AN ABSTRACT OF THE THESIS OF

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Abstract approved:

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Over the past several years, increases in the Supplemental Nutrition Assistance Program (SNAP) have coincided with the 2007-2008 recession and the higher rates of unemployment in the U.S. With SNAP being the largest program, in terms of spending embedded in the farm bill, it is likely to see some spending cuts. The question that this study poses is "What kind of economic impacts could SNAP spending cuts have on household welfare, the agricultural and food industries, and factor markets?" To assess these economic impacts a Computable General Equilibrium (CGE) Model using 2010 national level data is employed. A policy experiment is run where the SNAP program is eliminated creating a revenue neutral transfer of income from SNAP eligible households to ineligible households. The model finds changes in income and commodity output of the food and agriculture sectors and other sectors of the economy. There are almost no changes in primary factor markets and commodity prices. The experiment causes consumption patterns to change across household groups and creates a significant change in household welfare. The experiment shows that SNAP spending is miniscule in the United States' $15 trillion economy.

Key Words: Supplemental Nutrition Assistance Program (SNAP), Computable General Equilibrium (CGE) model, farm bill, food, agriculture

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Assessing the Economic Impacts of Food Assistance Policy

Using a Computable General Equilibrium Approach

By

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I understand that my project will become part of the permanent collection of Oregon State University, University Honors College. My signature below authorizes release of my project to any reader upon request.

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Tyler T. West, Author

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1. Introduction

1.1 The Supplemental Nutrition Assistance Program

The Supplemental Nutrition Assistance Program, known as SNAP, is the largest food assistance program offered by the federal government of the United States. The program is embedded in the farm bill which is passed by congress every five years. The program, formerly known as the food stamp program, changed its name to SNAP when the 2008 farm bill was passed. The food stamp program started in the 1930s and 1940s as a part of rural relief and commodity distribution policies, but became officially established in the 1964 Food Stamp Act. They first became a part of the farm bill when they were included in the 1977 Food and Agriculture Act. Since then food assistance programs have been an integral part of the farm bill (Dimitri, Effland, and Conklin, 2005).

Currently, U.S. food assistance programs represent the largest portion of farm bill spending, around 75% (Outlaw, Richardson, Close, 2011). As a result of the recent recession, the number of SNAP recipients peaked in late 2012 with about 47 million participants, and with expenditures reaching approximately $78 billion (USDA FNS, 2013).

To be eligible for SNAP benefits a household must meet three requirements. First, it must have a gross income at or below 130% of the poverty line. That works out to an annual income of about $24,100 for a household of three. Second, it must have a net

income after relevant deductions at or below the poverty line – about $18,500 per year. Third it must have assets of $2,000 or less. These criteria do not strictly apply for households with elderly or disabled members (CBPP, 2012). Most people who receive SNAP benefits live in households with very low income. In 2010 the average income of a benefit recipient household was $8,800 per year. The average benefit was $287 per household per month or $4.30 per person per day (FitzGerald et al. 2012).

The USDA Food Nutrition Services (2013) reported that in 2012, federal government spending on SNAP reached a high point of about $78 billion. Of that, 95% went directly to benefits and 5% went to administrative costs. The recession in 2007-2008 and the 2009 Recovery Act have drastically increased the number of households that qualify for SNAP, thus explaining the increase in the number of participants and spending levels in the last five years. SNAP spending as a percentage of GDP is expected to decease to pre-recession levels when the economy improves (CBPP, 2012). The Congressional Budget Office predicts that participation will continue to increase from 2012 to 2014, and then decline in the following years reflecting improving economic conditions and declining unemployment rates. By fiscal year 2022, it is projected that 34 million people will participate in SNAP each month and spending will be $73 billion (FitzGerald et al. 2012).

1.2 Guiding Inquiry

Over the past several years, increases in the SNAP program have coincided with the 2007-2008 recession and the higher rates of unemployment that the U.S. has experienced. In recent years the 2009 Recovery Act provided a funding boost to food

assistance programs, most notably SNAP. However, this funding trend appears to be short-lived based on the current budgetary climate (Paggi, 2012). In 2012, Congress failed to pass a new farm bill to replace the 2008 bill that expired on October 1, 2012. During farm bill discussions the Senate passed a bill that would cut a total of $23 billion of spending over ten years. This included cutting $4.5 billion from SNAP, $6.4 billion from conservation subsidies, and $5 billion from direct payments (Chite, 2012). The version of the bill passed by the House proposed cutting $35 billion over a 10 year period. The House version proposed to cut $16 billion out of SNAP, $6 billion out of conservation subsidies, and $14 billion from commodity programs (House Committee, 2012).

The current political atmosphere and the current budgetary conditions suggest there may be a change in the next farm bill. It is likely that some programs' spending will be cut and other programs will be eliminated from the bill. With SNAP being the largest program, in terms of spending, embedded in the farm bill, it is likely to see some spending cuts. The question that remains is "what kind of economic impacts could SNAP spending cuts have on household consumption, household welfare, the agricultural and food industries, and primary factor markets?" To assess these economic impacts a Computable General Equilibrium (CGE) Model will be used.

2. Background

2.1 Literature

The USDA brought insight into the issue of food assistance policy in 2002 when it published a study conducted by Hanson et al. (2002). The study was conducted for the USDA, and employed a CGE model. Their model was constructed for the sole purpose of evaluating food assistance programs. They ran two different policy scenarios: one where food assistance spending was decreased by $5 billion and one where food assistance disbursement was changed from vouchers to cash transfers. In the scenario where food assistance spending was decreased they modeled the decrease as a tax transfer from households that did not receive food assistance benefits to households that did receive benefits. Thus, taxes increased for benefit receiving households to model a $5 billion decrease in aggregate benefits, and taxes decreased for non-benefit receiving households to represent savings of $5 billion aggregately. In the second scenario, they cashed-out $18.5 billion in food assistance.

The study finds that a decrease in food assistance benefits of $5 billion led to a $1.3 billion decrease in farm and food processing production and a loss of 7,500 jobs. The $18.5 billion cash-out led to a $3.5 billion decrease in farm and food processing production and a loss of 18,500 jobs. The food stamp cut increased the number of "working poor." However, in aggregate the increased number of work hours did not fully compensate for the loss in food stamp income. The results indicate that a policy change that directly (adversely) affects the welfare of low-income recipients of food stamps may have significant impacts on other income groups (Hanson et al, 2002).

In another study, Hanson (2010) estimates a national input-output multiplier for SNAP spending stimulus using the Food Assistance National Input-Output Multiplier (FANIOM). The study primarily focuses on the stimulus effect of increasing SNAP benefits under the American Recovery and Reinvestment Act of 2009. The results indicate that $1 billion of SNAP spending results in $1.79 billion of economic activity, that is a $9 increase in economic activity for every $5 of SNAP benefits an individual receives. The results also indicate that the jobs impact ranges from 8,900 to 17,900 full-time-equivalent jobs.

These two studies suggest that SNAP plays a large role in economic stimulus and job creation and stability. They also indicate that the effects of SNAP policy changes are likely to go well beyond the benefit recipient households and potentially stretch to agricultural producers, food processors, food retailers, and even to non-eligible households.

