# ECONOMIC IMPACT OF ADOPTING SILVOPASTURE IN FLORIDA: A COMPUTABLE GENERAL EQUILIBRIUM ANALYSIS

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

UNIVERSITY OF FLORIDA

2004

To my parents, Timothy and Patricia Timko; and to my brother and sister, Todd and Tiffany Timko.

## ACKNOWLEDGMENTS

I would like to acknowledge the School of Forest Resources and Conservation at the University of Florida for supporting my education and research efforts. I would also like to acknowledge funding support from the United States Department of Agriculture through the Initiative for Future Agriculture and Food Systems.

Additionally, I would like to thank my committee members, Dr. Doug Carter and Dr. Richard Kilmer for helping me to understand the economics necessary to conduct my research; and for their guidance in the process of economic research and writing.

I give special thanks to my supervising committee chair, Dr. Janaki Alavalapati. His expert knowledge and instruction were crucial in helping me gain the understanding necessary to carry out this project. In addition, his ability to inspire confidence during the many challenging phases of this research project helped me find the skills to overcome the many hurdles that I faced, thereby making this research possible.

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December 2004

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Major Department: School of Forest Resources and Conservation

Silvopasture, a type of ranching operation, combines trees with forage alongside livestock and produces many environmental benefits over traditional ranching. These benefits include carbon sequestration, biodiversity from wildlife habitat improvement, and reduction in pollution runoff. However, policies targeted to further environmentally benign practices often have far-reaching and sometimes unintended economic consequences. It is therefore necessary to analyze the overall impacts of policies influencing silvopasture to provide policy makers with information on how these policies could affect the economy.

This research examines the effects of a 25% reduction available land base and a 25% increase in capital costs for cattle-ranchers in Florida. These shocks simulate the adoption of silvopasture by Floridian cattle-ranchers. A computable general equilibrium model was used to estimate the economic impacts of these policiy shocks under wage-flexible and wage-rigid closure scenarios. We examined changes in various demands for

commodities and factors of production for each of the five modeled sectors in response to the 25% reduction available land base and the 25% increase in capital costs. We also examined the impacts of policy shocks on macroeconomic variables (such as aggregate household expenditure, wages and unemployment). In addition, a cost-benefit analysis was conducted by comparing the costs to households in Florida and the benefits they receive from the environmental services provided by silvopasture.

The model results showed that there would be a decrease in the economic welfare of households in Florida under both closure scenarios after enforcing the policy shocks. This decrease in welfare was more severe under the wage-rigid scenario in comparison to the wage-flexible scenario. The cattle industry also experienced a moderate contraction as a result of the policy shocks under both closure scenarios. The effects of the policies on the welfare of Floridians changed slightly when the benefits that households perceived for the services provided by silvopasture were included in the overall change in household welfare. This change resulted in households in Florida experiencing a slight increase in welfare under the wage-flexible scenario. However, under the wage rigid-scenario, the model showed that Floridians still experienced a small decrease in overall welfare.

# CHAPTER 1
# INTRODUCTION

## Background

The cattle-ranching industry is an important agricultural enterprise in Florida, and has a significant influence on the state's economy. In the past several years, public concern for the environmental consequences of ranching has been increasing. One concern is increase in water pollution due to runoff of nutrients such as phosphorus from pastureland. This increase in phosphorus content causes eutrophication and subsequent damage in the lakes into which the waters drain. In Lake Okeechobee, for example, the phosphorus content has more than doubled, over the past century (Harvey and Havens 1999). Another concern is the production of methane by cattle. Methane is a greenhouse gas and may contribute to global warming[1] through the greenhouse effect.[2] In addition, the public is becoming more aware that there are opportunities available to help reducing some of these impacts. Silvopasture, a form of agroforestry,[3] offers environmental services that can help meet the public's demand for mitigating the environmental impacts of cattle-ranching. However, there will be costs associated with adopting silvopasture and

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[1] Global Warming is the potential augmentation of the greenhouse effect due to buildup of gasses that trap heat in the atmosphere (Milich 1999).

[2] The Greenhouse Effect is the sum of interactions between the heat that is attempting to escape from the earth to space and the molecules of various gasses that trap this heat, reradiating it within the atmosphere, and impeding its loss to space (Milich 1999).

[3] Agroforestry is the management of land for the simultaneous production of food, crops, and trees.

with providing these services to the public. Our study provides policy makers with more information on what these costs would be, if ranchers in Florida adopt silvopasture.

## Problem Statement

Previous research suggests that households in Florida prefer to have the above mentioned environmental services associated with the adoption of silvopasture (chapter 2) by ranchers. However, most of the environmental benefits provided by silvopasture are external to ranchers. In contrast, ranchers directly experience the costs of altering their ranching operations. Before making policy decisions regarding silvopasture, policy makers need information on the economy-wide impacts that these policy changes would have on Florida. Our study aimed to fill that gap by investigating how policies requiring Floridian cattle ranchers to adopt silvopasture would impact the Florida economy. We also aimed to analyze how the well-being of households in Florida will be impacted by these policies.

## Study Objectives

Our primary objectives were to analyze economy-wide impacts of a policy requiring all cattle ranchers in Florida to adopt silvopasture practices. Policies that required ranchers to adopt silvopasture would result in a decrease in the land available for cattle production by ranchers. They would simultaneously cause the operating costs of ranchers to increase. This study simulates the effects of both of these shocks being enforced on the cattle-ranching sector. This task was addressed through a computable general equilibrium analysis of the economy of Florida. The next two research questions were addressed.

- **Question 1:** How will the modeled changes impact the overall economy of Florida?

- **Question 2:** How will the welfare of Floridians change as a result of the simulated shocks when the environmental benefits of the policies are taken into account?

These two questions were explored under wage-flexible and wage-rigid scenarios.

# CHAPTER 2
# RANCHING, RANCHING IMPACTS, AND SILVOPASTURE

## Cattle-ranching and the Cattle Industry

Cattle-ranching in the North America began several hundred years ago, at the time of colonization of the New World. It provided an innovative land-use strategy that facilitated the settlement of the frontier, many times at the expense of native peoples (Jordan 1993). Since the time of colonization, cattle-ranching has managed to successfully spread throughout the United States. Over the last few decades the area of land being used for livestock production has been growing. In 1984, nearly 1 billion of the approximately 2.2 billion acres in the United States were grazed by livestock (Taylor 1984). Today, rangelands and pastures are found in all 50 states, and some studies estimate that they account for 55% of the country's land surface area (Weltz et al. 2003).

The cattle or beef industry is a major component of the agriculture industry in the United States. In 2003, the retail equivalent value of the United States cattle and beef industry was estimated at $70 billion dollars and the value of calf and cattle production was estimated at $33.2 billion (USDA 2003). The large difference between the two estimated values is due to the great deal of segmentation in the U.S. beef industry. The beef industry includes various loosely interlocking segments such as seed-stock producers, commercial cow calf producers, stocker operators, feeders, packers and retailers (Taylor 1984). However, our study was primarily concerned with the portion of the cattle industry that includes the raising of cattle on rangelands and pasturelands.

The United States as a whole is a net importer, and is the largest importer of beef from the world market. Before the disruption of the beef trade due to discovery of BSE[4] in the U.S., Canada was the largest source of imported beef for the United States, and Japan was the largest purchaser of U.S. beef exports. With nearly 100 million cattle and calves, the U.S. has the forth-highest cattle population behind India, Brazil and China. (FAS 2004). The Florida cattle-ranching industry, which contributes more than $300 million to the Florida economy annually, is a major agricultural enterprise and has a significant influence on the state's economy. According to USDA census data for Florida for 2002 (USDA 2002), there are approximately 1.74 million cattle in the state on over 19,000 ranches, making Florida the tenth largest cattle producing state in the U.S. Due to the large size and nature of this industry, it can have significant impacts on environmental quality.

**Environmental Impacts of Ranching**

The scale of the cattle industry in the United States makes it difficult for it to operate without impacting the environment to some extent. There are two main ways that the cattle industry adversely affects the environment. First, water pollution problems can result when water in the form of rainfall runoff comes into contact with manure and carries high concentrations of solids, nutrients, and disease organisms into surface waters and ground waters. Polluted runoff is the major contaminant of U.S. waterways according to the Environmental Protection Agency (EPA 1972). Water quality surveys conducted in twenty-two states found that out of 694,000 miles of river, 35,000 miles were adversely affected by animal feeding operations. Nitrogen and Phosphorus are both nutrients often

[4] BSE or Bovine Spongiform Encephalopathy (more commonly known as "mad cow disease") is a fatal neurodegenerative disease in cattle which may be transmittable to humans (FDA 2004).

associated with accelerated eutrophication.of surface water. Algae blooms of *Pfiesteria piscidida* and *Cytosporidium* in drinking water may be associated runoff from animal waste (Baker 1999). Phosphorus management strategies are often identified as important in limiting surface water eutrophication from agricultural sources since blue-green algae are able to utilize atmospheric nitrogen, thus leaving phosphorus as the limiting developmental factor for blue-green algae. (Gerber et al. 2004)

Environmental degradation from cattle-ranching is not, however, limited to water pollution. Global climatic change in the form of global warming can be attributed to several sources. The production of carbon dioxide through burning of fossil fuels and other sources, the production of methane, the release of nitrous oxide primarily from the application of fertilizer, and the production of ozone are major sources of the greenhouse gasses that influence global warming (Milich 1999) Cattle-ranching contributes to global warming through the greenhouse effect via the production of the greenhouse gas, methane. Methane is the second most significant greenhouse gas and is expected to contribute to 18% of the global warming from now until the year 2050. The largest source of methane emissions, 30%, is enteric fermentation from livestock, followed closely by methane emissions from rice paddies at 25 %. Also, due to the combination of factors such as their great numbers, large size, and high energy intake; cattle produce 70% of global methane produced by animals, humans included (Milich 1999). The quantity of methane released to the atmosphere is much less than the quantity of carbon dioxide, however, methane is twenty times as effective in trapping heat on a per molecule basis (Harrington and Lu 2002).

Regardless of the environmental impacts associated with cattle production, the worldwide consumption of beef is not likely to decrease dramatically in the foreseeable future. It is, therefore, necessary for society to seek solutions to help mitigate the environmental impacts of ranching while allowing producers to continue to provide the goods that people desire. The adoption of silvopasture practices by ranchers has been suggested as a possible means of helping to mitigate these environmental impacts.

## Benefits Associated with Silvopasture

Silvopasture is a form of agroforestry that combines spatial and rotational growth of timber, forage, and livestock, has many associated environmental benefits (Husak and Grado 2000). Silvopasture may be able to mitigate of some of the negative impacts of cattle production while, in addition, providing other environmental services to the public.

There are many benefits associated with silvopasture, which fall into several categories such as water quality improvement, soil conservation, carbon sequestration[5] and improvement of wildlife habitat (Shrestha and Alavalapati 2004). In a recent study, Shrestha and Alavalapati (2004) estimated the public's willingness to pay for these environmental services. Their research suggests that households in the Lake Okeechobee Watershed in Florida would be willing to pay $30.24 – $71.17 per year for five years to receive these environmental benefits.

### Benefits Mitigating the Impacts of Cattle-ranching

The adoption of silvopasture practices by ranchers would help to mitigate the negative impact that cattle-ranching has on water quality. Growing trees on farms and ranchlands would improve the quality of water through the reduction of pollution runoff,

[5] Carbon sequestration is the removal of carbon dioxide from the atmosphere and its storage in the form of biomass in the terrestrial biosphere. (Albrecht and Kandji 2002)

the replenishment of ground water aquifers, and the maintenance of the long-term water cycle. (Wu et al. 2001, Stednick 1996) Many silvopasture arrangements include tree and grass buffer strips as part of their overall design. Research suggests that tree and grass buffer strips twenty to thirty meters in width control up to 77% of phosphorus and 80% of nitrogen runoff (EPA 1995; Gerrett et al. 2000). Reduction in the quantities and stocking rates of cattle supported by silvopasture cattle ranches as opposed to conventional ranches would also have the effect of mitigating pollution by the reduction of the quantity and the concentration of animal wastes as the number and density of animals is reduced.

Adoption of silvopasture would also help to mitigate the negative effects that cattle-ranching has on the atmosphere through carbon sequestration (Shrestha and Alavalapati 2004). Carbon sequestration has been shown to be a cost effective means for mitigating global climatic change by compensating[6] for greenhouse gas emissions (Albrecht and Kandji 2002, Zhang and Xu 2003). The quantities of carbon dioxide stored as a result of adding tree cover can be substantial. According to recent literature, an acre of southern pine grown in silvopasture on a twenty year rotation could absorb anywhere between 145 to 220 tons of carbon dioxide (Cannell 1999, Grierson et al. 1992). As with the reduction in water pollution, reduction in the quantities and stocking rates of cattle supported because of adoption of silvopasture on cattle ranches would also cause a reduction in greenhouse gas emissions locally. This portion of the mitigating effect of silvopasture adoption might be reduced to some extent, however, if imports to the region increase signifying increased production in foreign regions.

[6] The sequestration of carbon would not directly reduce the amount of methane in the atmosphere, however, since both are greenhouse gasses, reduction of atmospheric carbon can help to offset methane emissions in the global warming context.

**Additional Benefits**

Throughout Florida, private pasture and ranchlands play an integral role in providing habitats for a diverse selection of wildlife species. Some of the species inhabiting these areas include the white-tailed deer, the Sandhill crane, and the Burrowing owl (Morrison and Humphrey 2001, Swisher et al. 2000). Many of the species that the trees and vegetation on these lands provide habitats for are threatened or endangered. Additionally, studies have been conducted in other states suggesting that agricultural lands that include wildlife habitat command higher prices per acre than similar land dominated by agricultural production (Bastian et al. 2002). This increased value may be attributed to the increased opportunities for hunting and wildlife watching on the land. Silvopasture may also be more aesthetically pleasing than open pastures while the additional tree cover could provide livestock with increased protection from summer heat and winter chill (Nowak et al. 2002)

**Possible Externality Dilemma**

The above reasons provide explanation for the increase in public interest in the incorporation of silvopasture technology on ranchlands as a means for realizing environmental services that they prefer to have. However, the adoption of silvopasture may result in a positive externality[7] problem for ranchers. In general, the environmental services or benefits that would be provided through silvopasture technologies on ranchlands are external to the production decisions of ranchers. Ranchers would incur increased management costs as well as reduced cattle output as a result of adopting

[7] "Positive externalities exist when the marginal social benefit of production and or consumption exceeds the marginal private benefit i.e. production and/or consumption generate external benefits that may go under-valued by the market" (Jones 2004).

silvopasture on their lands (Shrestha and Alavalapati 2004). Some examples of these increased costs include: establishment costs associated with tree planting, purchase of fencing, and temporary withdrawal of livestock from the areas.

While cattle ranchers' costs would be increasing, the benefits of their actions would be enjoyed by the public. There is no direct market mechanism for the public to pay the ranchers in compensation for these increased costs. However, cattle ranchers may be able to pass on some or all of these increased costs to consumers through raising their prices and not be worse off.

This provides some rationale for the government to seek information regarding the economic impacts of policies requiring ranchers in Florida to adopt silvopasture practices. If research shows that the cattle-ranching industry is severely negatively impacted by being required to adopt silvopasture practices, then policies that would serve to internalize the benefits that ranchers would provide to the public through adoption of silvopasture might be justified. Such policies might include additional taxes on households that the government could transfer to the cattle ranchers in exchange for provision of the environmental services the public desires.

CHAPTER 3
LITERATURE REVIEW

## Introduction

In this chapter a review of review of general equilibrium modeling techniques is provided. Next, the structure of general equilibrium models is discussed, followed by a review of literature on applications of CGE models. Finally a review of some examples of how cost benefit analysis has been applied to economics and the environment is provided.

## Why Use Computable General Equilibrium Modeling?

Policy makers require information concerning the probable effects of implementing policies that would require ranchers in Florida to adopt silvopasture practices since such policies could drastically influence Florida's economy. Analysts often utilize partial equilibrium analysis to determine the possible effects on an industry as a result of policy actions. While partial equilibrium analyses provide highly detailed information on the likely effects of policies to one particular industry, their downside is that they neglect intersectoral interactions within the economy. In order to address the economy-wide impacts of policies in a more comprehensive manner, general equilibrium modeling techniques have been developed and applied to policy analysis.

## General Equilibrium Modeling

### Introduction

General Equilibrium modeling techniques include several modeling methods, each of which is employed by policy analysts and researchers to conduct economy-wide impact analyses. As the techniques progress from the relatively simple input-output models to the increasingly more complex social accounting and computable general equilibrium models, the data requirements for the methods increase greatly. Likewise, the capacity of the modeling techniques to capture economy-wide impacts increases as the models become more general. The availability of data, the time and funding available for the analysis and the specific characteristics of the situation to be modeled are considered in selecting an appropriate model.

