces. All 4 scenarios of value-added potatoes and the 2022 baseline economic contribution analysis provide an argument for why potatoes are worth the land and water resources they use for production. The potato industry provides much more than the farm-gate value of the crop. It supports backward linkages as the industry buys inputs from other industries. As discussed above, the industry also supports a significant portion of the region's workforce. Scenarios 1 through 4 show an increase in the value of the industry and show the opportunity for more employment. Jobs and inter-industry transactions tied to the potato industry generate broad economic activity and help circulate money within the regional economy. Therefore, the industry supports local businesses and service providers beyond the potato producers. Investing scare resources, such as land and water, in an impactful industry like potatoes is a strategic decision for the San Luis Valley. The multiplier effects revealed through the analysis in this thesis demonstrate that the potato industry is an important economic contributor in the San Luis Valley.

4.1.4 Closing Remarks

In closing, this thesis demonstrates the important economic role the potato farming industry plays within the SLV region, and to a lesser degree, the state of Colorado. Through both the economic contribution analysis and the value-added market scenario modeling, the findings highlight the positive effect the potato industry has on the economies of both regions. Chapter 3: Essay 2 highlights the importance of adding value to sustain and prove the importance of an agricultural industry within a rural region. The insights offered from this research can help guide future policy and planning efforts aimed at regional development and agricultural economy resilience.

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