A third study, Castner and Mabli (2010), explores the spending patterns of SNAP participants, non-participants, and ineligible non-participants. The study uses the 2005 Consumer Expenditure Survey to compare household spending in the categories of food prepared at home, food prepared away from home, apparel, housing, health, transportation, and other. It finds that SNAP participants spend 24% of their income on food, 22% at grocery stores and 2% at restaurants. SNAP eligible non-participants spend 22% of their income on food, 18% at grocery stores and 4% at restaurants. The study also finds that low income households spend 39-43% of their income on housing. Ineligible households spend less of their budget on food, housing, and apparel and more on health, transportation, and other goods when compared to SNAP eligible households. This

suggests that income level does play a role in households' budget shares, and that SNAP eligible households that receive benefits consume food in a different pattern than SNAP eligible non-participants.

Finally, Reimer and Hertel (2004) explore consumption behavior by estimating income elasticities for ten different commodity categories using Global Trade Analysis Project (GTAP) and International Comparison Program (ICP) data. They estimate the parameters of an implicit, directly additive demand system (AIDADS). AIDADS is a demand system that allows for non-linear consumption while maintaining the parameterization of preferences. Like the linear expenditure (LES) demand system, it is non-homothetic and contains a subsistence level parameter. However, it allows for variance of marginal budget shares unlike LES demand systems. The study finds that the two different data sets produce similar results. The results indicate that staple foods – grains and other crops – have a lower income elasticity and higher subsistence level than foods such as meats and dairy products and goods such as recreation, transportation, and education. The findings reinforce the notion that the budget share for food decreases as income increases.

These studies have implications when it comes to addressing food assistance policy in the United States. They suggest that food assistance plays a role in commodity markets and that spending provides economic stimulus. They also indicate that consumption patterns differ across income categories and income elasticities differ across commodities. Thus, changes in food assistance policy could have significant reverberations through the entire economy.

2.2 Objectives

To analyze the economic impacts of SNAP spending cuts, the question of "What would happen if funding for the Supplemental Nutrition Assistance Program is eliminated?" is posed. A computable general equilibrium (CGE) model is employed to model this policy scenario and analyze how the elimination of SNAP benefits will have reverberations throughout the economy. The elimination of the program is considered because it poses the most drastic policy change and will show all relevant impacts the clearest. Relevant impacts include:

1. The change in net income of low and high income households
2. The change in consumption of food, agricultural, and other commodities
3. The change in prices – which could indirectly affect agricultural producers and producers of other commodities
4. The change in household spending patterns
5. The change in welfare of low and high income households
6. The change in commodity markets – price and output of commodities
7. The change in primary factor markets – returns to primary factors and demand for primary factors by commodity sectors

3. Methodology

3.1 Computable General Equilibrium Model

A Computable General Equilibrium (CGE) Model is a multi-sector economic model based on general equilibrium theory that can be calibrated with data. The model brings together producers, consumers, and government and measures changes in variables specified in the model through circular flows of income. The model is based on a competitive market and allows for several different closure options. Parameters are specified within the model and output is measured in a percent change from the baseline calibration of the model.

A CGE model is based on the socioeconomic structure of a Social Accounting Matrix (SAM) with its multi-sectoral and multiclass – household – disaggregation of income flows. The model is operated by agents and their behavior and produces results based on market equilibriums. Agents are specified in the SAM and behavior is dictated by the actions of producers, traders, households and government (Sadoulet and Janvry, 1995). Lofgren et al. (2002) provide a more technical description and an example that is shown in Figure 1.The SAM is a matrix of accounts where each account has a row and a column. The row represents an income flow and the column represents an expenditure flow. Each of these flows must equate, thus the matrix captures all flows of income throughout the economy.

In a CGE model, producers are profit maximizers and therefore decide how much to produce, how much of each input to buy and which markets to sell their product in. On the demand side households maximize their utility and choose how much of each good to

consume based on income and prices. Other behavioral assumptions are not price responsive and are therefore set to fixed amounts or constantly varying amounts. These include government behaviors such as investment, consumption taxes, and distribution of factor income (Sadoulet and Janvry, 1995).

Market equilibriums are reached by agents balancing their own, endogenous, accounts and the model user specifying the closure of the model. The model operates on macroeconomic constraints: the balance of payments, savings-investment balance, government budget balance, and the aggregate supply of primary factors constraint. The first three constraints are relatively straightforward from a macroeconomic perspective, but the fourth leaves room for variation. The closure of primary factor markets is where the model allows for the user to make assumptions; different combinations of labor and capital closures make the model customizable to the user. Labor can be fixed or variable and mobile or immobile. Labor may be fully employed or unemployment may be possible. The same is true for capital, providing a variety of different factor market closure options (Sadoulet and Janvry, 1995).

Figure 1. The Basic SAM Structure Used in the CGE Model (Lofgren et al. 2002)

	Expenditures								
Receipts	**Activities**	**Commodities**	**Factors**	**Households**	**Enterprises**	**Government**	**Savings-Investment**	**Rest of the World (ROW)**	**Total**
Activities		Marketed outputs		Home-consumed outputs					Activity income (gross output)
Commodities	Intermediate inputs	Transaction costs		Private consumption		Government consumption	Investment	Exports	Demand
Factors	Value-added							Factor income from ROW	Factor income
Households			Factor income to households	Interhousehold transfers	Surplus to households	Transfers to households		Transfers to households from ROW	Household income
Enterprises			Factor income to enterprises			Transfers to enterprises		Transfers to enterprises from ROW	Enterprise income
Government	Producer taxes, value-added tax	Sales taxes, tariffs, export taxes	Factor income to government, factor taxes	Transfers to government, direct	Surplus to Government, direct enterprise taxes			Transfer to Government from ROW	Government income
Savings-Investment				Household savings	Enterprise savings	Government savings		Foreign savings	Savings
Rest of the World (ROW)		Imports	Factor income to ROW		Surplus to ROW	Government transfers to ROW			Foreign exchange outflow
Total	Activity	Supply expenditures	Factor expenditures	Household expenditures	Enterprise expenditures	Government expenditures	Investment	Foreign exchange inflow	

4. The Model

The model employed in this analysis is based on the International Food Policy Research Institute (IFPRI) CGE model described in Lofgren et al. (2002) and adapted to the Regional CGE model developed by Stodick, Holland, and Devadoss (2004). Their model was developed initially as the Washington State Regional CGE model which can be used to construct an applied, price flexible general equilibrium, multiple-commodity, single-region model. It contains 543 equations and endogenous variables to represent income flows through the entire economy. The model was designed as a regional model and therefore, accounts for import and exports to the foreign market and the domestic market outside the region of analysis (Stodick, Holland, and Devadoss, 2004). The regional model is a version of the CGE Model in GAMS developed by Hans Lofgren et al. in 2002. The CGE model incorporates producers, consumers, the government, and trade. It is set up to handle a wide range of aggregation of data; from world to national and to regional data (Lofgren et al. 2002).

The model employed in this analysis uses the regional framework developed by Stodick, Holland, and Devadoss (2004), but eliminates domestic trade making it suitable to analyze the entire United States. The model is solved using GAMS software's PATH solver. The model is initially solved using the base year's SAM to calibrate initial parameters. The original model code is available publicly on the author's website. A copy of the model code in GAMS is included in Appendix B.