**Input-Output Models**

Input-output (I-O) models are the simplest of the three types of regional modeling systems presented. The essence of I-O models is that industries are related to each other through transactions between them through the buying and selling of raw materials (Pyatt, 1999). Of the general equilibrium modeling techniques discussed, I-O models have the benefit of having the lowest data requirement. There are several characteristics of I-O models that can, however, limit their ability to adequately analyze regional impacts of policies (West, 1995; Miller and Blair 1985).

The first of these characteristics is that input-output models have infinitely elastic supplies of inputs into production processes, resulting in a lack of supply-side constraints. Therefore, I-O models offer no market feedback mechanism between primary factors and final commodity demands (West 1995). The failure of this model type to show these connections is of concern because while sectors may not be linked directly by commodity flows in the economy, they still might interact through competition for scarce resources, most notably competition for primary factors of production (West 1995). Therefore, I-O models may only be appropriate for use in modeling situations where primary factors of production are less than fully employed and where producing sectors have excess capacity (Patriquin 2000).

Another limiting characteristic of I-O models is that prices of inputs and outputs are fixed therefore preventing the model from being able to capture the behavioral adjustments of consumers and producers that would occur in the face of endogenous prices. This limitation implies that I-O models may be appropriate only for the extremely short-run (Patriquin 2000). Another assumption of I-O models that restricts their application to the extreme short-run is that in input-output models, production technologies are assumed to have fixed input proportions therefore preventing substitution between factors of production.

Alternative modeling methods have been designed because of the inherent limitations of I-O models. Nevertheless, I-O models still serve a useful purpose as descriptive tools of economies. Additionally, they often serve as the base for other more complex modeling procedures (West 1995).

**Social Accounting Matrices**

The social accounting matrix (SAM) is the next more complex method presented for modeling regional economic policy impacts. Similar to I-O models, SAM models represent inter-industry linkages in the economy. In both I-O and SAM frameworks, the purchase of an intermediate input by one sector represents the sale of that same input by another sector. However, because the SAM utilizes double-entry bookkeeping, each transaction appears in the accounts of two different sectors, rather than in a single cell as represented in I-O (Robinson et al. 1999).

Additionally, in the SAM model framework, income for each sector must be equal to that sector's total expenditures. Total expenditures for an industry could include costs such as intermediate inputs, wages, imports, as well as capital services. Incomes appear along the rows of social accounting matrices and expenditures down their columns. The budget constraint, therefore, requires that the row and column sums must be equal (Robinson et al. 1999).

Similar to I-O models, SAM models can be utilized to model economic impacts. However, they have the added benefit of being able to capture distributional impacts as well. For example, households could be disaggregated within the SAM framework based on household income levels therefore giving them the ability to describe which segment of households would win or lose based upon a given policy shock (Stone 1985, Patriquin 2000).

SAM models are more complex and provide a greater level of sophistication in their ability to capture more detailed aspects of economic changes than IO models. However, because SAM and IO models are based on similar assumptions, SAM models are still vulnerable to some of the inherent limitations of IO models. Neither SAM nor IO models account for supply constraints or the substitution between inputs (Adelman and Robinson 1986). Additionally, in SAM models, the technical coefficients remain fixed as do prices. Because these limitations can reduce the applicability of both IO and SAM models, considerable effort has been devoted to deriving, developing and applying computable general equilibrium models.

**Computable General Equilibrium**

Computable general equilibrium (CGE) models represent then next more complicated building block in modeling that will be presented. CGE models incorporate a set of behavioral equations that describe the economic behavior of the agents identified in the model as well as the technological and institutional constraints that they face (Thissen 1998). These sets of equations are responsible for the enhanced flexibility and applicability of CGE models. The incorporation of these behavioral equations makes CGE models more robust than their predecessors because these models are able to capture certain economic behavioral relationships and characteristics that the neither IO nor SAM was capable of integrating into its framework. One such advantage of CGE models is their ability to handle endogenous prices therefore permitting the prices of inputs to vary with respect to changes in output prices. This feature allows the responses of CGE models to economic shocks to more closely approximate the responses of agents found in the economy.

Another advantage of CGE models is that they can include constraints on the availability of primary inputs. This feature of CGE models is significant because of the dampening effects that this type intersectoral linkage, based on resource limitations, can provide. Whereas in IO and SAM models, expansions in one industry lead directly to expansion in other industries based on the technical coefficients linking the industries in the models. These dampening effects can be seen when an increased quantity of a limited factor of production such labor, for example, is needed for an expanding industry. This industry's increased demand for labor will limit the supply of that factor available for other industries, resulting in a certain degree of contraction[8] in other industries competing for that factor (Patriquin 2000).

[8] The actual degree of contraction for industries competing for the same primary factor as is an expanding industry will be dependent on several factors including, but not limited to: the production structures of those industries, factor intensities, and the technical coefficients linking models industries to each other.

CGE models also have the distinct advantage of being highly customizable. For example, a CGE model could be constructed with the assumption that production structures allow no substitution between intermediate inputs and primary factors, similar to the structure of I-O models. In CGE models, assumptions such as these can also be relaxed or modified to a desired level depending on the specific characteristics of the economy being analyzed by the model (Alavalapati et al. 1998).

Although CGE modeling techniques offer several advantages over both I-O and SAM, they are not without weaknesses and limitations. One weakness of CGE models is that many CGE models are deterministic models. In other words, for a given data set and specified shock, a CGE model will determine one set of outputs without allowing for uncertainty within its framework (Xie 1996). Also, Shoven and Whalley (1984) pointed out that no consensus exists regarding the determination of the values of elasticities and other key parameters, yet they often play a pivotal role in the specification of CGE models. Another disadvantage of CGE models is that they frequently require large amounts of data. Often, to reduce the demand for data for CGE models, the models are calibrated on a benchmark data set for a single year. While making the models quicker and easier to construct, this can result in the models being very sensitive to one year data (Xie 1996). In addition, earlier CGE models were either static or only quasi-dynamic in nature and treat inter-temporal behavior such as investment inadequately. CGE models have also been criticized for being too complicated to understand for decision makers and the general public.

As research has moved forward on the construction and application of CGE models, many of their limitations and weaknesses have been addressed. Investment behavior has received more rigorous treatment in recent CGE models (Xie 1996). Cattaneo (2001), for example, combines factors such as agent's marginal propensity to save, investment demands, and planning horizons to develop a robust dynamic macroeconomic model of the effects of deforestation in the Brazilian Amazon. Also, econometric approaches have been more widely adopted for the estimation of parameters utilized in their behavioral equations (Patriquin 2000). In the following sections, a brief description of CGE modeling history and application is provided.

## Computable General Equilibrium Modeling

### Computable General Equilibrium Models for Policy Analysis

Over the past several years, CGE modeling has become an increasingly popular tool among researchers for policy analysis. They have been used to address a multitude of policy issues including: choice of development strategies, trade policies, income distribution, long term growth and structural changes, and structural adjustments to external shocks (Bandara 1991). In addition, much effort has been spent recently to develop CGE models that can simultaneously capture the above economic policy analyses while also describing the effects of the modeled policy shocks on the status of the environment.

Much of basis for current CGE modeling techniques originated several decades ago with the work of a small group of economists. One of the most notable is Lief Johansen, whose multi-sector growth model was the first empirically based price endogenous model analyzing resource allocation issues Although the model was originally developed as a forecasting tool, Johansen applied the model to answer policy questions in Norway (Shoven and Whalley 1984). Another important figure in the inception of CGE development was Arnold Herberger. In his 1962 article, "The Incidence of the

Corporation Income Tax" Herberger was the first economist to investigate taxes numerically in a two-sector general equilibrium framework (Shoven and Whalley 1984). Equally important was Ronald W. Jones' paper, "The Structure of Simple General Equilibrium Models." In this paper, he provides a detailed analysis of the structure of the simple competitive model of production, highlighting the similarities existing among several problems in comparative statics and economic growth (Jones 1965). This paper proved to be influential in the developmental course of CGE modeling.

As the number of CGE models began to increase, so too did the range of policy issues addressed by modelers. CGE models designed to analyze various impacts of changes in trade policies emerged. These trade policy impact analysis models frequently belonged to one of two major categories. The first major category was comprised of single-country models designed to investigate how developments abroad affected individual economies. The second major category contained multi-country models, which were designed to tackle global trade issues. (Shoven and Whalley 1984) Both of these two different types of trade models often incorporated the Armington[9] assumption, which differentiates home and foreign goods as imperfect substitutes in consumption. (Blonigen and Wilson 1999) Examples of CGE models utilized to analyze trade policies include: Dervis et al. (1982), Dixon et al. (1985), Mercenier and Waelbroeck (1985), and Shoven and Whalley (1984).

Models have also become more complex in their ability to capture inter-temporal features within their structures. Through the inclusion of equations describing how an

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[9] Armington Assumption - The assumption that internationally traded products are differentiated by country of origin. This assumption is now standard in international CGE models, and is used to generate smaller and more realistic responses of trade to price changes than implied by homogeneous products.( Deardorff, 2001)

economy evolves, inter-temporal CGE models can be used to describe the manner in which an economy reaches its equilibrium. This is a desirable feature to incorporate in CGE models because policy makers are often concerned with the rate at which an economy will move towards the long run equilibrium point as well as other transitional characteristics (Dixon et al 1999). However, inter-temporal models have the downside of being more complex to construct and harder to solve, and thus are more costly. Nevertheless, many dynamic models have now been constructed. These models can increase the meaningfulness of welfare change calculations in comparison to static modeling because of the abundance of dynamic elements in the real world (Seung and Kraybill 1999). Examples of inter-temporal, or dynamic, CGE models can be found in: Keuschnigg and Kohler (1994), Wang (1999), and Deepak et al. (2001).

**Computable General Equilibrium and the Environment**

Policy makers' decisions regarding environmental legislation implementation is often reliant on whether or not the legislation will harm economic growth. Various interest groups constantly influence policy makers to obtain the outcome in their favor. On one side are industry representatives, who typically forecast increased unemployment, reduction in international competitiveness, and depression of economic growth. Environmental lobbyists, conversely, stress the negative consequences of factors such as pollution while they downplay trade-offs between economic growth and a clean environment (Wajsman 1994). In effort to supply policy makers with unbiased information, scientists are required to carefully examine issues and describe both the probable positive and negative consequences of proposed environmental legislation.

A wide range of environmental-economic issues have been examined by CGE analyses. These environmental CGE models, although varying greatly in regional size and functional specification, typically fit into three general categories. The first category is comprised simply of standard CGE models that have been applied to address environmental issues. For example, in Olatubi and Hughes (2002), they use a general equilibrium model of Louisiana to analyze the effects of the Wetland Reserve Program[10] on the state's economy.

The second category includes environmentally extended CGE models. In order to provide more detailed descriptions of the environmental impacts of economic policy shocks, these models usually give indications of changes in pollution emissions using fixed coefficients per unit of sectoral output. In this type of model, these indicator outputs do not feed back into the behavioral equations of the CGE model, and therefore do not change the behavioral specifications of the models (Xie and Saltzman 2000). Models such as Patriquin's (2000) environmentally extended CGE model of the Foothills Model Forest in Alberta, Canada belong to this category.

Models that introduce environmental feedback to the economic systems belong to the last major category of environmental CGE models. Jorgenson and Wilcoxen (1990) specify pollution control costs in their production functions in order to achieve this environmental and economic integration. Alavalapati and Adamowicz (1999) utilize a simple general equilibrium model to study the interactions among tourism, other economic sectors, and the environment. In their tourism impact model, they specify the damage to the environment as a function of output and the extent of land used for production (Alavalapati and Adamowicz, 1999).

[10] Wetland Reserve Program (WRP) –"The Food, Agricultural, Conservation, and Trade Act of 1990 (FACTA) amended the Food Security Act of 1985 (FSA) to provide for the establishment of the WRP. The goals of the program are to ensure 'no net loss' of remaining wetlands and to increase the quality and the quantity of the nation's wetlands." (Olutabi and Hughes, 2002)

**Cost-Benefit Analysis**

The interaction of the economy and the environment are not modeled endogenously in this research. However, we utilize willingness to pay results for the environmental services of silvopasture of the residents in the Lake Okeechobee watershed and compare these values to changes in the income of Floridian households in a cost-benefit analysis framework.

Cost benefit analysis is a decision making tool used frequently by economists and other decision makers to determine whether or not a project is worth the necessary investment. This tool has been applied to many economic and environmental issues. Ervin and Dicks (1988) utilized a cost benefit analysis of the Conservation Reserve Program to analyze the economic welfare consequences of converting cropland to alternative uses to enhance conservation and environmental goals. Similarly, Moss et al. (1996) use a cost benefit approach to compare the social, financial, and ecological costs of several different land use options.

**Contribution**

The main contribution of this work will be estimating probable economy-wide impacts of policies requiring that all Floridian cattle ranchers adopt silvopasture. These impacts will be determined through the application of a five sector CGE model of the state. Additionally, this work will give some indication of possible changes in the welfare of Floridian households by comparing the perceived benefits of the services silvopasture provides with the costs to households.

# CHAPTER 4
# MODELING METHOD

## Introduction

This chapter outlines the construction of the model used in this research. First, information on the data source and aggregation is given. Next, the structure of the general equilibrium model used in the analysis is presented, including the equations modeled, the closures chosen, and the shocks implemented. Finally, a discussion of the cost benefit approach used to determine the change in the well being perceived by households in Florida under the two chosen closures is given.

## Florida Computable General Equilibrium Model Data

The data utilized in the construction of the social accounting matrix for this model was obtained from the IMPLAN database of the Minnesota IMPLAN Group. The original 1999 database for Florida consists of 528 individual sectors or industries. Industries were aggregated into five sectors for the final SAM based on the goals of this research and the general industry product categories. The five aggregated sectors are cattle, other agriculture and resources, forestry, manufacturing, and services.

Estimates indicate that the approximate the size of the cattle sector in Florida is approximately $300 million annually (Stainback et al. 2004). In aggregating sectors of the IMPLAN database, we determined that the size of the cattle sector in this model is approximately $188 million annually. This difference is most likely attributed to our selection of which industries to include in the cattle sector aggregation. For the model in this study, only range and ranch fed cattle are included in the cattle sector. Other value adding cattle related sectors, such as the various meat processing industries, are instead treated as part of the manufacturing sector.

**Model Structure**

The computable general equilibrium model that has been constructed in this study is a customized version of a Stylized Johansen Model. The development of the theoretical structure of a Johansen model includes formulating several sets of equations. Included in these are equations for: household and final commodity demands, intermediate and primary factor inputs, commodity pricing, and market clearing (Dixon et al. 1999). These equation sets form the framework for the model and determine how the model will react in response to shocks applied to the system of equations. Following the general structure from Dixon et al. (1999), a customized version of the Stylized Johansen Model is developed below utilizing the percentage change form equations necessary for solution of the computable general equilibrium model.

$$x_{i0} = y - p_i \qquad \text{for i} = 1, \ldots, 5 \tag{3-1}$$

Equation 3-1 represents the household demand equation for the commodities in the model. It shows that the household demand ($x_{i0}$) for a commodity will increase as the income increases, or the price of that commodity decreases. Each sector in the model produces one commodity, therefore resulting in five household demand equations, one for each commodity.

$$x_{ij} = x_j - \left\{ p_i - \left[ \left( \sum_{t=1}^{6} \alpha_{tj} p_t \right) + \left( \sum_{f=1}^{2} \alpha_{fj} p_{fj} \right) \right] \right\} \tag{3-2}$$

for i = 1, . . . ,8, j = 1, . . . , 5

Equation 3-2 represents the input demands for each of the inputs for industries one through five. Equation 3-2 says that the change in the demands for inputs by a sector is a function of several variables. First, it shows that the demands for the inputs to a sector ($x_{ij}$) will increase as the demands for the sector's output commodity ($x_j$) increase. It also shows that the change in the demand for input from a given source will be inversely related to the change in the relative price of that input.

For this research, the factors of production were disaggregated from labor and capital only, to labor capital and land. In the Stylized Johansen model, both labor and capital are treated the same, with one model price each for both wages and capital rental rates, thus allowing both labor and capital to be mobile between the various producing sectors. In this research, however, we chose to model capital (and the disaggregated land factor) as sector specific, while allowing labor to remain mobile. This is accomplished by utilizing sector specific prices ($p_{fj}$) in equation 3-2 for the capital and land factors of production inputs for the sectors.

$$p_j = \left( \sum_{t=1}^{6} \alpha_{tj} p_t \right) + \left( \sum_{f=1}^{2} \alpha_{fj} p_{fj} \right) \qquad \text{for } j = 1, \ldots, 5 \qquad (3\text{-}3)$$

Equation 3-3 is the percentage change form of the zero pure profits condition for the model. This equation shows that the percentage change in the price of good j will be a weighted sum of the percentage changes in the input prices for that industry's intermediate inputs and primary factors. The weights, or alphas, are the proportions of the cost that each input comprises in the total cost of all inputs for that commodity. The RHS of equation 3-3 is identical to the bracketed portion [*] of Equation 3-2.

$$x_i = \sum_{j=0}^{6} x_{ij}\beta_{ij} \qquad \text{for i} = 1, \ldots, 5 \tag{3-4}$$

Equation 3-4, the market clearing equation for the commodities of the CGE model, equates a weighted average of the percentage changes in the various demands for each commodity to the percentage change supply of that commodity. The weights, or betas, are the proportions of the demand that each source of demand (j) comprises in the total demand for each i good. For the purposes of this research, an additional demand, net export demand, was added to the model. Therefore, the sources of demand for a commodity in the model are: household demand (j = 0), intermediate demands from the five industries (j = 1,…,5), and net export demand for the commodity ( j = 6 ). The addition of export demand causes the model to depart from the Stylized Johansen model by transforming the CGE model from a closed economy model to an open economy model.

$$x_f = \sum_{j=1}^{5} x_{fj}\beta_{fj} \qquad \text{for f} = 1,2, \text{and } 3 \tag{3-5}$$

Equation 3-5, the market clearing equation for the primary factors in the CGE model, equates a weighted average of the percentage changes in the demands for each factor to the percentage change in the quantity supplied of that factor. The factors in the model are labor (1), capital (2), and land (3).

$$p_2 = 0 \tag{3-6}$$

Equation 3-6 represents the selection of sector two as the numeraire, or the unit of measure for money in the model. The other prices in the model are given in terms of the price of the numeraire commodity.

**Additional equations**

For the purposes of this research, additional equations we added to the model in order to incorporate features not captured in a Stylized Johansen model. A new export demand equation was added in order to change the model from a closed economy to an open economy.  In addition, an equation for labor employment was added, to allow the model to capture changes in the labor employment levels.

$$x_{ie} = -p_i + p_{iw} \qquad \text{for } i = 1, \ldots, 5 \tag{3-7}$$

Equation 3-7 represents the percentage change form of the net export equation for the CGE model. It shows that export demand for a good ($x_{ie}$) is inversely related to the change in the price of that good ($p_i$) resulting in a negative export elasticity of demand. More specifically, we have assumed, for simplicity of model construction, that the export elasticity of demand is negative one. Additionally, we assume that the economy of Florida is small relative to the rest of the world. Hence, we have chosen the world prices for the commodities ($p_{iw}$) as exogenous in the model.

$$l = \alpha_u u + \alpha_e e \tag{3-8}$$

Equation 3-8 relates a weighted sum of the change in unemployed labor force and employed labor force to changes in the total employable labor force available.  The addition of this equation gives the model the capability of capturing the effects of the policy shocks on the level of unemployment in the economy when the change in the employed labor force is chosen as endogenous.

Table 4-1. Specification of the five-sector Florida CGE model

| | | |
|---|---|---|
| 3-1 | $x_{i0} = y - p_i$ | i = 1,…,5 |
| 3-2 | $x_{ij} = x_j - \left\{ p_i - \left[ \left( \sum_{t=1}^{6} \alpha_{tj} p_t \right) + \left( \sum_{f=1}^{2} \alpha_{fj} p_{fj} \right) \right] \right\}$ | i = 1,…,8<br>j = 1,…,5 |
| 3-3 | $p_j = \left( \sum_{t=1}^{6} \alpha_{tj} p_t \right) + \left( \sum_{f=1}^{2} \alpha_{fj} p_{fj} \right)$ | j = 1,…,5 |
| 3-4 | $x_i = \sum_{j=0}^{6} x_{ij} \beta_{ij}$ | i = 1,….,5 |
| 3-5 | $x_f = \sum_{j=1}^{5} x_{fj} \beta_{fj}$ | f = 1,2,3 |
| 3-6 | $p_2 = 0$ | |
| 3-7 | $x_{ie} = -p_i + p_{iw}$ | i = 1,…,5 |
| 3-8 | $l = \alpha_u u + \alpha_e e$ | |

The set of equations in the CGE model form a matrix. For this matrix to have a solution, the number of equations in the model must be equal to the number of endogenous variables. By nature of their construction, these models will have more variables than the number of equations. As a result, some of the variables must be selected as exogenous, and the rest retained endogenous in order to fulfill the mathematical requirements for finding a solution to the model. Below is a list of the variables that we have chosen to retain endogenous in the model.

Table 4-2. Endogenous variables

| | |
|---|---|
| $y$ | Household income |
| $p_i$ $i=1,\ldots,5$ | Commodity price |
| $p_{fj}$ $f=2; j=1,\ldots,5$ | Price of land |
| $x_i$ $i=1,\ldots5$ | Demand for commodities |
| $x_f$ $f=2$ | Demand for capital |
| $x_f$ $f=3$ | Demand for land |
| $x_{i0}$ $i=1,...,5$ | Household consumption of commodities |
| $x_{ij}$ $i=1,\ldots,5; j=1,\ldots,5$ | Intermediate commodity inputs |
| $x_{fj}$ $f=1; j=1,\ldots,5$ | Labor factor input demand |
| $x_{fj}$ $f=2,3; j=1,\ldots,5$ | Capital and land factor input demands |
| $x_{ie}$ $i=1,\ldots,5$ | Net export demand for commodities |
| $u$ | Unemployed labor force |
| $p_t$ $t = 6$ | Price of labor ( wage rate ) |
| $x_f$ $f=1$ | Total demand for labor |

The rest of the variables, which are listed in Table 4-3 are selected as exogenous. Two of these variables, the aggregate supply of labor, and the wage rate, are utilized to create the two different closures that we utilize in the analyses in this research. Only one of the two will be exogenous at a given time. For the flexible wage scenario, the aggregate supply of labor will be selected as exogenous and the wage rate will be retained endogenous. For the rigid wage scenario, the wage rate will be selected as exogenous and the aggregate supply of labor will become endogenous. This will allow changes in unemployment to occur in the second model closure.

Table 4-3. Exogenous variables

| | |
|---|---|
| $p_{iw}$ | World price of commodity |
| l | Employable labor force in the economy |
| $p_{fj}$ f=2; j=1,…,5 | Price of capital |
| $x_{fj}$ f=3; j=1,…,5 | Supply of land to industries |
| $x_f$ f=1 | Total demand for labor |
| $p_t$ t = 6 | Price of labor (Wage rate) |

**Model closures**

The way that equilibrium is ensured in a CGE model is known as the closure of the model and is determined by selecting the set of variables that will be exogenous to the system. The chosen closure has significant theoretical implications directly affecting the behavioral characteristics of the model. Each of the two main schools of closure has its merits. Acknowledging that there are significant differences in the ways the model will react depending on the closure selected, we have chosen to model the shocks under two different main closure scenarios. This treatment should provide policy makers with more information on how the proposed policy shocks could influence the economy. The first closure we have chosen to enforce on the model has a variable wage rate, with the aggregate labor demand fixed as exogenous. This closure forces wage rate to vary such that full employment is ensured. This selection is similar to the Johansen[11] closure and

[11] "In the Neoclassical closure, aggregate investment is determined by aggregate savings, which in turn are determined endogenously through the fixed savings rate out of after tax income and the government deficit. In Johansen closure, aggregate investment is assumed to be fixed exogenously and the savings rate is

falls within the main school of Neoclassical closures. In the second closure, which is more structuralist in nature, labor employment is endogenous and the fixed the wage rate and forces the level of employment to vary to achieve equilibrium in the model. Table 4-4, derived from the model closure discussion in Kraev (2003), highlights some of the differences between these two main schools of closure for CGE modeling.

Table 4-4. Closures

| | Neoclassical | Structuralist | | |
|---|---|---|---|---|
| | | Elasticity | Micro | Macro |
| Full employment | Yes | Yes | Not necessarily (can restrict prices and labor mobility) | Not necessarily (emphasize macroeconomic disequilibria) |
| Full capacity utilization | Yes | Yes | Not necessarily (neoclassical disequilibrium) | Not necessarily (disequilibrium possible) |
| Marginal productivity determines prices | Yes | Yes | Not necessarily | Not necessarily |
| Substitution elasticities | Perfect substitutes | Limited substitution (Armington assumption) | Varies (limited or perfect substitution) | Varies (limited or perfect substitution) |
| Characteristics that separate some of the different closure types are given with a list of the main closure categories across the top. The only characteristic that separates a purely neoclassical closure from an elasticity-structuralist model is the utilization of limited substitution elasticities (Kraev 2003). | | | | |

**Modeling Shocks to the Existing Equilibrium**

The construction of the computable general equilibrium model establishes a base, static, or equilibrium condition of the economy. This condition is described by the calibrated data in the SAM database that is used as an input for the CGE model. The equation sets explained above create the structure of the economy being modeled and

assumed to generate the required savings. Johansen explicitly argues that macroeconomic fiscal and monetary policies, presumably outside the CGE framework will ensure that savings are generated to balance the investment."(Robinson 2003) describe how that economy will react in the event of a shock to the economic system. Once the model is in place, many simulations may be performed depending on the specific shock, or shocks, that the modeler has chosen to enforce on the model. Below, we describe the rationale for the shocks that we modeled.

**Shocks Modeled**

Ranchers would have to modify the composition of their ranchlands in the course of changing from traditional ranching operations to silvopasture. Planting additional trees on these lands will reduce the land area available to cattle ranchers for production of their livestock. In order to model the effects of the ranchers implementing this operational change, we chose as an exogenous variable the land factor of production for sector one, which represents the quantity of land available to the cattle industry for production. We then impose a twenty-five percent reduction in the cattle sector's available land base by applying a shock of -25% to the supply of the land factor of production for sector. Recently, research has been conducted on the values of trees or forests on ranchlands. That research was modeled such that for silvopasture adoption by ranchers, 20% of land would be taken out of production from ranching with additional lands taken out for the creation of riparian buffer strips (Shrestha and Alavalapati 2004). The level of environmental improvement offered by this size of land use change is similar to the level of improvement on which the willingness to pay data that was utilized in this study was also based. For that reason, a value of 25% was chosen for the negative shock to the land base for ranchers to include the change in land available due to adding trees to the ranchlands as well as to account for additional land for riparian buffers.

In addition, the adoption of silvopasture will cause ranchers to expend more in capital costs on items such as tractor and other timber management equipment rental required to practice silvopasture. The actual increase in capital costs for ranchers' adoption of silvopasture could vary greatly depending on factors such as the size of the ranching operations, the method chosen to protect young trees from cattle, and the amount of the necessary equipment already owned by the rancher. Because of the great deal of variation possible in cost increases, a twenty- five percent increase in capital costs was chosen in order to ensure this portion of the total shock would be significant in comparison to the shock to the land base. This is simulated in the model by applying a 25% increase to the cost of capital for the cattle sector. The effects of each shock are analyzed under each of the two closure scenarios wage-flexible, which ensures no change in employment, and wage-rigid, which allows for changes in employment.

**Cost-Benefit Analysis**

This analysis is conducted in order to give policy makers more information on the effects on the welfare of Floridians due to policies on silvopasture. In order to conduct a cost benefit analysis, both the costs and the benefits have to be expressed in the same units. The most common unit for both to be expressed in is in currency or dollar values. We utilized the change in the income of the households in Florida for each scenario as the cost side of the cost benefit analysis. The determination of the benefits side of the analysis is slightly more complicated, however. Because there is no direct market for the environmental services of silvopasture, alternative means of valuing these benefits must be utilized in order to compare their benefits to the costs in monetary terms. In order to address this problem, we utilize a study that was conducted to estimate the public's willingness to pay for these environmental services. Shrestha and Alavalapati (2004) determined that, within the Lake Okeechobee watershed, the public's willingness to pay for the environmental services associated with silvopasture totaled $924.4million.

There are 1.34 million households in the Lake Okeechobee watershed and 6.34 million households in the entire state of Florida (Shrestha and Alavalapati 2004). However, without having more information relating to the intensity of preferences for these benefits statewide as compared to the intensity of preferences in the Lake Okeechobee watershed, an accurate extrapolation cannot be calculated. Therefore, we have chosen to utilize the WTP estimate for the Lake Okeechobee watershed as a conservative estimate of the total willingness to pay of all Florida households.

Another complication in using this WTP value directly is that this willingness to pay estimate is the value that these households attach to having these benefits forever. The WTP value must therefore be converted to a yearly amount in order to compare it with the results from the CGE analysis, which are based on yearly data from 1999.

$$PV = pmt / i$$

The yearly contribution necessary to realize this benefit forever can be calculated by utilizing the above equation for a perpetual annuity. We chose a common discount rate of .05, or 5% to calculate the present value. We acknowledge that with higher estimates of the discount rate the estimate yearly benefit will increase.

Additionally, if environmental services provided by silvopasture are not inferior goods, then the public's desire for the environmental services of silvopasture will decrease as household income decreases. Income elasticities of demand for environmental services similar to those provided by silvopasture have been estimated in Sweden. Hokby and Soderqvist (2001) estimated that the income elasticity of demand for reducing nitrogen loads in waters in Sweden were about 1.10. Also, the income elasticity of demand for preserving agricultural landscape in Sweden was estimated at 0.91 by

Drake et al. (1991). We assume that the elasticitiy of demand for the environmental services provided by silvopasture are comparable and we will therefore use an income elasticity of demand of 1.0 to evaluate the change in demand for these environmental services as income changes.

# CHAPTER 5
# MODEL RESULTS

## Simulation Results

The customized Five Sector Florida CGE model described in chapter three is utilized to simulate the impacts of cattle ranchers in Florida adopting silvopasture practices on their ranch and pasturelands. The simulations were conducted under two closure scenarios. Under the first closure, the wage rate was endogenous to the model and flexible. Under the second closure scenario, however, the wage rate is held constant, or rigid, by making the wage rate exogenous and applying no change to the price of labor.

### Wage-flexible Scenario

Two simultaneous shocks, a 25% decrease in the land base available for cattle production and a 25% increase in capital costs for the ranching sector, are imposed on the CGE model for each of the two closure scenarios. The 25% decrease in land base available for production of cattle represents land that will be taken out of cattle production and instead be utilized for growing trees. The increase in capital costs in sector one represents additional capital costs, such as tractor and other timber management equipment rental required to practice silvopasture. The shocks simulate the effects that adopting silvopasture will have on the cattle-ranching sector directly. The model then simulates, through the CGE framework, how the changes imposed on the cattle sector will affect the rest of the economy of Florida. The results of the wage-flexible scenario are presented in Tables 5-1, 5-2, and 5-3.

Table 5-1. Macro-economic impacts of -25% land base and +25% capital costs

| Variable | % Change | Original level | New level | Change |
|---|---|---|---|---|
| Total household expenditure(millions) | -0.009218 | $240,336.56 | $240,314.41 | -$22.15 |
| Wage rate | -0.006444 | 1.00 | 0.99993556 | -0.00006 |
| Percent unemployment | 0 | 3.9 | 3.9 | 0 |

Table 5-1 presents some of the macroeconomic impacts of the shocks on the Florida economy. Household demand for goods has dropped, -$22.15million, reflecting the negative effect on the income of Floridians as a result of these environmentally benign policies. Although this is a large change relative to other magnitudes in this simulation, it reflects a drop of just under one one-hundredth of a percent of the total expenditures of Floridians. The wage rate drops only slightly, -0.0006%, to keep employment levels constant at the 1999 level for Florida of 3.9%.