The Regional CGE model has several features that make it suitable for examining the economy-wide economic impacts of potential SNAP policy scenarios. The features in the model are as follows:

- Households are divided into 9 categories based on income level
- Government activity includes state and federal government consumption, transfers to households, and taxes
- Industry sectors include the agricultural and food sectors which are aggregated to reflect SNAP rules
- Commodity markets establish goods prices endogenously while allowing for imperfect substitution between goods
- Households maximize utility subject to their income constraint and consume their optimal bundle of goods
- Model closure rules allow the impact of the policy change to flow towards households
- National level data for 2010 are used
- Exogenous parameters are set by the user to demonstrate characteristics of agents' behaviors in the model

These model specifications build a framework suitable for measuring the distributional effects of SNAP policy in an economy-wide setting.

4.1 Household Categories

The model breaks households into 9 different categories depending on their level of income. Households gain income from labor, capital, inter-household transfers, federal and state government transfers, and investment. Consequently they spend money on

commodities, inter-household transfers, federal and state government taxes, and investment. The SAM in the model is calibrated so each household's income and expenditure accounts are balance. The specification of the 9 household categories allows the user to specify which households are affected by a certain policy change based on income level. Table 1 presents each household category, their income bracket, and their aggregate income in the initial model – measured in hundreds of thousands of dollars.

Table 1. Household Income

Household Category		Labor	Capital	Services	Interhousehold Transfers	Federal Government	State Government	Investments	Total
1	$0-10K	13,106	35,656	7,818	1,423	84,709	127,071	108,610	378,392
2	$10-15K	8,668	41,297	11,377	1,639	137,750	67,856	6,785	275,372
3	$15-25K	17,857	224,462	43,193	6,027	324,248	105,098	24,946	745,831
4	$25-35K	17,806	403,523	71,757	9,236	302,289	73,805	38,229	916,646
5	$35-50K	23,023	820,145	139,409	16,451	361,343	56,527	68,089	1,484,986
6	$50-75K	27,506	1,693,401	233,072	25,985	306,098	67,238	107,550	2,460,850
7	$75-100K	13,273	1,180,122	201,634	19,641	164,284	30,637	81,293	1,690,885
8	$100-150K	12,199	1,274,444	300,465	20,891	128,343	21,230	86,467	1,844,040
9	$150K+	9,097	1,367,747	933,473	72,107	149,235	20,515	298,451	2,850,625

4.2 Government Activity

In the model, both the state and federal government have expenditures and revenue. Government entities are broken down into federal government defense, non-defense, and investment and state government education, non-education, and investment. In the model, government is categorized as an institution along with households and the rest of the world. Government revenue comes from collecting taxes – income and consumption – and from transfers from other institutions. Government expenditures include commodity purchases and transfers to other institutions. Purchases are measured in quantity terms while transfers as CPI-indexed (Lofgren et al. 2002). This setup allows for different aspects of government expenditure and revenue to be shocked to model a

policy change. In this analysis federal government transfers to households – non-defense spending – and federal household income are suitable for modeling changes in SNAP spending. Table 2 shows income tax rates and federal government transfers to households in the initial model.

Table 2. Federal Government Income Taxes and Federal Government Transfers

Household Category	Total Income	Income Tax	Income Tax Rate	Fed. Gov. Non-Defense (FGOVND) Transfers	FGOVND Transfers as a Percentage of Income
1	378,392	-1,489	-0.39%	84,709	22.39%
2	275,372	-6,807	-2.47%	137,750	50.02%
3	745,831	-4,843	-0.65%	324,248	43.47%
4	916,646	14,915	1.63%	302,289	32.98%
5	1,484,986	58,282	3.92%	361,343	24.33%
6	2,460,850	161,561	6.57%	306,098	12.44%
7	1,690,885	142,646	8.44%	164,284	9.72%
8	1,844,040	190,977	10.36%	128,343	6.96%
9	2,850,625	343,870	12.06%	149,235	5.24%
Total	12,647,627	899,112	7.11%	1,958,300	15.48%

* all values are in hundreds of thousands of dollars

4.3 Industry Sectors

The model employs national data from 509 different industries. These industries are aggregated into 11 different sectors in the model. Sectors were based on the normally suggested aggregation and then were manipulated to fit the SNAP policy context. This aggregation scheme allows for data to be captured about relevant industries when the model is shocked to represent a policy change. In this model changes in food and agricultural sectors due to the SNAP policy shock will be focused on. Table 3 outlines the sector aggregation in the model. See appendix A for a full list of industries included in each of the specified sectors.

Table 3. Commodity Sector Aggregation

No.	Name	Description
1	SNAPFD	Food that can be purchased under SNAP
2	SINPROD	Alcohol and cigarettes
3	FDRTL	Retail food and beverage purchases
4	AGR	Agriculture
5	NATRES	Nonfood agriculture and natural resource extraction
6	CONST	Construction
7	UTIL	Utilities
8	TRAD	Wholesale and retail trade
9	MIN	Mining and quarrying,
10	MAN	Manufacturing
11	SER	Services

4.4 Commodity Markets

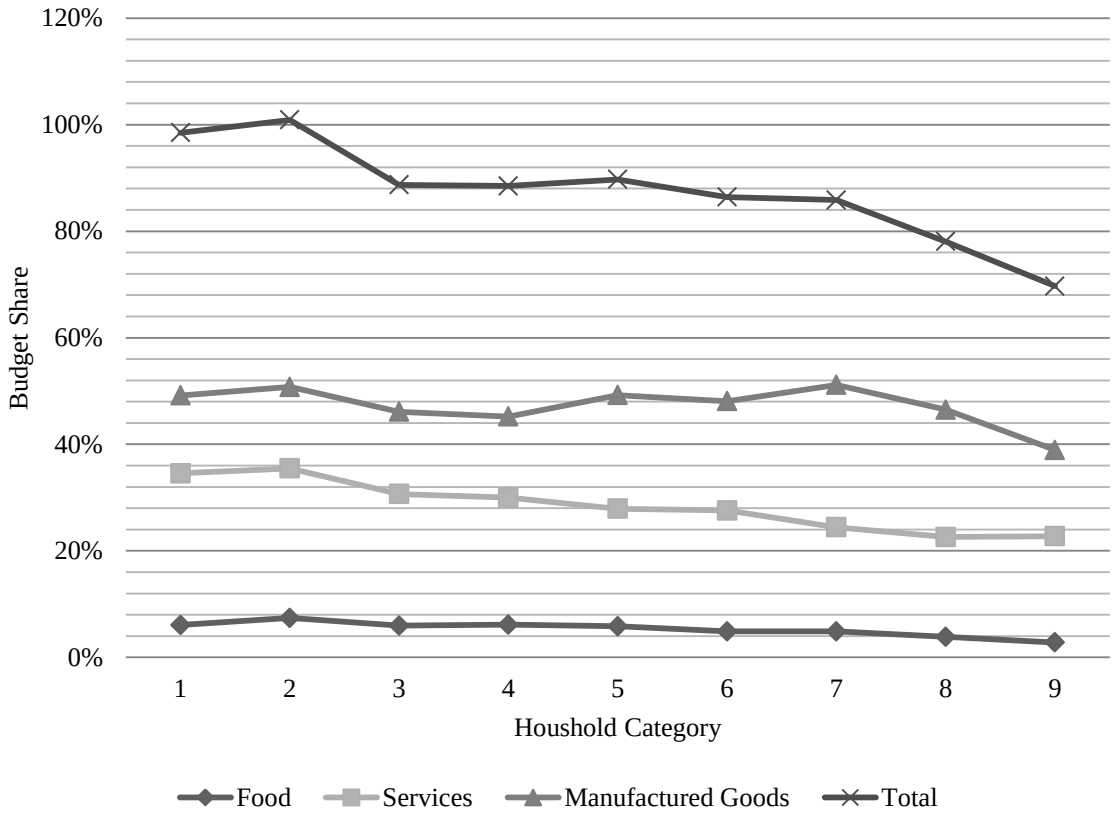
In the model commodity markets clear with endogenously determined goods prices. Goods are consumed domestically and traded on the free market. Aggregate output is generated from the output of different activities and is characterize by a constant elasticity of substitution (CES) production function. These outputs are imperfect substitutes because of differences in timing, quality, and distance from the market. Demand is constructed by minimizing costs to supply a given amount of aggregate output subject to the CES function. Aggregate output is then allocated between domestic and foreign sale and determined based on endogenous domestic prices and exogenous foreign or world prices. Domestic demand is for a composite commodity composed of imports and domestic output and is made up of demand for household consumption, government consumption, investment, intermediate inputs (activity consumption), and transaction inputs (Lofgren et al, 2002). Therefore changes in the demand of any entity – households, government, activities – effect prices and outputs in the commodity market. Prices,