Table 5-2. Commodity market impacts of -25% land base and +25% capital costs

| | Sector | % Change | Original level ($) | New level ($) | Change ($) |
|---|---|---|---|---|---|
| Price of commodity | 1 | 3.03419 | 1.00 | 1.03 | 0.030 |
| | 2 | 0.00000 | 1.00 | 1.00 | 0.000 |
| | 3 | -0.00082 | 1.00 | 1.00 | 0.000 |
| | 4 | 0.00060 | 1.00 | 1.00 | 0.000 |
| | 5 | -0.00436 | 1.00 | 1.00 | 0.000 |
| | | | | | |
| Total commodity demand | 1 | -2.94759 | 188.56 | 183.00 | -5.558 |
| (levels in millions) | 2 | -0.00286 | 7,694.74 | 7,694.52 | -0.220 |
| | 3 | 0.00074 | 405.84 | 405.84 | 0.003 |
| | 4 | -0.00521 | 54,213.16 | 54,210.33 | -2.825 |
| | 5 | -0.00232 | 416,915.56 | 416,905.89 | -9.668 |
| | | | | | |
| HH commodity demand | 1 | -2.9540 | 0.00 | 0.00 | 0.000 |
| (levels in millions) | 2 | -0.0092 | 1,126.35 | 1,126.25 | -0.104 |
| | 3 | -0.0084 | 1.90 | 1.90 | 0.000 |
| | 4 | -0.0098 | 17,089.29 | 17,087.62 | -1.677 |
| | 5 | -0.0049 | 222,119.02 | 222,108.23 | -10.782 |
| | | | | | |
| Export demand | 1 | -2.94507 | 61.00 | 59.20 | -1.796 |
| (levels in millions) | 2 | 0.00000 | 3,969.55 | 3,969.55 | 0.000 |
| | 3 | 0.00081 | 400.36 | 400.36 | 0.003 |
| | 4 | -0.00059 | 20,293.49 | 20,293.37 | -0.121 |
| | 5 | 0.00436 | 78,871.04 | 78,874.48 | 3.443 |

Table 5-2 presents the economic impacts to the markets for commodity outputs of sectors one through five for a 25% decrease in land base and 25% increase in capital costs for cattle ranchers in Florida under the flexible wage rate scenario. Changes to commodity prices, total commodity demands, total household demands, and export demands are shown. In addition, the pre-shock levels, post-shock levels, and level deltas are given. The commodity output results show that the price of sector one's output (commodity one) has increased by 3.03%. This increase in the output price of the cattle sector can be attributed to the increases in their input costs that are passed along to consumers[12] through raising the price of their product. The price of commodity two remains unchanged since it has been fixed as the numeraire. The manufacturing sector, sector four, also experiences a small increase of 0.0006% in the price of its output. One reason for this increase is because sector four contains many of the cattle consuming industries, such as meat packing plants as well as sausage and other beef processing industries. The price of their cattle input goes up, so they must adjust their output price as well to maintain zero pure profits.

The shocks to the cattle sector have caused the overall economy of Florida to contract. As a result of this contraction, consumer demand for most of the sector outputs has declined. This drop in demand has the largest impact, in terms of dollar value decrease, to the service sector, sector five, which experiences a drop of $9.67 million. The service sector is the largest sector in the model however, and this drop reflects a change of only -0.0023%. The shocks were applied to the cattle sector directly, thus this sector experienced the largest percentage drop of -2.95% in demand following their relatively high price increase.

As a result of the contracting economy, Floridian households have less income to spend on consumption of goods. Hence the demand for all commodities by households has decreased accordingly. Although the model shows that largest decrease in household demand by percentage is in sector one, households do not actually directly consume output from the cattle sector. Households instead purchase the processed cattle output from the manufacturing sector. This output carries along with it a higher price due to the

[12] Consumers, in this case, refers not only to households in the model, but to all who purchase the output of sector one, including: sector one through purchase of its own output as an intermediate input, other sectors through purchase of intermediate inputs from sector one, and foreign importers purchase of commodity one.

increase in intermediate costs of the input from sector one. This price increase along with the decrease in household expenditure causes the manufacturing sector to experience the second largest drop in consumer demand of the five industries, a decrease of -.0098%.

Export demand changes are the least complicated changes to analyze with this model since we assume a constant exchange rate and the changes in export demand are therefore functions of only the change world price of the commodity and the change in the price of that sector's commodity. Because our treatment of Florida follows the small country assumption, changes in the production of goods in the Florida economy have no effect on world prices. We have therefore fixed world prices exogenously and export demand changes remain functions only of changes in the goods' prices. Accordingly, there was a rise in net exports for commodities three and five and a decline in net exports for commodities one and four. The demand for net exports for commodity two remains fixed because of the selection of sector two as the numeraire in the model.

Table 5-3. Factor market impacts of -25% land base and +25% capital costs

| Variable | Sector | % Change | Original level ($) | New level ($) | Change ($) |
|---|---|---|---|---|---|
| Labor Demand | 1 | 0.00386 | 75.11100 | 75.11 | 0.00290 |
| (levels in millions) | 2 | 0.00358 | 3541.36792 | 3,541.49 | 0.12675 |
| | 3 | 0.00636 | 15.22300 | 15.22 | 0.00097 |
| | 4 | 0.00183 | 21113.47800 | 21,113.86 | 0.38574 |
| | 5 | -0.00024 | 215591.42200 | 215,590.90 | -0.51742 |
| | | | | | |
| Capital Demand | 1 | -20.03132 | 10.63860 | 8.50755 | -2.13105 |
| (levels in millions) | 2 | -0.00287 | 1102.93994 | 1102.90834 | -0.03160 |
| | 3 | -0.00008 | 125.98700 | 125.98690 | -0.00010 |
| | 4 | -0.00462 | 8250.00000 | 8249.61910 | -0.38090 |
| | 5 | -0.00668 | 93277.50000 | 93271.26626 | -6.23374 |
| | | | | | |
| Land Prices | 1 | 33.32833 | 1.00000 | 1.33328 | 0.33328 |
| | 2 | -0.00287 | 1.00000 | 0.99997 | -0.00003 |
| | 3 | -0.00008 | 1.00000 | 1.00000 | 0.00000 |
| | 4 | -0.00462 | 1.00000 | 0.99995 | -0.00005 |
| | 5 | -0.00668 | 1.00000 | 0.99993 | -0.00007 |

Table 5-3 presents the impacts to Florida's factor markets as a result of the shocks simulating the adoption of silvopasture by Florida's ranching sector. Since this scenario is under flexible wage rate assumption, aggregate demand for labor is fixed exogenously and the price of labor varies to maintain full employment of labor in Florida. Although the aggregate supply of labor is fixed in this closure, labor is not sector specific. This allows unrestricted mobility of labor within the economy. Each sector has its own degree of labor intensity. Thus, as demand for output from each of the sectors changes each sector will shift its demand for labor by the amount necessary, relative to its labor intensity, to maintain the desired level of output. This can be observed as the individual sectors adjust their employment levels as a result of the shocks. Sector five, which has a relatively large decrease demand for output, \$9.67million, experiences in a decrease in its demand for labor even with the decrease in the wage rate. Labor from this sector then mobilizes and relocates to the other sectors, keeping the aggregate labor supply constant.

Capital is sector specific in this model and therefore cannot move between sectors. The decrease in the output demand for sector one combined with the higher costs of capital in that sector, have resulted in a large drop in capital demand in sector one. This decrease in demand by sector one does not benefit the other sectors because of the immobility of capital. Therefore, the other sectors do not experience a gain in resources available that might be felt under a mobile capital model specification. The other four sectors each experience a slight reduction in capital utilization as a result of the contracting economy. Supply of land for all sectors was held exogenous in the model, but the land rental rates were allowed to vary. Land, like capital, is treated as sector specific, and sectors one (cattle-ranching), two (other agriculture) and three (forestry) are the land utilizing sectors of this model. As a result of the reduction to the land available for production of cattle for sector one, the rental rates for ranchlands have increased dramatically, 33.24%. The remaining four sectors each experience a slight decrease in rental rates.

**Wage-rigid Scenario**

Following the same reasoning for simulating the changes to the economy as a result of Florida's cattle ranchers adopting silvopasture as in the flexible wage scenario, identical shocks, consisting of a 25% decrease in the land base available for cattle production and a 25% increase in capital costs for the cattle-ranching sector, are imposed on the CGE model for the wage-rigid scenario. The results of the wage-rigid scenario are presented in Tables 5-4, 5-5, and 5-6.

Table 5-4. Macro-economic impacts of -25% land base and +25% capital costs

| Variable | % Change | Original level | New level | Change |
|---|---|---|---|---|
| Total household expenditure(millions) | -0.137373 | $240,336.56 | $240,006.40 | -$330.158 |
| Wage rate | 0 | 1.00 | 1.00 | 0.000 |
| Percent unemployment | 1.842082 | 3.9 | 3.9718412 | 0.072 |

Some of the key macroeconomic impacts of the shocks on the Florida economy are presented in Table 5-4. This closure represents a more short-term reaction of the economy to the imposed shocks. This is because, in the event of a shock to an economy, the initial response to changes in demand for labor will be met by changes in the unemployment rate rather than by changes in the real wage. (Domingues and Haddad 2003) The unemployment rate in Florida increases by from 3.90% to 3.97% as a result of imposing the shocks on the economy and the wage rate remained fixed exogenously by the closure. According to the U.S Census Bureau, there were 7,407,458 people employed in Florida in 1999. According to these employment levels, 5322 Floridians will lose their jobs as a result of the policy shocks when the unemployment level in Florida rise from

3.90% to 3.97. As a result of this increase in unemployment and the contraction experienced throughout the Florida economy, households have much less income to spend and therefore total household expenditures decreased by over $330million. It is clear from these macro-economic responses that under this closure, the imposed shocks will have a more negative effect on the economy.

Table 5-5. Commodity market impacts of -25% land base and +25% capital costs

| Variable | Sector | % Change | Original level ($) | New level ($) | Change ($) |
|---|---|---|---|---|---|
| Price of commodity | 1 | 3.03727 | 1.00 | 1.03 | 0.030 |
| | 2 | 0.00000 | 1.00 | 1.00 | 0.000 |
| | 3 | -0.00016 | 1.00 | 1.00 | 0.000 |
| | 4 | 0.00510 | 1.00 | 1.00 | 0.000 |
| | 5 | 0.00012 | 1.00 | 1.00 | 0.000 |
| | | | | | |
| Total commodity demand | 1 | -2.98542 | 188.56 | 182.93 | -5.629 |
| (levels in millions) | 2 | -0.04269 | 7,694.74 | 7,691.45 | -3.285 |
| | 3 | -0.00103 | 405.84 | 405.83 | -0.004 |
| | 4 | -0.07390 | 54,213.16 | 54,173.10 | -40.061 |
| | 5 | -0.09972 | 416,915.56 | 416,499.83 | -415.732 |
| | | | | | |
| HH commodity demand | 1 | -3.0813 | 0.00 | 0.00 | 0.000 |
| (levels in millions) | 2 | -0.1374 | 1,126.35 | 1,124.80 | -1.547 |
| | 3 | -0.1372 | 1.90 | 1.89 | -0.003 |
| | 4 | -0.1425 | 17,089.29 | 17,064.95 | -24.346 |
| | 5 | -0.1375 | 222,119.02 | 221,813.62 | -305.400 |
| | | | | | |
| Export demand | 1 | -2.94797 | 61.00 | 59.20 | -1.798 |
| (levels in millions) | 2 | 0.00000 | 3,969.55 | 3,969.55 | 0.000 |
| | 3 | 0.00016 | 400.36 | 400.36 | 0.001 |
| | 4 | -0.00510 | 20,293.49 | 20,292.46 | -1.034 |
| | 5 | -0.00012 | 78,871.04 | 78,870.94 | -0.095 |

The economic impacts to the markets for commodity outputs of sectors one through five for a 25% decrease in land base and 25% increase in capital costs for cattle ranchers in Florida under the wage-rigid scenario are presented in Table 4-5. The price change in the cattle sector under this closure was approximately the same as the change in the previous, wage-flexible, closure. This is due to the changes imposed on the cattle sector being much larger than other general equilibrium effects. In general the other commodity price changes are slightly higher in magnitude as apposed to the first closure, with the exception of the numeraire, whose price remains fixed.

The demand for output from the cattle sector remains nearly the same as in the first closure because the price change for sector one is relatively large and therefore enforces a more binding constraint on the amount of commodity one purchased by the other sectors than changes in their input demands would impose. The remaining four sectors experience a large decrease in total demand. The largest portion of this decrease in total demand comes from the decrease in demand by households for those commodities. Household demand drops sharply because the impact on employment under the rigid wage scenario causes a large decrease in the amount of money households have to spend. As in the first closure, change in the net export demand is dependent only on the change in the commodity price.

Table 5-6. Factor market impacts of -25% land base and +25% capital costs

| Variable | Sector | % Change | Original level ($) | New level ($) | Change ($) |
|---|---|---|---|---|---|
| Labor Demand | 1 | -0.03858 | 75.11100 | 75.08 | -0.02898 |
| (levels in millions) | 2 | -0.04269 | 3541.36792 | 3,539.86 | -1.51174 |
| | 3 | -0.00119 | 15.22300 | 15.22 | -0.00018 |
| | 4 | -0.06880 | 21113.47800 | 21,098.95 | -14.52628 |
| | 5 | -0.09960 | 215591.42200 | 215,376.70 | -214.71828 |
| | | | | | |
| Capital Demand | 1 | -20.06023 | 10.63860 | 8.50447 | -2.13413 |
| (levels in millions) | 2 | -0.04269 | 1102.93994 | 1102.46912 | -0.47082 |
| | 3 | -0.00119 | 125.98700 | 125.98550 | -0.00150 |
| | 4 | -0.06880 | 8250.00000 | 8244.32392 | -5.67608 |
| | 5 | -0.09960 | 93277.50000 | 93184.60027 | -92.89973 |
| | | | | | |
| Land Prices | 1 | 33.19060 | 1.00000 | 1.33191 | 0.33191 |
| | 2 | -0.04269 | 1.00000 | 0.99957 | -0.00043 |
| | 3 | -0.00119 | 1.00000 | 0.99999 | -0.00001 |
| | 4 | -0.06880 | 1.00000 | 0.99931 | -0.00069 |
| | 5 | -0.09960 | 1.00000 | 0.99900 | -0.00100 |

The impacts under the wage-rigid scenario to Florida's factor markets as a result of the shocks simulating the adoption of silvopasture by Florida's ranching sector are presented in Table 4-6. Since wages are fixed exogenously under this closure, industries are forced to reduce their employment levels in order to reduce total spending on wages to meet the new, lower desired levels of output while minimizing costs. The largest impacts are in the service and manufacturing sectors, which reduce spending on labor by $214.7 million and $14.5 million respectively.

As in the previous closure, capital is sector specific. Therefore capital cannot move between the model's five sectors. In sector one, the combined effects of the decrease in the output demand for sector one and the higher costs of capital in that sector have resulted in a large drop in capital demand in sector one. As a result of the contracting economy, the service sector's capital expenditures decreased by $92.8 million. The manufacturing sector also experienced a large reduction in capital expenditures of $5.7million.

Due to the reduction to the land available for production of cattle for sector one, the rental rates for ranchlands have increased dramatically, 33.19%. Because land is sector specific as well, an increase in the price of ranchland has no direct effect on the prices of other land in the model. Therefore, the decrease in output levels and therefore the desire for land input causes the land rental rates to drop since land quantities are exogenous.

The model produced a large number of outputs for changes in the intermediate demands by sectors. These changes in the demands for each sector's intermediate good input are not presented here. However, the full set of output data for each closure scenario is available in Appendix A.

## Cost-Benefit Analysis

The introduction of these shocks simulated the effect on the economy of cattle ranchers across the state of Florida adopting silvopasture. Impacts to the economy of Florida varied greatly, depending on the closure chosen, with a decrease of household income of $22.16 million for the wage-flexible closure and $330.16 million under the wage-rigid closure. This reduction in income, however, may be partially compensated for by benefits gained by Florida residents in the form of environmental services resulting from the adoption of silvopasture practices.

As explained in chapter 3, there is no direct market for the environmental services of silvopasture; therefore, an alternative means of valuing these benefits must be utilized in order to compare their benefits in monetary terms. We utilized the WTP estimate of $924.4 from the Lake Okeechobee watershed from Shrestha and Alavalapati (2004) as a conservative estimate of the statewide WTP of Floridians for these services. When converting this value to a yearly benefit contribution, we calculated an annual benefit value of $46.22million. Utilizing the costs from the decrease in the income of households and the above calculated benefit value we estimated the total net benefit below.

Table 5-7. Estimated costs and benefits of providing silvopasture

| | Wage-flexible | Wage-rigid |
|---|---|---|
| Watershed WTP estimate (Benefit) | 46.22 | 46.22 |
| Income change (Cost) | -22.16 | -330.16 |
| | 24.06 | -283.94 |

Table 5-7 compares willingness to pay for the environmental services of silvopasture with the costs in terms of the income change that households were subjected to under each of the two model closures. This comparison shows that the benefits outweigh the costs by $24.06 million for wage-flexible scenario, but that the costs exceed the benefits by $284 million under the wage-rigid scenario.