output, and income then determine how much commodity is consumed by production activities as intermediate inputs and by government and households as final goods.

4.5 Household Consumption

Households demand goods based on maximizing a Stone-Geary utility function. This results in a set of linear expenditure system (LES) demand functions for all the commodity sectors in the model. Thus, every household category consumes a unique bundle of goods from the 11 sectors of the economy. Figure 2 shows the budget shares for all 9 household categories for total commodity consumption – all 11 commodity sectors – and the top 3 commodities consumed: manufactured goods, services, and food. Goods from the other sectors make up the remaining portion of each household's bundle of goods.

Figure 2. Household Budget Shares



4.6 Model Closure

The model allows for different combinations of closure rules for the user to specify. Closure rules are specified for labor markets, capital markets, foreign trade markets, savings and investment, and foreign savings (Stodick, Holland, and Devadoss, 2004). In this model, closure rules are specified to direct impacts of the policy experiment back to households. Closure rules are as follows: capital is mobile and supply is fixed, labor is mobile and unemployment is possible, savings is investment driven, and foreign savings is fixed and the exchange rate is variable. Therefore, there are fixed primary factor supplies, fixed investment and fixed foreign savings. This type of closure is ideal

for analyzing policy alternatives using a single-period model (Lofgren et al, 2002). A sensitivity analysis where closure rules are changed is located in Appendix C.

4.7 Model Data

Data used to calibrate the CGE model are obtained through the IMPLAN Group. IMPLAN data are in a standardized dataset of national, state, and county level data. The dataset includes industry input output data, household income data, households transfers data, consumer expenditure data, and government expenditure data. They are obtained from National Income and Product Accounts, Census of Population, BEA REIS datasets, BLS Consumer Expenditure Survey, and the Annual Survey of State and Local Government Expenditures (Vargas et al. 1999). In this CGE model the 2010 national level IMPLAN dataset is used to construct the SAM and parameterize the initial model.

4.8 Exogenous Model Parameters

The model contains 9 different exogenous parameters that are set by the user. These parameters are used to characterize different agents' behavior in the model. Parameters that involve trade include the elasticity of demand for world exports, elasticity of substitutions for production, the Armington trade function, and the transformation between domestic and foreign demand. The model also includes parameters that affect demand for commodities and factors: income elasticity of demand, consumption flexibility – the minimum subsistence level parameter known as the Frisch parameter – and demand elasticity for labor and capital. The parameters that affect consumption of goods – which are relevant to analyzing SNAP policy – are the income

elasticity of demand and consumption flexibility – subsistence level. Income elasticities are established for all 11 sectors of the economy and are based on the findings in Reimer and Hertel (2004). These values are displayed in Table 4. Consumption Flexibility is established to be -0.988864 and is also based on the findings of Reimer and Hertel (2004).

Table 4. Income Elasticity Specification

Sector	Income Elasticity
SNAPFD	0.53
SINPROD	0.65
FDRTL	0.65
AGR	0.57
NATRES	0.62
CONST	1.13
UTIL	1.16
TRAD	1.16
MIN	0.87
MAN	0.87
SER	1.19

5. Policy Scenario

5.1 Elimination of the Supplemental Nutrition Assistance Program

To analyze the question of "What would happen if funding for the Supplemental Nutrition Assistance Program is eliminated?" an experiment is run where the parameters of the CGE model are changed to represent an elimination of SNAP spending on benefits and administrative costs. The premise for this policy analysis relies on the fact that the federal government taxes households and uses a portion of its revenue to spend on SNAP benefits – transfers back to many eligible households in the form of food vouchers – and on costs to administer the program – primarily consumption of services and other various commodities.

The policy experiment assesses the impact of a redistribution of income from low-income households by a cut in food stamps to higher income households by a cut in income tax. SNAP eligible households are defined by the federal government generally as households at or below 130% of the poverty line, which is roughly households that earn $24,100 or less annually for a three person household (CBPP, 2012). Thus the experiment splits households into two groups: SNAP eligible households and SNAP ineligible households. Household categories 1-3 represent all households earning $25,000 or less and therefore form the SNAP eligible group. Consequently, household categories 4-9 represent all households earning more than $25,000 and form the non-eligible category. These two groups represent an aggregate of individual household categories that will be used to assess the effects of eliminating SNAP. The SNAP eligible household group will lose income via an increase in federal income tax that offsets all SNAP

benefits paid to that group. SNAP ineligible households will consequently receive a decrease in federal income tax to offset all benefits paid to SNAP eligible households and administrative costs spent by the federal government. This represents a revenue neutral policy change where SNAP spending is completely eliminated from the model.

To calculate these changes the 2010 SNAP spending data from the USDA and the constructed SAM using 2010 national level IMPLAN data were used. The USDA Food and Nutrition Service (2013) reports that in 2010 the federal government spent a total of $68.3 billion dollars on SNAP. Of which $64.7 billion went directly to benefits. The remaining sum was spent on administrative costs. Thus, an increase in federal income tax of SNAP eligible households of $64.7 billion – representing benefits only – and a decrease in federal income tax of non-eligible households of $68.3 billion – total SNAP spending – is used to model the elimination of SNAP.

In the model, income tax is measured by a parameter that specifies the rate of income tax that one household group pays to each specific government entity. The parameter is simply a measure of the tax paid divided by the total income for that household group. Thus, the change in tax rates when $63.7 billion is eliminated from SNAP eligible households and $68.3 billion is given back to SNAP ineligible households is used to scale the income tax parameter for each household group. A counterfactual scales income tax to represent this policy change and to shock the model. The model is re-evaluated after this income tax shock, and results are compared to the baseline. Model code in GAMS that includes the counterfactual is included in Appendix B.

6. Results

6.1 Model Output

The results represent the new equilibriums of the different variables that result from the policy experiment described in the policy scenario section above. The model output displays data on a number of variables; the initial calibration of the variable, the new calibration of the variable, the change in value, and the percent change in value are displayed in the results. For the purposes of this study, the percentage change and absolute change – in hundreds of thousands of dollars – in relevant variables is used to evaluate the economy-wide impacts of the policy experiment. The results are displayed and discussed in terms of the policy's impact on household consumption, food, agriculture, and other sectors of the economy, factor markets, and household welfare – measured in utility and equivalent variation.

6.2 Household Consumption

The experiment decreases household consumption of SNAP eligible households because it effectively decreases disposable income of those households. SNAP eligible households experience a collective decrease of $73.3 billion in disposable income. SNAP ineligible household experience a collective increase of $71.8 billion in consumption. This results in a collective decrease of only $1.4 billion in disposable income across all households. These changes in net – disposable – income are displayed in Table 5.

Table 5. Change in Household Net Income

Household	Base	Policy Experiment	Difference	Percent Change
1	372,696	364,002	-8,694	-2.3%
2	277,888	238,133	-39,756	-14.3%
3	661,652	636,826	-24,826	-3.8%
4	811,129	812,853	1,725	0.2%
5	1,332,307	1,337,193	4,886	0.4%
6	2,126,569	2,139,531	12,962	0.6%
7	1,451,923	1,463,071	11,149	0.8%
8	1,439,799	1,454,637	14,838	1.0%
9	1,986,971	2,013,257	26,286	1.3%

Due to changes in disposable income, there are changes in consumption across income categories and between SNAP eligible and ineligible households. Changes in consumption for SNAP eligible and ineligible household groups for all 11 sectors are displayed in Tables 6 and 7. The two household groups experience a change in consumption equal to their change in income.

The changes in consumption across sectors is due to differences in initial budget shares – displayed in Figure 2 – and differences in income elasticities of demand specified in Table 4. These create a situation where budget shares change as income changes, and thus, consumption patterns differ. The consumption changes for household category 2 and household category 9 – the two household categories that experience the largest opposite absolute changes in disposable income – clarify this concept more. These consumption patterns are displayed in Table 8 and Table 9, respectively.

Table 6. Change in SNAP Eligible Household Consumption

Sector	Base	Policy Experiment	Difference	Percent Change
SNAPFD	81,281	78,703	-2,578	-3.2%
SINPROD	9,599	9,231	-369	-3.8%
FDRTL	9	8	0	-4.3%
AGR	6,411	6,193	-219	-3.4%
NATRES	2,779	2,681	-97	-3.5%
CONST	14,931	13,942	-988	-6.6%
UTIL	28,463	26,479	-1,985	-7.0%
TRAD	42,055	39,555	-2,500	-5.9%
MIN	99	94	-5	-5.0%
MAN	669,579	636,320	-33,258	-5.0%
SER	457,031	425,755	-31,276	-6.8%

Table 7. Change in Ineligible Household Consumption

Sector	Base	Policy Experiment	Difference	Percent Change
SNAPFD	458,475	460,296	1,821	0.4%
SINPROD	79,273	79,704	431	0.5%
FDRTL	84	84	0	0.5%
AGR	36,602	36,758	156	0.4%
NATRES	20,696	20,804	107	0.5%
CONST	85,169	85,899	730	0.9%
UTIL	139,537	140,731	1,193	0.9%
TRAD	321,287	324,417	3,130	1.0%
MIN	809	815	6	0.7%
MAN	5,161,232	5,198,086	36,854	0.7%
SER	2,845,533	2,872,950	27,418	1.0%

Table 8. Household Category 2 Change in Consumption

Sector	Base	Policy Experiment	Difference	Percent Change
SNAPFD	18,857	17,388	-1,469	-7.8%
SINPROD	2,269	2,052	-217	-9.6%
FDRTL	2	2	0	-9.6%
AGR	1,484	1,360	-124	-8.4%
NATRES	571	519	-52	-9.1%
CONST	3,284	2,738	-545	-16.6%
UTIL	6,631	5,500	-1,131	-17.1%
TRAD	7,347	6,094	-1,253	-17.1%
MIN	21	18	-3	-12.8%
MAN	139,767	121,890	-17,877	-12.8%
SER	97,656	80,571	-17,084	-17.5%

Table 9. Household Category 9 Change in Consumption

Sector	Base	Policy Experiment	Difference	Percent Change
SNAPFD	73,482	74,010	528	0.7%
SINPROD	19,499	19,671	172	0.9%
FDRTL	13	14	0	0.9%
AGR	5,878	5,924	45	0.8%
NATRES	5,253	5,297	44	0.8%
CONST	14,628	14,852	224	1.5%
UTIL	21,673	22,013	341	1.6%
TRAD	88,087	89,472	1,385	1.6%
MIN	199	201	2	1.2%
MAN	1,110,051	1,123,141	13,089	1.2%
SER	648,207	658,662	10,455	1.6%

6.3 Food, Agriculture, and Other Sectors

As a result of the policy experiment the food and agricultural sectors experience a decrease in output and therefore, a decrease in overall value. Prices do not change; therefore, all changes in output are equivalent to changes in value. The total value of output decreases by $2.1 billion. The food, agriculture, and service sectors contract slightly while the manufacturing sector expands. Overall, food and agricultural production decrease by a total of $1.2 billion. Changes in value and output of all commodities sectors are displayed in Table 10.

Table 10. Change in Sector Value and Output

Sector	Base	Policy Experiment	Difference	Percent Change
SNAPFD	802,069	801,136	-933	-0.1%
SINPROD	25,883	25,898	16	0.1%
FDRTL	24,541	24,546	5	0.0%
AGR	289,261	288,980	-281	-0.1%
NATRES	82,375	82,348	-26	0.0%
CONST	1,444,224	1,443,870	-355	0.0%
UTIL	432,429	431,618	-811	-0.2%
TRAD	535,251	535,899	648	0.1%
MIN	378,825	378,773	-52	0.0%
MAN	16,086,698	16,090,220	3,521	0.0%
SER	5,714,392	5,710,592	-3,800	-0.1%

6.4 Factor Markets

The policy experiment does not have any outstanding effect on primary factor markets. The labor closure specifies that labor is mobile and unemployment is possible. The capital closure specifies that capital is mobile and supply is fixed. Since the policy experiment only shocks federal income tax and leads to a change in disposable income, only demand side impacts occur. Labor and capital markets are not directly affected by the shock. Thus, there is only a small amount of change that occurs in primary factor markets. Capital and labor are redistributed due to changes in sector output. There is a 0.00% change in the rental rate of capital, and since unemployment is possible, there is a 0.02% decrease in the wage rate and labor supply. These results and a sensitivity analysis are displayed in Appendix C.

6.5 Household Welfare

In the model, household welfare is measured by maximizing a Stone-Geary utility function (Lofgren et al, 2002). The policy experiment shows an aggregate decrease in household utility for the SNAP eligible households with the largest decrease being for household category 2. It also shows an increase in utility for the non-eligible households with the largest increase in utility being in the household category 9, the wealthiest household. Welfare changes more drastically for the poorest households and the wealthiest households effectively creating larger welfare inequality between wealthy and poor households. The changes in household utility from the policy experiment are shown in Figure 3.

Due to the nature of the welfare function, the results are ordinal, not cardinal. Thus, the magnitude of the welfare change cannot be measured. To measure the magnitude, equivalent variation is used. Equivalent variation represents a measure of the willingness to pay to avoid the policy for households that lose from the policy change and willingness to accept payment to forgo the policy change for households that gain from the policy change. Equivalent variation measures for each household are shown in Figure 4. The measures are fairly consistent with the changes in utility but also establish the magnitude of the welfare changes. It is confirmed that household 2 does experience a more drastic decrease in welfare than household category 1 and 3.