We use an income elasticity of demand of 1.0 to evaluate the change in demand for the environmental services provided by silvopasture. The change in income of Floridians was observed to be -0.0092% and -0.1374% for the wage-flexible and wage-rigid closures respectively. Since we utilize the WTP estimates for the environmental services of silvopasture in place of the demand for this non-market good, the estimates need to be adjusted for the change in income experienced by households in Florida. Although household incomes in Florida were decreased by millions of dollars under both closures, this amount is actually a very small percentage of overall household income and therefore, the adjusted WTP estimates differ very little form the previous estimates. The equations for the change in willingness to pay for the wage-flexible and wage-rigid scenarios are presented next.

$$\frac{\partial WTP_{flex}}{\partial I_{flex}} = \frac{\partial WTP_{flex}}{-0.000092} \qquad \text{and,} \qquad \frac{\partial WTP_{rigid}}{\partial I_{rigid}} = \frac{\partial WTP_{rigid}}{-0.001374}$$

Assuming the income elasticity as 1.0, these equations yield.

$$\partial WTP_{flex} = (-0.000092)(1.0) \qquad \text{and,} \qquad \partial WTP_{rigid} = (-0.001374)(1.0)$$

$$\partial WTP_{flex} = -0.000092 \qquad \text{and,} \qquad \partial WTP_{rigid} = -0.001374$$

By multiplying these deltas by the original WTP and subtracting the output from the original estimates yields the income adjusted values in table 4-8.

Table 5-8. Income adjusted changes in WTP estimates

| | Wage-flexible | Wage-rigid |
|---|---|---|
| Income adjusted WTP estimate | $46.2157 | $46.1565 |
| Base WTP estimate | $46.2200 | $46.2200 |
| Change | -$0.0043 | $0.0635 |

We arrive at Table 5-9 by substituting these new values into the cost-benefit analysis.

Table 5-9. Income adjusted estimated costs and benefits of silvopasture

| | Wage-flexible | Wage-rigid |
|---|---|---|
| WTP estimate (Benefit) | 46.216 | 46.156 |
| Income change (Cost) | -22.160 | -330.160 |
| | 24.056 | -284.004 |

These results show that for the wage-flexible closure scenario, the benefits outweigh the costs by $24.056million. However, for the wage-rigid closure scenario, the costs exceed the benefits by $284.004million. These results present evidence that silvopasture will not necessarily give a positive benefit to society under all closure scenarios. This leads to some important questions. If the wage-rigid scenario is a more short term of the interactions in the economy, how long is the duration of these more intense negative impacts? How long will it take before industries make adjustments to their wage rates? Questions such as these could possibly be answered by constructing more advanced CGE models. Although these results do not currently provide conclusive evidence that the overall benefits to households will exceed the costs, it does show the possibility that they could. The above findings provide grounds for the need for more research in this area with more complex and detailed CGE models capable of adequately handling these issues.

CHAPTER 6
SUMMARY, IMPLICATIONS, AND RESEARCH OPPORTUNITIES

## Summary

In our study, we used a five sector CGE model of Florida to analyze the impacts to the economy of Florida in response to shocks simulating the adoption of silvopasture by all cattle ranchers in the state. We wanted to answer two questions. Primarily, we wanted to know how the modeled policy changes would impact Florida's economy.

We analyzed this question under both a flexible and fixed wage enclosure and found that the incomes of Floridians would decrease by $22.16 million for the wage-flexible closure and $330.16 million under the wage-rigid closure. In addition, under the fixed wage enclosure scenario, we estimated that 5,322 Floridians would lose their employment. The cattle-ranching sector is found to lose approximately 3.0% or $5.6million as a result of the shocks. This decrease in sector activity is small when compared to the magnitude of the imposed shocks on that sector since ranchers pass on the higher costs of business to the manufacturing sector, which eventually results in higher beef prices for consumers.

We also wanted to answer the question of how the welfare of Floridians would change as a result of the policy shocks when the environmental benefits of the policies are taken into account. Utilizing a cost benefit approach, we found that under the wage-flexible closure, households in Florida would come out ahead under the flexible wage scenario by $24.056million. However, under the wage fixed scenario, they would be worse off by $284.004million.

**Policy Implications**

The two different scenarios paint different pictures for policy makers of the possible severity of the impacts having ranchers in Florida adopt silvopasture. Since scenarios modeled with rigid wages reflect a shorter term than flexible wage scenarios, the actual response by the economy might be that first the economy reaches an equilibrium more closely in line with the wage-rigid scenario, and then over time moves towards the flexible wage scenario. This might imply that over the long run, the public will be better off in response to Floridian ranchers having to adopt silvopasture. However, policy makers are understandably reluctant to enact policies that will cause a large number of their constituent voters to lose their employment. This might imply to policy makers that they should employ policies that would not cause the entire state to adopt silvopasture at once.

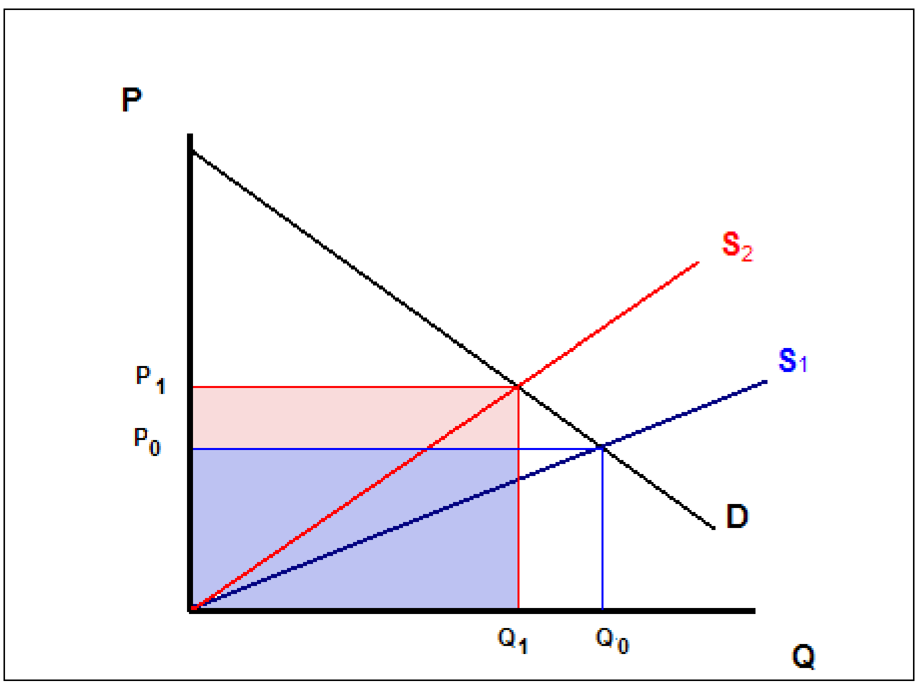


Figure 6-1. Difference in profitability for cattle-ranchers in Florida

Although smaller incremental policies that required only certain areas to adopt silvopasture would certainly decrease the total economic impact to Florida, they would have much different effects on the local cattle ranchers. This can be shown from Figure 6-1. If policy makers implemented policies that affected all of the state's cattle ranchers, then price will increase from P0 to P1 as quantity dropped as a result of the higher cost of producing the cattle under silvopasture. If only a small percentage of ranchers were affected at a time however, they would act as price takers, and the price may not rise. This would reduce the profits of the ranchers practicing silvopasture as they would no longer be able to capture the pink shaded area as part of their revenues and would only receive the blue shaded area representing revenues from the reduced quantity at the original price. This might imply that policy makers will have to develop policies such as tax incentives or carbon sequestration payments that would compensate the ranchers who are forced to adopt silvopasture for the environmental services they produce since they would be unable to pass their increased costs on to consumers through higher cattle prices.

## Model Limitations

Because of the static nature of our model, it does not show the reactions of the economy in response to the shocks over time. Information on how the economy behaves in the transition period from the initial shock to the equilibrium point would be useful to policy makers. Another limitation is that we employed relatively simplistic Cobb-Douglas utility and production functions in the model. Other functional forms might improve how accurately the model reflects the behavior of economic agents in the real world. Changes such as these also greatly increase the data requirements of CGE models. Also, this model is constructed with data aggregated into only five sectors. With a greater degree of sector disaggregation, the number of possible policy shocks that this model could capture would increase. Also, the impacts of adopting silvopasture in Florida could be more accurately modeled. Also, we did not include economic returns from timber sales as part of the economic gain to ranchers because the returns would be received far in the future relative to the model's yearly data and including a present value of these gains might present a distorted picture of the benefits ranchers actually observe.

In addition to these limitations, the model results are highly affected by the allocations of costs described by the database that we used. The model is particularly sensitive to changes in the costs of the factors of production to which the shocks to the model were applied. It is possible that the proportion of factor costs associated with labor for the cattle sector in our model were overestimated while the proportion of factor costs associated with land rental costs were underestimated. In order to show how the results of the model could vary with a change in these factor cost proportions, we utilized an ufinished cow-calf budget, provided by Dr. Anton in the Food and Resource Economics Department at the Univeristy of Florida, to estimate the costs in labor for the cattle industry at $24 million annually. We then adjusted the original database values accordingly and ran the model again for both the wage-flexible and wage-rigid scenarios.

The results for the model after these changes were made are provided in Appendix B. Under the wage-flexible scenario, this change caused the impact to Floridian household income to increase to $96 million from the $22 million estimated loss using the original model data. This larger drop can be attributed to the increased impact of the shock to the land base in the cattle sector as the proportion of that lands cost contribution increases. Similarly, the impact to the cattle sector increased as well from a

$5.5 million decrease in industry demand to a $22.9 million drop after changing the model data.

The increase in the impacts of the shocks as a result of changing the database input data were felt much more severly under the wage-rigid scenario. Under this scenario, the impacts on household income increased from a $330 million decrease to a drop of over $1.4 billion. The change in the impact to the cattle sector was comparable to the change under the wage-flexible scenario with the new data, with a decrease in sector demand of $23.1 million.

These changes to the original database provide one extreme reference point to how the model would be impacted by changing the data for the cost allocations within the cattle sector. In order to provide an additional point of reference, we tripled the original cost of the land factor for the model and redistributed the remaining factor costs to the labor factor of production. The effects of these data changes were between the other two scenarios and the full list model results with the new data as an imput to the model are listed in Appendix C.

Under the wage-flexible scenario, the impact to household income for Floridians increased from the $22 million loss in the original scenario to a loss of almost $43 million. The model showed that the impact to cattle sector demand would also increase to $10 million from $5.5million. Under the fixed-wage scenario, the increase in the household income impact increased by a similar scale from $330 million to $635 million. Similar to the decrease in cattle sector demand under the wage-flexible scenario, the impact to the demand from the cattle sector the under wage-fixed scenario also increased to about $10 million.

These large variations in the output, resulting from changing the input data for the cattle sector, demonstrate one limitation of this model in its sensitivity to this type of change. As a result of this limitation, it is important that research is conducted to gather data specifically on the cost strucutres of the land utilizing portion of the cattle ranching industry in Florida. Increasing the accuracy of the data utilized to represent the cost structure of the cattle industry in this CGE model would have a great impact on the ability of the model to accurately determine economic impacts of shocks to the Florida economy. The results of the output changes after changing the input data were discussed to show the sensitivity of the model to this type of change, hence the results were not discussed in the same level of detail as the original model. However, the full model output sets for each of the two changes are provided in Appendicies B and C.

## Research Opportunities

There are several areas for future research opportunities relating to this study. First of all, a dynamic model, which has the ability to analyze the economic impacts to policy shocks related to silvopasture with respect to time, could be investigated. This would give policy makers more information on the time it would take for the effects to be felt by the economy. It would also give more information on the smoothness of the transitions experienced in the economy over time. Also, equations that capture the impacts that the policy changes would have on the environment as well as environmental feedbacks into the economy could be introduced into the CGE model. At the same time, a model could be developed based on a utility function incorporating environmental variables as part of the welfare of households, providing a more robust analysis of the well being of households as a result of the sum of the economic and environmental changes they experience.

# APPENDIX A
# MODEL OUTPUT

## Wage-flexible Scenario Output

```
SETS
 ----

  No Name          Size    Description
--------------------------------------
    1 SECT            5   Sectors
    2 FAC             3   Factors
    3 NUM_SECT        1    sector 1
    4 TWO_SECT        4   sectors 2-5
    5 NSEC_SECT       1   sector 2
    6 FORE_SECT       1   sector 3
    7 LAB_FAC         1   Labor Factor of Production, factor 1
    8 KD_FAC          2   Capital and Land Factors, factors 2&3
    9 LAND_FAC        1   Land Factor of Production, factor 3

 VARIABLES
 ---------
  No Name            Size     Arguments (if any) and Description
 ----------------------------------------------------------------
    1 p_Y               1   Total household expenditure
    2 p_PC              5 (SECT)  Price of commodities
    3 p_PFL             1 (LAB_FAC)  Price of Labor
    4 p_PF             10 (KD_FAC,SECT)  Price of factors
    5 p_XCOM            5 (SECT)  Total demand for (or supply of) commod ...
    6 p_XFACL           1 (LAB_FAC)  Total demand for (or supply of) factors
    7 p_XFACKD          2 (KD_FAC)  Total demand for (or supply of) factors
    8 p_XH              5 (SECT)  Household consumption of commodities
    9 p_XC             25 (SECT,SECT)  Intermediate commodity inputs
   10 p_XFL             5 (LAB_FAC,SECT)  Intermediate factor inputs
   11 p_XFKD           10 (KD_FAC,SECT)  Intermediate factor inputs
   12 p_XEXP            5 (SECT)  Net Exports of commodities
   13 p_PW              5 (SECT)  World Price of Commodity
   14 p_TLF             1   Total Labor Force
   15 p_ULF             1   Unemployed Labor Force
   16 p_T               1   Consumer Market Tax

  TOTAL NUMBER OF exogenous VARIABLES IS 18.
    THEY ARE AS FOLLOWS:

 Just 5 of the 10 components of 'p_PF' -- namely components:
 1, 3, 5, 7, 9
 All 1 components of 'p_XFACL'
 Just 5 of the 10 components of 'p_XFKD' -- namely components:
 2, 4, 6, 8, 10
 All 5 components of 'p_PW'
 All 1 components of 'p_TLF'
 All 1 components of 'p_T'

  TOTAL NUMBER OF endogenous VARIABLES IS 65.
    THEY ARE AS FOLLOWS:
```

```
All 1 components of 'p_Y'
All 5 components of 'p_PC'
All 1 components of 'p_PFL'
Just 5 of the 10 components of 'p_PF' -- namely components:
2, 4, 6, 8, 10
All 5 components of 'p_XCOM'
All 2 components of 'p_XFACKD'
All 5 components of 'p_XH'
All 25 components of 'p_XC'
All 5 components of 'p_XFL'
Just 5 of the 10 components of 'p_XFKD' -- namely components:
1, 3, 5, 7, 9
All 5 components of 'p_XEXP'
All 1 components of 'p_ULF'

 TOTAL NUMBER OF shocked VARIABLES IS 2.
   THEY ARE AS FOLLOWS:

Just 1 of the 10 components of 'p_PF' -- namely components: 1
Just 1 of the 10 components of 'p_XFKD' -- namely components: 2

           THE SHOCKS ARE AS FOLLOWS.

       p_PF
       1       SHOCK = 25.000000

       p_XFKD
       2       SHOCK = -25.000000

  END OF THE SHOCKS.


  ALL THE endogenous VARIABLES ARE cumulatively-retained endogenous.

           SHOCKS RELEVANT TO THE PRINT-OUT BELOW


       p_PF
       1       SHOCK = 25.000000

       p_XFKD
       2       SHOCK = -25.000000

  THE RESULTS BELOW ARE CUMULATIVE EFFECTS OF ALL SHOCKS ABOVE.

When levels values are available for a variable,
 they are shown underneath the percent-change or change result.
The 4 results are shown in the order:
 Percent-change (or change), Pre-simulation, Post-simulation, Change.

For example
     3.000 (percent change)
     500.0 (pre-sim level)
     515.0 (post-sim level)
      15.0 (change)

p_Y   Total household expenditure

    -0.009218
240336.562000
240314.406000
   -22.156250
```

```
p_PC (SECT)  Price of commodities

     s1             s2             s3             s4             s5
     3.034190       0.000000*     -0.000819       0.000595      -0.004364
     1.000000       1.000000       1.000000       1.000000       1.000000
     1.030342       1.000000       0.999992       1.000006       0.999956
     0.030342       0.000000*     -0.000008       0.000006      -0.000044

p_PFL (LAB_FAC)  Price of Labor

    labor
    -0.006444
     1.000000
     0.999936
    -0.000064

p_PF (KD_FAC,SECT)  Price of factors
 p_PF(-,s1) results where '-' is in set 'KD_FAC'.

    land
    33.238327
     1.000000
     1.332383
     0.332383

 p_PF(-,s2) results where '-' is in set 'KD_FAC'.

    land
    -0.002865
     1.000000
     0.999971
    -0.000029

 p_PF(-,s3) results where '-' is in set 'KD_FAC'.

    land
    -0.000080
     1.000000
     0.999999
    -0.000001

 p_PF(-,s4) results where '-' is in set 'KD_FAC'.

    land
    -0.004617
     1.000000
     0.999954
    -0.000046

p_PF (KD_FAC,SECT)  Price of factors
 p_PF(-,s5) results where '-' is in set 'KD_FAC'.

    land
    -0.006683
     1.000000
     0.999933
    -0.000067

p_XCOM (SECT)  Total demand for (or supply of) commodities

     s1             s2             s3             s4             s5
    -2.947586      -0.002865       0.000739      -0.005211      -0.002319
```

```
   188.559998    7694.735350     405.838989   54213.156200  416915.562000
   183.002029    7694.515140     405.841980   54210.332000  416905.906000
    -5.557968      -0.220215       0.002991      -2.824219      -9.656250

p_XFACKD (KD_FAC)  Total demand for (or supply of) factors

   capital         land
    -0.008778      -0.245993
102767.062000     828.379639
102758.039000     826.341858
    -9.023438      -2.037781

p_XH (SECT)  Household consumption of commodities

     s1             s2             s3             s4             s5
    -2.954021      -0.009218      -0.008400      -0.009813      -0.004854
     0.000000*   1126.350950       1.897000   17089.293000  222119.016000
     0.000000*   1126.247070       1.896841   17087.615200  222108.234000
     0.000000*     -0.103882      -0.000159      -1.677734     -10.781250

p_XC (SECT,SECT)  Intermediate commodity inputs
 p_XC(-,s1) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
    -2.947586      -0.002589      -0.001770      -0.003183       0.001776
    41.120998       7.355000       0.000000*      3.335000      43.889000
    39.908920       7.354810       0.000000*      3.334894      43.889778
    -1.212078      -0.000190       0.000000*     -0.000106       0.000778

 p_XC(-,s2) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
    -2.947854      -0.002865      -0.002046      -0.003459       0.001500
     9.930000     870.853027       0.087000     303.221008    1131.000000
     9.637279     870.828064       0.086998     303.210510    1131.016970
    -0.292722      -0.024963      -0.000002      -0.010498       0.016968

 p_XC(-,s3) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
    -2.945151      -0.000080       0.000739      -0.000674       0.004285
     0.000000*    122.128998       0.315000       5.378000      52.792999
     0.000000*    122.128899       0.315002       5.377964      52.795261
     0.000000*     -0.000099       0.000002      -0.000036       0.002262

p_XC (SECT,SECT)  Intermediate commodity inputs
 p_XC(-,s4) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
    -2.949555      -0.004617      -0.003798      -0.005211      -0.000252
    76.509003     748.979004       3.179000    8959.433590   15060.677700
    74.252327     748.944397       3.178879    8958.966800   15060.639600
    -2.256676      -0.034607      -0.000121      -0.466797      -0.038086

 p_XC(-,s5) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
    -2.951561      -0.006683      -0.005864      -0.007278      -0.002319
     0.000000*    849.520996       0.000000*   7559.000000   99637.156200
     0.000000*    849.464233       0.000000*   7558.449710   99634.843800
     0.000000*     -0.056763       0.000000*     -0.550293      -2.312500

p_XFL (LAB_FAC,SECT)  Intermediate factor inputs
```

```
 p_XFL(-,s1) results where '-' is in set 'LAB_FAC'.

    labor
     0.003855
    75.111000
    75.113899
     0.002899

 p_XFL(-,s2) results where '-' is in set 'LAB_FAC'.

    labor
     0.003579
  3541.367920
  3541.494630
     0.126709

 p_XFL(-,s3) results where '-' is in set 'LAB_FAC'.

    labor
     0.006364
    15.223000
    15.223969
     0.000969

 p_XFL(-,s4) results where '-' is in set 'LAB_FAC'.

    labor
     0.001827
 21113.478500
 21113.863300
     0.384766

 p_XFL(-,s5) results where '-' is in set 'LAB_FAC'.

    labor
    -0.000240
215591.422000
215590.906000
    -0.515625

p_XFKD (KD_FAC,SECT)  Intermediate factor inputs
 p_XFKD(-,s1) results where '-' is in set 'KD_FAC'.

   capital
   -20.031319
    10.638600
     8.507548
    -2.131052

 p_XFKD(-,s2) results where '-' is in set 'KD_FAC'.

   capital
    -0.002865
  1102.939940
  1102.908330
    -0.031616

 p_XFKD(-,s3) results where '-' is in set 'KD_FAC'.

   capital
    -0.000080
   125.987000
   125.986900
```

```
    -0.000099

 p_XFKD(-,s4) results where '-' is in set 'KD_FAC'.

   capital
    -0.004617
  8250.000000
  8249.619140
    -0.380859

 p_XFKD(-,s5) results where '-' is in set 'KD_FAC'.

   capital
    -0.006683
 93277.500000
 93271.265600
    -6.234375

p_XEXP (SECT)  Net Exports of commodities

     s1             s2             s3             s4             s5
    -2.945074       0.000000*      0.000819      -0.000595       0.004365
    61.000000    3969.547120     400.360992   20293.494100   78871.039100
    59.203506    3969.547120     400.364258   20293.373000   78874.484400
    -1.796494       0.000000*      0.003265      -0.121094       3.445312

p_ULF   Unemployed Labor Force

     0.000000*
     3.900000
     3.900000
     0.000000*
```

## Wage-rigid Scenario Output

```
SETS
 ----

  No Name          Size    Description
--------------------------------------
    1 SECT            5   Sectors
    2 FAC             3   Factors
    3 NUM_SECT        1    sector 1
    4 TWO_SECT        4   sectors 2-5
    5 NSEC_SECT       1   sector 2
    6 FORE_SECT       1   sector 3
    7 LAB_FAC         1   Labor Factor of Production, factor 1
    8 KD_FAC          2   Capital and Land Factors, factors 2&3
    9 LAND_FAC        1   Land Factor of Production, factor 3

 VARIABLES
 ---------
  No Name            Size     Arguments (if any) and Description
 ----------------------------------------------------------------
    1 p_Y                1   Total household expenditure
    2 p_PC               5 (SECT)  Price of commodities
    3 p_PFL              1 (LAB_FAC)  Price of Labor
    4 p_PF              10 (KD_FAC,SECT)  Price of factors
    5 p_XCOM             5 (SECT)  Total demand for (or supply of) commod ...
    6 p_XFACL            1 (LAB_FAC)  Total demand for (or supply of) factors
    7 p_XFACKD           2 (KD_FAC)  Total demand for (or supply of) factors
    8 p_XH               5 (SECT)  Household consumption of commodities
    9 p_XC              25 (SECT,SECT)  Intermediate commodity inputs
```

```
  10 p_XFL              5 (LAB_FAC,SECT)  Intermediate factor inputs
  11 p_XFKD            10 (KD_FAC,SECT)  Intermediate factor inputs
  12 p_XEXP             5 (SECT)  Net Exports of commodities
  13 p_PW               5 (SECT)  World Price of Commodity
  14 p_TLF              1   Total Labor Force
  15 p_ULF              1   Unemployed Labor Force
  16 p_T                1   Consumer Market Tax


  THE SHOCKS ARE AS FOLLOWS.

       p_PF
       1       SHOCK = 25.000000

       p_XFKD
       2       SHOCK = -25.000000

  END OF THE SHOCKS.

  THE RESULTS BELOW ARE CUMULATIVE EFFECTS OF ALL SHOCKS ABOVE.

p_Y   Total household expenditure

    -0.137372
240336.562000
240006.406000
  -330.156250

p_PC (SECT)  Price of commodities

     s1             s2             s3             s4             s5
     3.037269       0.000000*     -0.000163       0.005098       0.000121
     1.000000       1.000000       1.000000       1.000000       1.000000
     1.030373       1.000000       0.999998       1.000051       1.000001
     0.030373       0.000000*     -0.000002       0.000051       0.000001

p_PF (KD_FAC,SECT)  Price of factors
 p_PF(-,s1) results where '-' is in set 'KD_FAC'.

    land
    33.190601
     1.000000
     1.331906
     0.331906

 p_PF(-,s2) results where '-' is in set 'KD_FAC'.

    land
    -0.042688
     1.000000
     0.999573
    -0.000427

 p_PF(-,s3) results where '-' is in set 'KD_FAC'.

    land
    -0.001191
     1.000000
     0.999988
    -0.000012

 p_PF(-,s4) results where '-' is in set 'KD_FAC'.
```

```
    land
    -0.068801
     1.000000
     0.999312
    -0.000688

 p_PF(-,s5) results where '-' is in set 'KD_FAC'.

    land
    -0.099595
     1.000000
     0.999004
    -0.000996

p_XCOM (SECT)  Total demand for (or supply of) commodities

     s1             s2             s3             s4             s5
    -2.985418      -0.042688      -0.001028      -0.073895      -0.099716
   188.559998    7694.735350     405.838989   54213.156200  416915.562000
   182.930695    7691.450680     405.834808   54173.093800  416499.844000
    -5.629303      -3.284668      -0.004181     -40.062500    -415.718750

p_XFACL (LAB_FAC)  Total demand for (or supply of) factors

    labor
    -0.096026
240336.594000
240105.812000
  -230.781250

p_XFACKD (KD_FAC)  Total demand for (or supply of) factors

   capital         land
    -0.098693      -0.245993
102767.062000     828.379639
102665.641000     826.341858
  -101.421875      -2.037781

p_XH (SECT)  Household consumption of commodities

     s1             s2             s3             s4             s5
    -3.081308      -0.137372      -0.137209      -0.142463      -0.137493
     0.000000*   1126.350950       1.897000   17089.293000  222119.016000
     0.000000*   1124.803710       1.894397   17064.947300  221813.609000
     0.000000*     -1.547241      -0.002603     -24.345703    -305.406250

p_XC (SECT,SECT)  Intermediate commodity inputs
 p_XC(-,s1) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
    -2.985418      -0.038578      -0.038414      -0.043673      -0.038699
    41.120998       7.355000       0.000000*      3.335000      43.889000
    39.893364       7.352163       0.000000*      3.333544      43.872017
    -1.227634      -0.002837       0.000000*     -0.001456      -0.016983

 p_XC(-,s2) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
    -2.989408      -0.042688      -0.042525      -0.047783      -0.042809
     9.930000     870.853027       0.087000     303.221008    1131.000000
     9.633152     870.481262       0.086963     303.076111    1130.515870
    -0.296848      -0.371765      -0.000037      -0.144897      -0.484131
```

```
 p_XC(-,s3) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
    -2.949130      -0.001191      -0.001028      -0.006288      -0.001312
     0.000000*    122.128998       0.315000       5.378000      52.792999
     0.000000*    122.127541       0.314997       5.377662      52.792305
     0.000000*     -0.001457      -0.000003      -0.000338      -0.000694

p_XC (SECT,SECT)  Intermediate commodity inputs
 p_XC(-,s4) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
    -3.014753      -0.068801      -0.068638      -0.073895      -0.068922
    76.509003     748.979004       3.179000    8959.433590   15060.677700
    74.202446     748.463684       3.176818    8952.813480   15050.297900
    -2.306557      -0.515320      -0.002182      -6.620117     -10.379883

 p_XC(-,s5) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
    -3.044641      -0.099595      -0.099432      -0.104687      -0.099716
     0.000000*    849.520996       0.000000*   7559.000000   99637.156200
     0.000000*    848.674927       0.000000*   7551.086910   99537.804700
     0.000000*     -0.846069       0.000000*     -7.913086     -99.351563

p_XFL (LAB_FAC,SECT)  Factor inputs
 p_XFL(-,s1) results where '-' is in set 'LAB_FAC'.

    labor
    -0.038578
    75.111000
    75.082024
    -0.028976

 p_XFL(-,s2) results where '-' is in set 'LAB_FAC'.

    labor
    -0.042688
  3541.367920
  3539.856200
    -1.511719

 p_XFL(-,s3) results where '-' is in set 'LAB_FAC'.

    labor
    -0.001191
    15.223000
    15.222818
    -0.000181

 p_XFL(-,s4) results where '-' is in set 'LAB_FAC'.

    labor
    -0.068801
 21113.478500
 21098.953100
   -14.525391

 p_XFL(-,s5) results where '-' is in set 'LAB_FAC'.

    labor
    -0.099595
215591.422000
```

```
215376.703000
  -214.718750


p_XFKD (KD_FAC,SECT)  Factor inputs
 p_XFKD(-,s1) results where '-' is in set 'KD_FAC'.

   capital
   -20.060226
    10.638600
     8.504473
    -2.134128

 p_XFKD(-,s2) results where '-' is in set 'KD_FAC'.

   capital
    -0.042688
  1102.939940
  1102.469120
    -0.470825

 p_XFKD(-,s3) results where '-' is in set 'KD_FAC'.

   capital
    -0.001191
   125.987000
   125.985497
    -0.001503

 p_XFKD(-,s4) results where '-' is in set 'KD_FAC'.

   capital
    -0.068801
  8250.000000
  8244.324220
    -5.675781

 p_XFKD(-,s5) results where '-' is in set 'KD_FAC'.

   capital
    -0.099595
 93277.500000
 93184.601600
   -92.898438

p_XEXP (SECT)  Net Exports of commodities

     s1             s2             s3             s4             s5
    -2.947974       0.000000*      0.000163      -0.005097      -0.000121
    61.000000    3969.547120     400.360992   20293.494100   78871.039100
    59.201736    3969.547120     400.361633   20292.459000   78870.945300
    -1.798264       0.000000*      0.000641      -1.035156      -0.093750

p_ULF   Unemployed Labor Force

     1.842080
     3.900000
     3.971841
     0.071841
```