Figure 3. Change in Household Utility

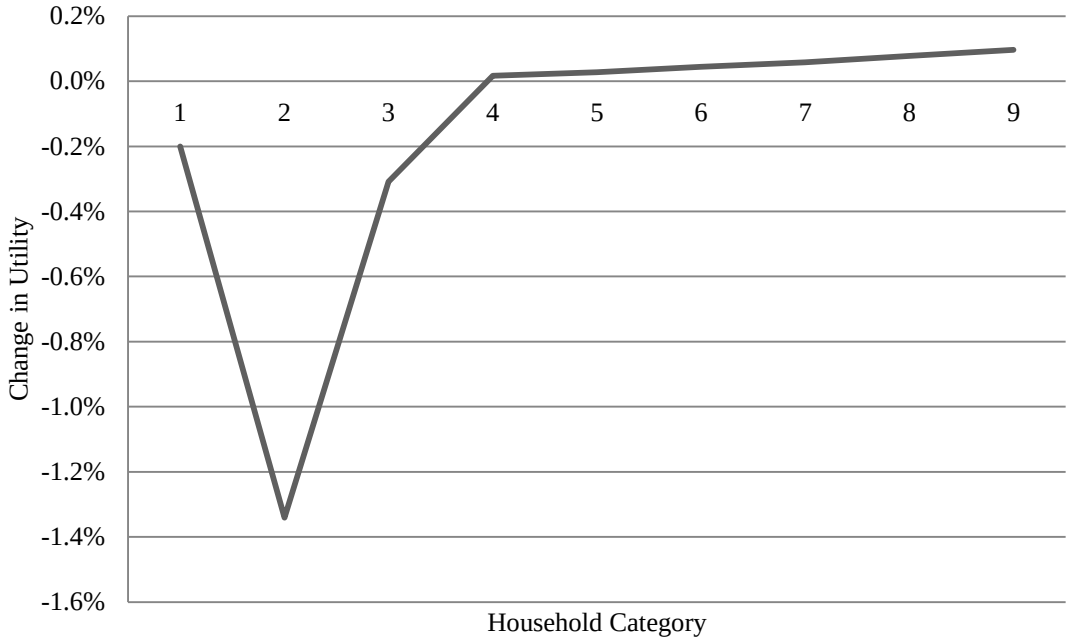
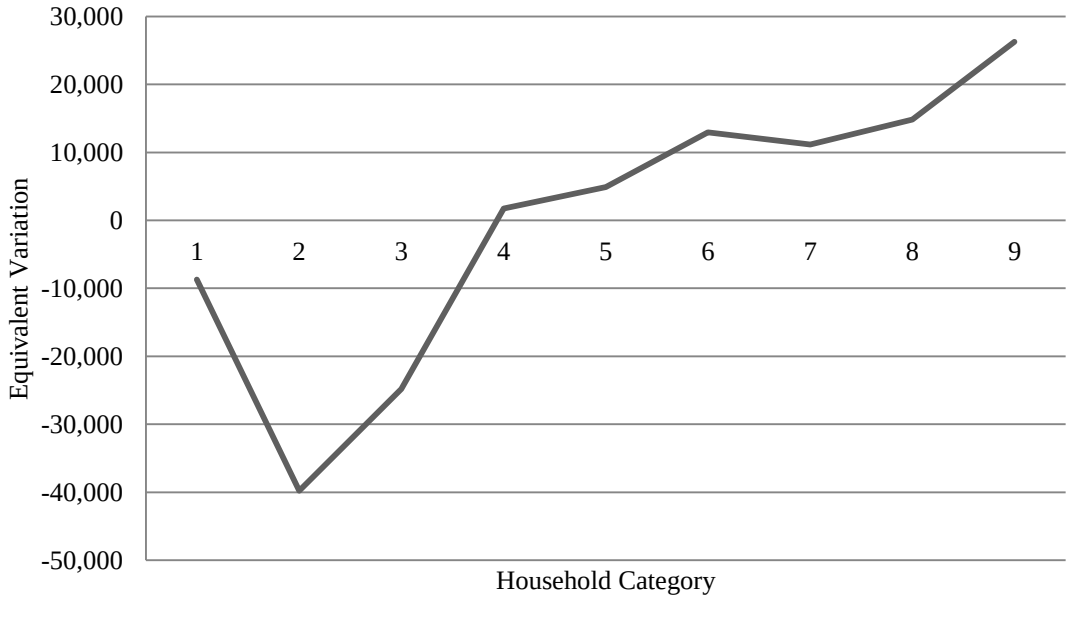


Figure 4. Change in Household Equivalent Variation



7. Discussion

The Computable General Equilibrium (CGE) framework used in the model allows the user to track results in a circular flow of income throughout the economy. The policy experiment increases income tax for SNAP eligible households and decreases income tax for ineligible households to model the elimination of SNAP. This directly results in a difference in net income which leads to changes in household consumption patterns. SNAP eligible households now consume significantly less while ineligible households consume more. The model employs a linear expenditure system (LES) demand system based on the Stone-Geary utility function. Due to the specification of the subsistence level of consumption and income elasticities of demand budget shares change when income changes thus changing consumption patterns. Therefore, changes in income lead to changes in consumption based on the established parameters in Table 4. This decreases consumption demand for SNAP eligible households shifting their demand functions in and increases consumption demand for ineligible households shifting their demand curves out. This causes changes in output throughout the commodity markets. Aggregately consumption remains relatively constant – only decreasing by $2.25 billion – but causes consumption patterns to change due to the redistribution of income.

Changes in the commodity markets cause shifts in the employment of primary factors which lead to slight changes in primary factor markets. The model closure specifies that capital is mobile and its supply is fixed, and labor is mobile and unemployment is possible. Therefore, capital is redistributed across industries but remains fully employed, while labor is redistributed across industries with the possibility of unemployment. Like the redistribution in the commodity market, these redistributions keep aggregate demand

relatively constant and therefore lead to negligible effects on the wage rate and the rental rate of capital. Since households supply primary factors, these changes slightly affect household income. Thus, the changes result in a full loop describing how income flows throughout the economy when the model is shocked to represent an elimination of the SNAP program.

The policy experiment models a revenue neutral change in income by cutting income – SNAP benefits – from SNAP eligible households and simultaneously increasing income to ineligible households. The experiment is not intended to change government revenue; it is aimed at redistributing income away from SNAP recipients. This creates several effects that fall almost entirely on the demand side of the economy, and ultimately end up being fairly insignificant on an economy-wide scale.

The policy experiment of eliminating SNAP results in economy-wide effects that impact household consumption, the food, agriculture, and other industries, primary factor markets, and household welfare. It finds that household consumption decreases for SNAP eligible households and increases for ineligible households. The food and agriculture industries experience contraction due to decreased output while other sectors, most notably the manufacturing sector, experience expansion. Overall, there is a total net industry contraction of $2.1 billion which is effectively negligible in the United States' $15 trillion economy. Factor markets are not significantly affected; however, the labor market does experience a very slight decrease in the wage rate by 2 hundredths of a percent. Labor and capital demand is shifted throughout commodity sectors but virtually no supply side change occurs. This can be attributed to the fact that all the changes in the policy experiment were demand side changes. Household welfare decreases for SNAP

eligible households due to their decrease in net income; conversely, household welfare increases for ineligible households. Changes in equivalent variation follow this same pattern with household 2 experiencing the most drastic change – decrease – in overall welfare. Overall, the elimination of SNAP decreases net income of SNAP eligible households by $73.3 billion aggregately and increases net income of ineligible households by $71.8 billion. This in more than the $64.7 billion decrease in SNAP benefits to eligible households and more than the $68.3 billion decrease in taxes paid by ineligible households.