# APPENDIX B
# ADJUSTED DATA SET MODEL OUTPUT ONE

## Wage-flexible Scenario Output

```
SETS
 ----

  No Name          Size    Description
--------------------------------------
    1 SECT             5   Sectors
    2 FAC              3   Factors
    3 NUM_SECT         1    sector 1
    4 TWO_SECT         4   sectors 2-5
    5 NSEC_SECT        1   sector 2
    6 FORE_SECT        1   sector 3
    7 LAB_FAC          1   Labor Factor of Production, factor 1
    8 KD_FAC           2   Capital and Land Factors, factors 2&3
    9 LAND_FAC         1   Land Factor of Production, factor 3

 VARIABLES
 ---------
  No Name            Size     Arguments (if any) and Description
 ----------------------------------------------------------------
    1 p_Y                 1   Total household expenditure
    2 p_PC                5 (SECT)  Price of commodities
    3 p_PFL               1 (LAB_FAC)  Price of Labor
    4 p_PF               10 (KD_FAC,SECT)  Price of factors
    5 p_XCOM              5 (SECT)  Total demand for (or supply of) commod ...
    6 p_XFACL             1 (LAB_FAC)  Total demand for (or supply of) factors
    7 p_XFACKD            2 (KD_FAC)  Total demand for (or supply of) factors
    8 p_XH                5 (SECT)  Household consumption of commodities
    9 p_XC               25 (SECT,SECT)  Intermediate commodity inputs
   10 p_XFL               5 (LAB_FAC,SECT)  Intermediate factor inputs
   11 p_XFKD             10 (KD_FAC,SECT)  Intermediate factor inputs
   12 p_XEXP              5 (SECT)  Net Exports of commodities
   13 p_PW                5 (SECT)  World Price of Commodity
   14 p_TLF               1   Total Labor Force
   15 p_ULF               1   Unemployed Labor Force
   16 p_T                 1   Consumer Market Tax


   THE SHOCKS ARE AS FOLLOWS.

        p_PF
        1       SHOCK = 25.000000

        p_XFKD
        2       SHOCK = -25.000000

   END OF THE SHOCKS.

   ALL THE endogenous VARIABLES ARE cumulatively-retained endogenous.
```

```
  SHOCKS RELEVANT TO THE PRINT-OUT BELOW

       p_PF
       1       SHOCK = 25.000000

       p_XFKD
       2       SHOCK = -25.000000

  THE RESULTS BELOW ARE CUMULATIVE EFFECTS OF ALL SHOCKS ABOVE.

p_Y   Total household expenditure

    -0.039933
240336.562000
240240.594000
   -95.968750

p_PC (SECT)  Price of commodities

     s1             s2             s3             s4             s5
    13.819850       0.000000*     -0.003548       0.002576      -0.018910
     1.000000       1.000000       1.000000       1.000000       1.000000
     1.138198       1.000000       0.999965       1.000026       0.999811
     0.138198       0.000000*     -0.000035       0.000026      -0.000189

p_PFL (LAB_FAC)  Price of Labor

    labor
    -0.027917
     1.000000
     0.999721
    -0.000279

p_PF (KD_FAC,SECT)  Price of factors
 p_PF(-,s1) results where '-' is in set 'KD_FAC'.

    land
    33.226902
     1.000000
     1.332269
     0.332269

 p_PF(-,s2) results where '-' is in set 'KD_FAC'.

    land
    -0.012409
     1.000000
     0.999876
    -0.000124

 p_PF(-,s3) results where '-' is in set 'KD_FAC'.

    land
    -0.000346
     1.000000
     0.999997
    -0.000003

 p_PF(-,s4) results where '-' is in set 'KD_FAC'.
```

```
    land
    -0.020000
     1.000000
     0.999800
    -0.000200

p_PF (KD_FAC,SECT)  Price of factors
 p_PF(-,s5) results where '-' is in set 'KD_FAC'.

    land
    -0.028951
     1.000000
     0.999711
    -0.000289

p_XCOM (SECT)  Total demand for (or supply of) commodities

     s1             s2             s3             s4             s5
   -12.159436      -0.012409       0.003201      -0.022575      -0.010044
   188.559998    7694.735350     405.838989   54213.156200  416915.562000
   165.632172    7693.780270     405.851990   54200.918000  416873.688000
   -22.927826      -0.955078       0.013000     -12.238281     -41.875000

p_XFACKD (KD_FAC)  Total demand for (or supply of) factors

   capital         land
    -0.030328      -1.885813
102767.062000     879.490234
102735.898000     862.904663
   -31.164062     -16.585571

p_XH (SECT)  Household consumption of commodities

     s1             s2             s3             s4             s5
   -12.184669      -0.039933      -0.036387      -0.042507      -0.021027
     0.000000*   1126.350950       1.897000   17089.293000  222119.016000
     0.000000*   1125.901120       1.896310   17082.029300  222072.312000
     0.000000*     -0.449829      -0.000690      -7.263672     -46.703125

p_XC (SECT,SECT)  Intermediate commodity inputs
 p_XC(-,s1) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
   -12.159436      -0.011214      -0.007667      -0.013789       0.007697
    41.120998       7.355000       0.000000*      3.335000      43.889000
    36.120918       7.354175       0.000000*      3.334540      43.892380
    -5.000080      -0.000825       0.000000*     -0.000460       0.003380

 p_XC(-,s2) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
   -12.160485      -0.012409      -0.008862      -0.014984       0.006501
     9.930000     870.853027       0.087000     303.221008    1131.000000
     8.722464     870.744934       0.086992     303.175568    1131.073490
    -1.207537      -0.108093      -0.000008      -0.045441       0.073486

 p_XC(-,s3) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
   -12.149884      -0.000346       0.003201      -0.002922       0.018567
     0.000000*    122.128998       0.315000       5.378000      52.792999
     0.000000*    122.128578       0.315010       5.377842      52.802803
```

```
     0.000000*     -0.000420       0.000010      -0.000157       0.009804

p_XC (SECT,SECT)  Intermediate commodity inputs
 p_XC(-,s4) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
   -12.167155      -0.020000      -0.016453      -0.022575      -0.001091
    76.509003     748.979004       3.179000    8959.433590   15060.677700
    67.200035     748.829224       3.178477    8957.411130   15060.513700
    -9.308968      -0.149780      -0.000523      -2.022461      -0.164062

 p_XC(-,s5) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
   -12.175018      -0.028951      -0.025405      -0.031526      -0.010044
     0.000000*    849.520996       0.000000*   7559.000000   99637.156200
     0.000000*    849.275024       0.000000*   7556.616700   99627.148400
     0.000000*     -0.245972       0.000000*     -2.383301     -10.007812

p_XFL (LAB_FAC,SECT)  Intermediate factor inputs
 p_XFL(-,s1) results where '-' is in set 'LAB_FAC'.

    labor
     0.016708
    24.000000
    24.004009
     0.004009

 p_XFL(-,s2) results where '-' is in set 'LAB_FAC'.

    labor
     0.015512
  3541.367920
  3541.917240
     0.549316

 p_XFL(-,s3) results where '-' is in set 'LAB_FAC'.

    labor
     0.027579
    15.223000
    15.227198
     0.004198

 p_XFL(-,s4) results where '-' is in set 'LAB_FAC'.

    labor
     0.007920
 21113.478500
 21115.150400
     1.671875

 p_XFL(-,s5) results where '-' is in set 'LAB_FAC'.

    labor
    -0.001034
215591.422000
215589.188000
    -2.234375

p_XFKD (KD_FAC,SECT)  Intermediate factor inputs
 p_XFKD(-,s1) results where '-' is in set 'KD_FAC'.
```

```
   capital
   -20.038233
    10.638600
     8.506813
    -2.131787

 p_XFKD(-,s2) results where '-' is in set 'KD_FAC'.

   capital
    -0.012409
  1102.939940
  1102.803100
    -0.136841

 p_XFKD(-,s3) results where '-' is in set 'KD_FAC'.

   capital
    -0.000346
   125.987000
   125.986565
    -0.000435

 p_XFKD(-,s4) results where '-' is in set 'KD_FAC'.

   capital
    -0.020000
  8250.000000
  8248.349610
    -1.650391

 p_XFKD(-,s5) results where '-' is in set 'KD_FAC'.

   capital
    -0.028951
 93277.500000
 93250.492200
   -27.007812

p_XEXP (SECT)  Net Exports of commodities

     s1             s2             s3             s4             s5
   -12.149580      0.000000*      0.003548      -0.002575       0.018913
    61.000000   3969.547120     400.360992   20293.494100   78871.039100
    53.588757   3969.547120     400.375183   20292.970700   78885.953100
    -7.411243      0.000000*      0.014191      -0.523438      14.914062
```

## Wage-fixed Scenario Output

```
SETS
 ----

  No Name          Size    Description
-------------------------------------
    1 SECT            5   Sectors
    2 FAC             3   Factors
    3 NUM_SECT        1    sector 1
    4 TWO_SECT        4   sectors 2-5
    5 NSEC_SECT       1   sector 2
    6 FORE_SECT       1   sector 3
    7 LAB_FAC         1   Labor Factor of Production, factor 1
    8 KD_FAC          2   Capital and Land Factors, factors 2&3
    9 LAND_FAC        1   Land Factor of Production, factor 3
```

```
VARIABLES
---------
 No Name            Size     Arguments (if any) and Description
----------------------------------------------------------------
   1 p_Y                1   Total household expenditure
   2 p_PC               5 (SECT)  Price of commodities
   3 p_PFL              1 (LAB_FAC)  Price of Labor
   4 p_PF              10 (KD_FAC,SECT)  Price of factors
   5 p_XCOM             5 (SECT)  Total demand for (or supply of) commod ...
   6 p_XFACL            1 (LAB_FAC)  Total demand for (or supply of) factors
   7 p_XFACKD           2 (KD_FAC)  Total demand for (or supply of) factors
   8 p_XH               5 (SECT)  Household consumption of commodities
   9 p_XC              25 (SECT,SECT)  Intermediate commodity inputs
  10 p_XFL              5 (LAB_FAC,SECT)  Intermediate factor inputs
  11 p_XFKD            10 (KD_FAC,SECT)  Intermediate factor inputs
  12 p_XEXP             5 (SECT)  Net Exports of commodities
  13 p_PW               5 (SECT)  World Price of Commodity
  14 p_TLF              1   Total Labor Force
  15 p_ULF              1   Unemployed Labor Force
  16 p_T                1   Consumer Market Tax


  THE SHOCKS ARE AS FOLLOWS.


       p_PF
       1       SHOCK = 25.000000

       p_XFKD
       2       SHOCK = -25.000000

  END OF THE SHOCKS.

  THE RESULTS BELOW ARE CUMULATIVE EFFECTS OF ALL SHOCKS ABOVE.


p_Y   Total household expenditure

    -0.591877
240336.562000
238914.062000
 -1422.500000

p_PC (SECT)  Price of commodities

     s1             s2             s3             s4             s5
    13.762493      0.000000*     -0.000703       0.021981       0.000522
     1.000000      1.000000       1.000000       1.000000       1.000000
     1.137625      1.000000       0.999993       1.000220       1.000005
     0.137625      0.000000*     -0.000007       0.000220       0.000005

p_PF (KD_FAC,SECT)  Price of factors
 p_PF(-,s1) results where '-' is in set 'KD_FAC'.

    land
    33.021626
     1.000000
     1.330216
     0.330216
```

```
 p_PF(-,s2) results where '-' is in set 'KD_FAC'.

    land
    -0.183923
     1.000000
     0.998161
    -0.001839

 p_PF(-,s3) results where '-' is in set 'KD_FAC'.

    land
    -0.005132
     1.000000
     0.999949
    -0.000051

 p_PF(-,s4) results where '-' is in set 'KD_FAC'.

    land
    -0.296434
     1.000000
     0.997036
    -0.002964

 p_PF(-,s5) results where '-' is in set 'KD_FAC'.

    land
    -0.429110
     1.000000
     0.995709
    -0.004291


p_XCOM (SECT)  Total demand for (or supply of) commodities

     s1             s2             s3             s4             s5
   -12.251341      -0.183923      -0.004429      -0.318346      -0.429630
   188.559998    7694.735350     405.838989   54213.156200  416915.562000
   165.458862    7680.583010     405.821014   54040.570300  415124.375000
   -23.101135     -14.152344      -0.017975    -172.585938   -1791.187500

p_XFACL (LAB_FAC)  Total demand for (or supply of) factors

    labor
    -0.413785
240285.500000
239291.234000
  -994.265625

p_XFACKD (KD_FAC)  Total demand for (or supply of) factors

   capital         land
    -0.417583      -1.885812
102767.062000     879.490234
102337.922000     862.904724
  -429.140625     -16.585510

p_XH (SECT)  Household consumption of commodities

     s1             s2             s3             s4             s5
   -12.625557      -0.591877      -0.591178      -0.613724      -0.592396
     0.000000*   1126.350950       1.897000   17089.293000  222119.016000
     0.000000*   1119.684330       1.885785   16984.412100  220803.188000
```

```
    0.000000*     -6.666626      -0.011215    -104.880859   -1315.828120

p_XC (SECT,SECT)  Intermediate commodity inputs
 p_XC(-,s1) results where '-' is in set 'SECT'.

    s1             s2             s3             s4             s5
  -12.251341      -0.166210      -0.165508      -0.188150      -0.166731
   41.120998       7.355000       0.000000*      3.335000      43.889000
   36.083126       7.342775       0.000000*      3.328725      43.815823
   -5.037872      -0.012225       0.000000*     -0.006275      -0.073177

 p_XC(-,s2) results where '-' is in set 'SECT'.

    s1             s2             s3             s4             s5
  -12.266912      -0.183923      -0.183221      -0.205859      -0.184445
    9.930000     870.853027       0.087000     303.221008    1131.000000
    8.711896     869.251343       0.086841     302.596802    1128.913940
   -1.218104      -1.601685      -0.000159      -0.624207      -2.086060

 p_XC(-,s3) results where '-' is in set 'SECT'.

    s1             s2             s3             s4             s5
  -12.109735      -0.005132      -0.004429      -0.027107      -0.005654
    0.000000*    122.128998       0.315000       5.378000      52.792999
    0.000000*    122.122726       0.314986       5.376542      52.790012
    0.000000*     -0.006271      -0.000014      -0.001458      -0.002987


p_XC (SECT,SECT)  Intermediate commodity inputs
 p_XC(-,s4) results where '-' is in set 'SECT'.

    s1             s2             s3             s4             s5
  -12.365824      -0.296434      -0.295733      -0.318346      -0.296955
   76.509003     748.979004       3.179000    8959.433590   15060.677700
   67.048035     746.758789       3.169599    8930.912110   15015.954100
   -9.460968      -2.220215      -0.009401     -28.521484     -44.723633

 p_XC(-,s5) results where '-' is in set 'SECT'.

    s1             s2             s3             s4             s5
  -12.482463      -0.429110      -0.428409      -0.450992      -0.429630
    0.000000*    849.520996       0.000000*   7559.000000   99637.156200
    0.000000*    845.875610       0.000000*   7524.909670   99209.085900
    0.000000*     -3.645386       0.000000*    -34.090332    -428.070312

p_XFL (LAB_FAC,SECT)  Intermediate factor inputs
 p_XFL(-,s1) results where '-' is in set 'LAB_FAC'.

   labor
   -0.166210
   24.000000
   23.960110
   -0.039890

 p_XFL(-,s2) results where '-' is in set 'LAB_FAC'.

   labor
   -0.183923
 3541.367920
 3534.854490
   -6.513428

 p_XFL(-,s3) results where '-' is in set 'LAB_FAC'.
```

```
   labor
   -0.005132
   15.223000
   15.222219
   -0.000781

p_XFL(-,s4) results where '-' is in set 'LAB_FAC'.

   labor
   -0.296434
21113.478500
21050.890600
  -62.587891

p_XFL(-,s5) results where '-' is in set 'LAB_FAC'.

   labor
   -0.429110
215591.422000
214666.297000
  -925.125000


p_XFKD (KD_FAC,SECT)  Intermediate factor inputs
 p_XFKD(-,s1) results where '-' is in set 'KD_FAC'.

   capital
   -20.162603
    10.638600
     8.493582
    -2.145019

p_XFKD(-,s2) results where '-' is in set 'KD_FAC'.

   capital
    -0.183923
  1102.939940
  1100.911380
    -2.028564

p_XFKD(-,s3) results where '-' is in set 'KD_FAC'.

   capital
    -0.005132
   125.987000
   125.980537
    -0.006462

p_XFKD(-,s4) results where '-' is in set 'KD_FAC'.

   capital
    -0.296434
  8250.000000
  8225.543950
   -24.456055

p_XFKD(-,s5) results where '-' is in set 'KD_FAC'.

   capital
    -0.429110
 93277.500000
 92877.234400
```

-400.265625

p_XEXP (SECT)  Net Exports of commodities

| s1 | s2 | s3 | s4 | s5 |
|---|---|---|---|---|
| -12.105221 | 0.000000* | 0.000703 | -0.021976 | -0.000522 |
| 61.000000 | 3969.547120 | 400.360992 | 20293.494100 | 78871.039100 |
| 53.615814 | 3969.547120 | 400.363800 | 20289.035200 | 78870.625000 |
| -7.384186 | 0.000000* | 0.002808 | -4.458984 | -0.414062 |

p_ULF   Unemployed Labor Force

8.194535
3.900000
4.219587
0.319587

# APPENDIX C
# ADJUSTED DATA SET MODEL OUTPUT TWO

## Wage-flexible Scenario Output

```
SETS
 ----

  No Name          Size    Description
--------------------------------------
    1 SECT            5   Sectors
    2 FAC             3   Factors
    3 NUM_SECT        1    sector 1
    4 TWO_SECT        4   sectors 2-5
    5 NSEC_SECT       1   sector 2
    6 FORE_SECT       1   sector 3
    7 LAB_FAC         1   Labor Factor of Production, factor 1
    8 KD_FAC          2   Capital and Land Factors, factors 2&3
    9 LAND_FAC        1   Land Factor of Production, factor 3

 VARIABLES
 ---------
  No Name            Size     Arguments (if any) and Description
 ----------------------------------------------------------------
    1 p_Y                 1   Total household expenditure
    2 p_PC                5 (SECT)  Price of commodities
    3 p_PFL               1 (LAB_FAC)  Price of Labor
    4 p_PF               10 (KD_FAC,SECT)  Price of factors
    5 p_XCOM              5 (SECT)  Total demand for (or supply of) commod ...
    6 p_XFACL             1 (LAB_FAC)  Total demand for (or supply of) factors
    7 p_XFACKD            2 (KD_FAC)  Total demand for (or supply of) factors
    8 p_XH                5 (SECT)  Household consumption of commodities
    9 p_XC               25 (SECT,SECT)  Intermediate commodity inputs
   10 p_XFL               5 (LAB_FAC,SECT)  Intermediate factor inputs
   11 p_XFKD             10 (KD_FAC,SECT)  Intermediate factor inputs
   12 p_XEXP              5 (SECT)  Net Exports of commodities
   13 p_PW                5 (SECT)  World Price of Commodity
   14 p_TLF               1   Total Labor Force
   15 p_ULF               1   Unemployed Labor Force
   16 p_T                 1   Consumer Market Tax


   THE SHOCKS ARE AS FOLLOWS.

        p_PF
        1       SHOCK = 25.000000

        p_XFKD
        2       SHOCK = -25.000000

   END OF THE SHOCKS.

   THE RESULTS BELOW ARE CUMULATIVE EFFECTS OF ALL SHOCKS ABOVE.
```

```
p_Y   Total household expenditure

    -0.017755
240336.562000
240293.891000
   -42.671875

p_PC (SECT)  Price of commodities

     s1            s2            s3            s4            s5
     5.925771      0.000000*    -0.001577      0.001145     -0.008407
     1.000000      1.000000      1.000000      1.000000      1.000000
     1.059258      1.000000      0.999984      1.000011      0.999916
     0.059258      0.000000*    -0.000016      0.000011     -0.000084

p_PFL (LAB_FAC)  Price of Labor

    labor
    -0.012412
     1.000000
     0.999876
    -0.000124

p_PF (KD_FAC,SECT)  Price of factors
 p_PF(-,s1) results where '-' is in set 'KD_FAC'.

    land
    33.235149
     1.000000
     1.332351
     0.332351

 p_PF(-,s2) results where '-' is in set 'KD_FAC'.

    land
    -0.005517
     1.000000
     0.999945
    -0.000055

 p_PF(-,s3) results where '-' is in set 'KD_FAC'.

    land
    -0.000154
     1.000000
     0.999998
    -0.000002

 p_PF(-,s4) results where '-' is in set 'KD_FAC'.

    land
    -0.008892
     1.000000
     0.999911
    -0.000089

p_PF (KD_FAC,SECT)  Price of factors
 p_PF(-,s5) results where '-' is in set 'KD_FAC'.

    land
    -0.012873
     1.000000
```

```
     0.999871
    -0.000129
```

p_XCOM (SECT)  Total demand for (or supply of) commodities

| s1 | s2 | s3 | s4 | s5 |
|---|---|---|---|---|
| -5.600160 | -0.005517 | 0.001423 | -0.010037 | -0.004466 |
| 188.559998 | 7694.735350 | 405.838989 | 54213.156200 | 416915.562000 |
| 178.000336 | 7694.311040 | 405.844757 | 54207.714800 | 416896.938000 |
| -10.559662 | -0.424316 | 0.005768 | -5.441406 | -18.625000 |

p_XFACKD (KD_FAC)  Total demand for (or supply of) factors

| capital | land |
|---|---|
| -0.014767 | -0.724580 |
| 102767.062000 | 842.587219 |
| 102751.883000 | 836.481995 |
| -15.179688 | -6.105225 |

p_XH (SECT)  Household consumption of commodities

| s1 | s2 | s3 | s4 | s5 |
|---|---|---|---|---|
| -5.612217 | -0.017755 | -0.016178 | -0.018900 | -0.009349 |
| 0.000000* | 1126.350950 | 1.897000 | 17089.293000 | 222119.016000 |
| 0.000000* | 1126.151000 | 1.896693 | 17086.062500 | 222098.250000 |
| 0.000000* | -0.199951 | -0.000307 | -3.230469 | -20.765625 |

p_XC (SECT,SECT)  Intermediate commodity inputs
p_XC(-,s1) results where '-' is in set 'SECT'.

| s1 | s2 | s3 | s4 | s5 |
|---|---|---|---|---|
| -5.600160 | -0.004985 | -0.003408 | -0.006130 | 0.003422 |
| 41.120998 | 7.355000 | 0.000000* | 3.335000 | 43.889000 |
| 38.818157 | 7.354633 | 0.000000* | 3.334796 | 43.890503 |
| -2.302841 | -0.000367 | 0.000000* | -0.000204 | 0.001503 |

p_XC(-,s2) results where '-' is in set 'SECT'.

| s1 | s2 | s3 | s4 | s5 |
|---|---|---|---|---|
| -5.600662 | -0.005517 | -0.003940 | -0.006662 | 0.002890 |
| 9.930000 | 870.853027 | 0.087000 | 303.221008 | 1131.000000 |
| 9.373855 | 870.804993 | 0.086997 | 303.200806 | 1131.032710 |
| -0.556146 | -0.048035 | -0.000003 | -0.020203 | 0.032715 |

p_XC(-,s3) results where '-' is in set 'SECT'.

| s1 | s2 | s3 | s4 | s5 |
|---|---|---|---|---|
| -5.595598 | -0.000154 | 0.001423 | -0.001299 | 0.008253 |
| 0.000000* | 122.128998 | 0.315000 | 5.378000 | 52.792999 |
| 0.000000* | 122.128807 | 0.315004 | 5.377930 | 52.797356 |
| 0.000000* | -0.000191 | 0.000004 | -0.000070 | 0.004356 |

p_XC (SECT,SECT)  Intermediate commodity inputs
p_XC(-,s4) results where '-' is in set 'SECT'.

| s1 | s2 | s3 | s4 | s5 |
|---|---|---|---|---|
| -5.603850 | -0.008892 | -0.007315 | -0.010037 | -0.000486 |
| 76.509003 | 748.979004 | 3.179000 | 8959.433590 | 15060.677700 |
| 72.221550 | 748.912415 | 3.178767 | 8958.534180 | 15060.604500 |
| -4.287453 | -0.066589 | -0.000232 | -0.899414 | -0.073242 |

p_XC(-,s5) results where '-' is in set 'SECT'.

```
     s1             s2             s3             s4             s5
    -5.607608      -0.012873      -0.011296      -0.014018      -0.004466
     0.000000*    849.520996       0.000000*   7559.000000   99637.156200
     0.000000*    849.411621       0.000000*   7557.940430   99632.703100
     0.000000*     -0.109375       0.000000*     -1.059570      -4.453125

p_XFL (LAB_FAC,SECT)  Intermediate factor inputs
 p_XFL(-,s1) results where '-' is in set 'LAB_FAC'.

    labor
     0.007427
    60.900002
    60.904526
     0.004524

 p_XFL(-,s2) results where '-' is in set 'LAB_FAC'.

    labor
     0.006895
  3541.367920
  3541.612060
     0.244141

 p_XFL(-,s3) results where '-' is in set 'LAB_FAC'.

    labor
     0.012259
    15.223000
    15.224866
     0.001866

 p_XFL(-,s4) results where '-' is in set 'LAB_FAC'.

    labor
     0.003520
 21113.478500
 21114.220700
     0.742188

 p_XFL(-,s5) results where '-' is in set 'LAB_FAC'.

    labor
    -0.000461
215591.422000
215590.422000
    -1.000000


p_XFKD (KD_FAC,SECT)  Intermediate factor inputs
 p_XFKD(-,s1) results where '-' is in set 'KD_FAC'.

   capital
   -20.033243
    10.638600
     8.507343
    -2.131257

 p_XFKD(-,s2) results where '-' is in set 'KD_FAC'.

   capital
    -0.005517
  1102.939940
```

```
 1102.879150
   -0.060791

 p_XFKD(-,s3) results where '-' is in set 'KD_FAC'.

   capital
    -0.000154
   125.987000
   125.986809
    -0.000191

 p_XFKD(-,s4) results where '-' is in set 'KD_FAC'.

   capital
    -0.008892
  8250.000000
  8249.266600
    -0.733398

 p_XFKD(-,s5) results where '-' is in set 'KD_FAC'.

   capital
    -0.012873
 93277.500000
 93265.492200
   -12.007812

 p_XEXP (SECT)  Net Exports of commodities

      s1              s2              s3              s4              s5
    -5.595454       0.000000*       0.001577       -0.001145        0.008407
    61.000000    3969.547120     400.360992    20293.494100    78871.039100
    57.586773    3969.547120     400.367310    20293.261700    78877.671900
    -3.413227       0.000000*       0.006317       -0.232422        6.632812
```

## Wage-fixed Scenario Output

```
SETS
 ----

  No Name          Size    Description
--------------------------------------
    1 SECT             5   Sectors
    2 FAC              3   Factors
    3 NUM_SECT         1    sector 1
    4 TWO_SECT         4   sectors 2-5
    5 NSEC_SECT        1   sector 2
    6 FORE_SECT        1   sector 3
    7 LAB_FAC          1   Labor Factor of Production, factor 1
    8 KD_FAC           2   Capital and Land Factors, factors 2&3
    9 LAND_FAC         1   Land Factor of Production, factor 3

 VARIABLES
 ---------
  No Name            Size     Arguments (if any) and Description
 ----------------------------------------------------------------
    1 p_Y                 1   Total household expenditure
    2 p_PC                5 (SECT)  Price of commodities
    3 p_PFL               1 (LAB_FAC)  Price of Labor
    4 p_PF               10 (KD_FAC,SECT)  Price of factors
    5 p_XCOM              5 (SECT)  Total demand for (or supply of) commod ...
    6 p_XFACL             1 (LAB_FAC)  Total demand for (or supply of) factors
```

```
  7 p_XFACKD            2 (KD_FAC)  Total demand for (or supply of) factors
  8 p_XH                5 (SECT)  Household consumption of commodities
  9 p_XC               25 (SECT,SECT)  Intermediate commodity inputs
 10 p_XFL               5 (LAB_FAC,SECT)  Intermediate factor inputs
 11 p_XFKD             10 (KD_FAC,SECT)  Intermediate factor inputs
 12 p_XEXP              5 (SECT)  Net Exports of commodities
 13 p_PW                5 (SECT)  World Price of Commodity
 14 p_TLF               1   Total Labor Force
 15 p_ULF               1   Unemployed Labor Force
 16 p_T                 1   Consumer Market Tax


 THE SHOCKS ARE AS FOLLOWS.

      p_PF
      1       SHOCK = 25.000000

      p_XFKD
      2       SHOCK = -25.000000

 END OF THE SHOCKS.

 THE RESULTS BELOW ARE CUMULATIVE EFFECTS OF ALL SHOCKS ABOVE.

p_Y   Total household expenditure

    -0.264188
240336.562000
239701.625000
  -634.937500

p_PC (SECT)  Price of commodities

     s1             s2             s3             s4             s5
     5.923539       0.000000*     -0.000314       0.009806       0.000233
     1.000000       1.000000       1.000000       1.000000       1.000000
     1.059235       1.000000       0.999997       1.000098       1.000002
     0.059235       0.000000*     -0.000003       0.000098       0.000002

p_PF (KD_FAC,SECT)  Price of factors
 p_PF(-,s1) results where '-' is in set 'KD_FAC'.

    land
    33.143456
     1.000000
     1.331435
     0.331435

 p_PF(-,s2) results where '-' is in set 'KD_FAC'.

    land
    -0.082095
     1.000000
     0.999179
    -0.000821

 p_PF(-,s3) results where '-' is in set 'KD_FAC'.

    land
    -0.002291
     1.000000
     0.999977
    -0.000023
```

```
 p_PF(-,s4) results where '-' is in set 'KD_FAC'.

    land
    -0.132315
     1.000000
     0.998677
    -0.001323

 p_PF(-,s5) results where '-' is in set 'KD_FAC'.

    land
    -0.191536
     1.000000
     0.998085
    -0.001915

p_XCOM (SECT)  Total demand for (or supply of) commodities

     s1             s2             s3             s4             s5
    -5.663516      -0.082095      -0.001977      -0.142107      -0.191769
   188.559998    7694.735350     405.838989   54213.156200  416915.562000
   177.880875    7688.418460     405.830963   54136.117200  416116.062000
   -10.679123      -6.316895      -0.008026     -77.039063    -799.500000

p_XFACL (LAB_FAC)  Total demand for (or supply of) factors

    labor
    -0.184679
240322.391000
239878.562000
  -443.828125

p_XFACKD (KD_FAC)  Total demand for (or supply of) factors

   capital         land
    -0.187670      -0.724580
102767.062000     842.587219
102574.203000     836.481995
  -192.859375      -6.105225

p_XH (SECT)  Household consumption of commodities

     s1             s2             s3             s4             s5
    -5.842914      -0.264188      -0.263875      -0.273967      -0.264421
     0.000000*   1126.350950       1.897000   17089.293000  222119.016000
     0.000000*   1123.375240       1.891994   17042.474600  221531.688000
     0.000000*     -2.975708      -0.005006     -46.818359    -587.328125

p_XC (SECT,SECT)  Intermediate commodity inputs
 p_XC(-,s1) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
    -5.663516      -0.074191      -0.073877      -0.083988      -0.074424
    41.120998       7.355000       0.000000*      3.335000      43.889000
    38.792103       7.349543       0.000000*      3.332199      43.856335
    -2.328896      -0.005457       0.000000*     -0.002801      -0.032665

 p_XC(-,s2) results where '-' is in set 'SECT'.

     s1             s2             s3             s4             s5
    -5.670979      -0.082095      -0.081782      -0.091892      -0.082328
     9.930000     870.853027       0.087000     303.221008    1131.000000
```

```
     9.366872    870.138123      0.086929    302.942383   1130.068850
    -0.563128     -0.714905     -0.000071     -0.278625     -0.931152

 p_XC(-,s3) results where '-' is in set 'SECT'.

     s1            s2            s3            s4            s5
    -5.595626     -0.002291     -0.001977     -0.012095     -0.002524
     0.000000*   122.128998      0.315000      5.378000     52.792999
     0.000000*   122.126198      0.314994      5.377349     52.791668
     0.000000*    -0.002800     -0.000006     -0.000650     -0.001331

p_XC (SECT,SECT)  Intermediate commodity inputs
 p_XC(-,s4) results where '-' is in set 'SECT'.

     s1            s2            s3            s4            s5
    -5.718398     -0.132315     -0.132002     -0.142107     -0.132548
    76.509003    748.979004      3.179000   8959.433590  15060.677700
    72.133911    747.987976      3.174803   8946.701170  15040.714800
    -4.375092     -0.991028     -0.004196    -12.732422    -19.962891

 p_XC(-,s5) results where '-' is in set 'SECT'.

     s1            s2            s3            s4            s5
    -5.774314     -0.191536     -0.191223     -0.201322     -0.191769
     0.000000*   849.520996      0.000000*  7559.000000  99637.156200
     0.000000*   847.893860      0.000000*  7543.782230  99446.085900
     0.000000*    -1.627136      0.000000*   -15.217773   -191.070313

p_XFL (LAB_FAC,SECT)  Intermediate factor inputs
 p_XFL(-,s1) results where '-' is in set 'LAB_FAC'.

    labor
    -0.074191
    60.900002
    60.854820
    -0.045181

 p_XFL(-,s2) results where '-' is in set 'LAB_FAC'.

    labor
    -0.082095
  3541.367920
  3538.460690
    -2.907227

 p_XFL(-,s3) results where '-' is in set 'LAB_FAC'.

    labor
    -0.002291
    15.223000
    15.222651
    -0.000349

 p_XFL(-,s4) results where '-' is in set 'LAB_FAC'.

    labor
    -0.132315
 21113.478500
 21085.543000
   -27.935547

 p_XFL(-,s5) results where '-' is in set 'LAB_FAC'.
```

```
    labor
    -0.191536
215591.422000
215178.484000
  -412.937500


p_XFKD (KD_FAC,SECT)  Intermediate factor inputs
 p_XFKD(-,s1) results where '-' is in set 'KD_FAC'.

   capital
   -20.088785
    10.638600
     8.501434
    -2.137166

 p_XFKD(-,s2) results where '-' is in set 'KD_FAC'.

   capital
    -0.082095
  1102.939940
  1102.034420
    -0.905518

 p_XFKD(-,s3) results where '-' is in set 'KD_FAC'.

   capital
    -0.002291
   125.987000
   125.984116
    -0.002884

 p_XFKD(-,s4) results where '-' is in set 'KD_FAC'.

   capital
    -0.132315
  8250.000000
  8239.083980
   -10.916016

 p_XFKD(-,s5) results where '-' is in set 'KD_FAC'.

   capital
    -0.191536
 93277.500000
 93098.843800
  -178.656250

p_XEXP (SECT)  Net Exports of commodities

     s1             s2             s3             s4             s5
    -5.593462       0.000000*      0.000314      -0.009805      -0.000233
    61.000000    3969.547120     400.360992   20293.494100   78871.039100
    57.587986    3969.547120     400.362244   20291.503900   78870.851600
    -3.412014       0.000000*      0.001251      -1.990234      -0.187500


p_ULF   Unemployed Labor Force
      3.574265
     3.900000
     4.039396
     0.139396
```

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