Changes in disposable income are transferred directly to changes in consumption. However, as income changes, budget shares change due to the specification of income elasticities. This creates changes in consumption patterns. Tables 6 and 7 show these change for SNAP eligible households and ineligible households while Tables 8 and 9 show these changes specifically for household categories 2 and 9. Table 6 shows that as SNAP eligible households lose income they consume less of everything. Consumption decreases more drastically for goods such as services and manufactured goods and less drastically for food. Services and manufactured goods decrease by 6.8% and 5.0% respectively, while food decreases by only 3.2%. For ineligible households, consumption increases across all sectors. However, services and manufactured goods experience a larger increase than food does. Services and manufactured goods increases by 1.0% and 0.7% respectively, while food increases by 0.1%. For household category 2 the effect is the same but more drastic with services and manufactured goods decreasing by 17.5% and 12.8% respectively, and food decreasing by 7.8%. For household category 9,

consumption of services and manufactured goods increase by 1.6% and 1.2% respectively, and food consumption increases by 0.7%.

These changes can be explained by the income elasticity specifications made in Table 4. Food is relatively inelastic compared to services and manufactured goods. Therefore as income changes, food consumption does not change as much as service and manufactured goods consumption. These consumption patterns are consistent with the pattern described in Castner and Mabli (2010) and the changes exemplify the notion that food consumption is relatively inelastic compared to other goods.

The trends seen in the differences in budget shares between households and the difference in income elasticities between commodities drive the changes in the commodity markets. In sectors where the budget share declines as income rises, such as food and services, there is contraction. Since food is relatively income inelastic, when SNAP eligible households lose income they spend a little less on food, and when ineligible households gain income they spend almost none of that additional income on food. Therefore the food sector contracts as a result of the income transfer. Since manufactured goods are more income elastic, their consumption changes more drastically as income changes. As SNAP eligible households lose money they spend far less on manufactured goods, and as ineligible households gain money they spend more on manufactured goods relative to other goods such as food. These consumption pattern changes drive changes in sector output. Although output changes for commodities prices do not change, so the change in value is equal to the change in output. Therefore, it is hard to tell the affect that his policy experiment has on agricultural producers other than the fact that it reduces output.

From a welfare stand point, the model hits household category 2 the hardest. Household category 2 represents households with income between $10,000 and $15,000. It has the largest budget share for food and total commodity consumption – shown in Figure 2 – and also experiences the largest decrease in disposable income. Overall, the SNAP eligible group experiences a larger absolute change in welfare than the ineligible group due to the policy experiment.

The results of this policy experiment indicate that the elimination of the Supplemental Nutrition Assistance Program has economic implications at the national level that affect more than just the direct recipients of SNAP benefits. The effects lead to a decrease in income of 1.13 times the amount of the decrease in SNAP benefits for SNAP eligible households and an increase in income of 1.05 times the initial increase in income due to the tax break for ineligible households. Factor markets don't change significantly, but they do change enough to result in these changes in income. The agricultural and food industries experience contraction while manufacturing, which is not directly affected by SNAP benefits, experiences expansion. Welfare also changes more drastically for the poorest and the wealthiest households than it does for middle households. This effectively creates larger inequality between poor and wealthy households.

A sensitivity analysis indicates that there are no real differences in the model results due to differences in labor and capital closures. This is not surprising due to the fact that results indicate that changes only take place on the demand side of the economy. The different closures do produce very slight changes in factor markets, which cause negligible reverberations through the model and therefore do not affect other results.

Changes in returns to factors and factor income change by less than one tenth of a percent and do not impact the results in any other category. Therefore, the labor and capital closures considered in the sensitivity analysis do not contribute significantly to any of the policy experiment's outcomes. The full analysis can be found in Appendix C.

Although the model uses real data for the United States, it still is an imperfect theoretical framework that models the behavior of economic agents. This inevitably leads to many opportunities to improve the function and usefulness of the model and its results. One opportunity is to improve the specification of demand in the model. The model currently includes specifications for income elacticities across commodities and the specification of consumption flexibility – the subsistence level. Thus, the model could be improved if income elasticities and the subsistence level were updated, and if income elasticities were differed across income categories – differed between SNAP eligible households and ineligible households.

Reimer and Hertel (2004) estimate demand behavior for input-output models. They estimate the parameters of an implicit, directly additive demand system (AIDADS) using Global Trade Analysis Project (GTAP) and International Comparison Program data. Their estimates are used to calculate the income elasticities and subsistence level used in this study. These are good estimates, but they could be improved upon for this study's purposes. The estimates use an AIDADS demand system while this model uses a LES demand system, they rely on GTAP model and ICP data, whereas this model employs IMPLAN data based on U.S. Bureau of Economic Activity (BEA), census and other national data sources, and their commodity categories do not match perfectly with the ones in this model. Thus, it would be useful to estimate new income elasticities and a

new subsistence level parameter using a LES demand system, current – ideally 2010 – U.S. BEA and census data, and more consistent commodity categories.

Since the model compares the economic impacts of the policy change on two populations – SNAP eligible households and ineligible households – it would also be useful to estimate different income elasticities for these two groups. This would allow the model to distinguish between general consumptive behaviors of the two groups. Castner and Mable (2010) show a distinct difference in spending patterns between these two groups. It is probable that income elasticities differ as well. These changes would create a better specified demand system and would improve the function and validity of the policy experiment.

Finally, this study is limited in scope because it only shows the results of one policy experiment. It would be helpful for policy makers to be able to compare the economic impacts of several different policy scenarios. Thus, it would be useful to create additional SNAP policy scenarios for comparison.

8. Conclusion

The study assesses the economy-wide impacts of eliminating the Supplemental Nutrition Assistance Program (SNAP) by employing a computable general equilibrium (CGE) model. Results are analyzed as an absolute and percentage change from the baseline calibration of the CGE model. The impacts on household consumption, food, agriculture, and other sectors of the economy, factor markets, and household welfare are analyzed and discussed.

The model finds that the effects of eliminating SNAP affect the income, consumption, and welfare of all households and the food, agriculture, and other sectors of the economy. There is almost no change in primary factor markets. The policy experiment shows that eliminating SNAP ultimately leads to a decrease in net income of $73.3 billion aggregately for SNAP eligible households and an increase in net income of $71.8 billion aggregately for ineligible households. This is more than the $64.7 billion decrease in SNAP benefits to eligible households and more than the $68.3 billion decrease in taxes paid by ineligible households that is modeled in the policy experiment. Consumption patterns change due to changes in income and lead to a slight redistribution of sector output.

Overall the policy experiment models a revenue neutral income transfer to represent the elimination of the SNAP program. This transfer affects only disposable income and has little or no impact on commodity prices, commodity output, and factor markets. It does affect disposable income, spending patterns, and welfare of all households. It shows a fairly drastic decrease in income, consumption and welfare for SNAP eligible

households and a less drastic, but noticeable increase in income, consumption, and welfare of ineligible households.

It is important to remember that the $68.3 billion that was spent on SNAP in 2010 represents a miniscule amount of spending in the $15 trillion United States economy. Therefore, the impacts of eliminating the program are not far reaching. However, as shown in this study, eliminating the SNAP program does result in significant welfare losses for SNAP benefit recipients and increases inequality between poor and wealthy households.

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APPENDICES

Appendix A: Commodity aggregation

SNAPFD Food that can be purchased under SNAP

```
   48   ! Flour milling
   49   ! Rice milling
   50   ! Malt manufacturing
   51   ! Wet corn milling
   52   ! Soybean processing
   53   ! Other oilseed processing
   54   ! Fats and oils refining and blending
   55   ! Breakfast cereal manufacturing
   56   ! Sugar manufacturing
   57   ! Confectionery manufacturing from cacao beans
   58   ! Confectionery manufacturing from purchased chocola
   59   ! Nonchocolate confectionery manufacturing
   60   ! Frozen food manufacturing
   61   ! Fruit and vegetable canning and drying
   62   ! Fluid milk manufacturing
   63   ! Creamery butter manufacturing
   64   ! Cheese manufacturing
   65   ! Dry condensed and evaporated dairy products
   66   ! Ice cream and frozen dessert manufacturing
   67   ! Animal  except poultry  slaughtering
   68   ! Meat processed from carcasses
   69   ! Rendering and meat byproduct processing
   70   ! Poultry processing
   71   ! Seafood product preparation and packaging
   72   ! Frozen cakes and other pastries manufacturing
   73   ! Bread and bakery product  except frozen  manufactu
   74   ! Cookie and cracker manufacturing
   75   ! Mixes and dough made from purchased flour
   76   ! Dry pasta manufacturing
   77   ! Tortilla manufacturing
   78   ! Roasted nuts and peanut butter manufacturing
   79   ! Other snack food manufacturing
   80   ! Coffee and tea manufacturing
   81   ! Flavoring syrup and concentrate manufacturing
   82   ! Mayonnaise  dressing  and sauce manufacturing
   83   ! Spice and extract manufacturing
   84   ! All other food manufacturing
   85   ! Soft drink and ice manufacturing
```

SINPROD Alcohol and cigarettes

```
   86   ! Breweries
   87   ! Wineries
   88   ! Distilleries
   89   ! Tobacco stemming and redrying
   90   ! Cigarette manufacturing
   91   ! Other tobacco product manufacturing
```

FDRTL Food and beverage stores

```
  405   ! Food and beverage stores
```

AGR Agriculture

1 ! Oilseed farming
2 ! Grain farming
3 ! Vegetable and melon farming
4 ! Tree nut farming
5 ! Fruit farming
9 ! Sugarcane and sugar beet farming
10 ! All other crop farming
11 ! Cattle ranching and farming
12 ! Poultry and egg production
13 ! Animal production except cattle and poultry and e

NATRES Nonfood agriculture and natural resource extraction

6 ! Greenhouse and nursery production
7 ! Tobacco farming
8 ! Cotton farming
14 ! Logging
15 ! Forest nurseries forest products and timber trac
16 ! Fishing
17 ! Hunting and trapping
18 ! Agriculture and forestry support activities

CONST Construction

33 ! New residential 1-unit structures nonfarm
34 ! New multifamily housing structures nonfarm
35 ! New residential additions and alterations nonfarm
36 ! New farm housing units and additions and alteratio
37 ! Manufacturing and industrial buildings
38 ! Commercial and institutional buildings
39 ! Highway street bridge and tunnel construction
40 ! Water sewer and pipeline construction
41 ! Other new construction
42 ! Maintenance and repair of farm and nonfarm residen
43 ! Maintenance and repair of nonresidential buildings
44 ! Maintenance and repair of highways streets bridg
45 ! Other maintenance and repair construction

MIN Mining

19 ! Oil and gas extraction
20 ! Coal mining
21 ! Iron ore mining
22 ! Copper nickel lead and zinc mining
23 ! Gold silver and other metal ore mining
24 ! Stone mining and quarrying
25 ! Sand gravel clay and refractory mining
26 ! Other nonmetallic mineral mining
27 ! Drilling oil and gas wells
28 ! Support activities for oil and gas operations
29 ! Support activities for other mining

UTIL Utilities

```
  30   ! Power generation and supply
  31   ! Natural gas distribution
  32   ! Water  sewage and other systems
 495   ! Federal electric utilities
 498   ! State and local government electric utilities
```

TRAD Wholesale and retail trade

```
 390   ! Wholesale trade
 400   ! Warehousing and storage
 401   ! Motor vehicle and parts dealers
 402   ! Furniture and home furnishings stores
 403   ! Electronics and appliance stores
 404   ! Building material and garden supply stores
 406   ! Health and personal care stores
 407   ! Gasoline stations
 408   ! Clothing and clothing accessories stores
 409   ! Sporting goods  hobby  book and music stores
 410   ! General merchandise stores
 411   ! Miscellaneous store retailers
 412   ! Nonstore retailers
```

MAN Manufactures

```
  46   ! Dog and cat food manufacturing
  47   ! Other animal food manufacturing
  92   ! Fiber  yarn  and thread mills
  93   ! Broadwoven fabric mills
  94   ! Narrow fabric mills and schiffli embroidery
  95   ! Nonwoven fabric mills
  96   ! Knit fabric mills
  97   ! Textile and fabric finishing mills
  98   ! Fabric coating mills
  99   ! Carpet and rug mills
 100   ! Curtain and linen mills
 101   ! Textile bag and canvas mills
 102   ! Tire cord and tire fabric mills
 103   ! Other miscellaneous textile product mills
 104   ! Sheer hosiery mills
 105   ! Other hosiery and sock mills
 106   ! Other apparel knitting mills
 107   ! Cut and sew apparel manufacturing
 108   ! Accessories and other apparel manufacturing
 109   ! Leather and hide tanning and finishing
 110   ! Footwear manufacturing
 111   ! Other leather product manufacturing
 112   ! Sawmills
 113   ! Wood preservation
 114   ! Reconstituted wood product manufacturing
 115   ! Veneer and plywood manufacturing
 116   ! Engineered wood member and truss manufacturing
 117   ! Wood windows and door manufacturing
 118   ! Cut stock  resawing lumber  and planing
 119   ! Other millwork  including flooring
 120   ! Wood container and pallet manufacturing
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```
121   ! Manufactured home  mobile home  manufacturing
122   ! Prefabricated wood building manufacturing
123   ! Miscellaneous wood product manufacturing
124   ! Pulp mills
125   ! Paper and paperboard mills
126   ! Paperboard container manufacturing
127   ! Flexible packaging foil manufacturing
128   ! Surface-coated paperboard manufactuing
129   ! Coated and laminated paper and packaging materials
130   ! Coated and uncoated paper bag manufacturing
131   ! Die-cut paper office supplies manufacturing
132   ! Envelope manufacturing
133   ! Stationery and related product manufacturing
134   ! Sanitary paper product manufacturing
135   ! All other converted paper product manufacturing
136   ! Manifold business forms printing
137   ! Books printing
138   ! Blankbook and looseleaf binder manufacturing
139   ! Commercial printing
140   ! Tradebinding and related work
141   ! Prepress services
142   ! Petroleum refineries
143   ! Asphalt paving mixture and block manufacturing
144   ! Asphalt shingle and coating materials manufacturin
145   ! Petroleum lubricating oil and grease manufacturing
146   ! All other petroleum and coal products manufacturin
147   ! Petrochemical manufacturing
148   ! Industrial gas manufacturing
149   ! Synthetic dye and pigment manufacturing
150   ! Other basic inorganic chemical manufacturing
151   ! Other basic organic chemical manufacturing
152   ! Plastics material and resin manufacturing
153   ! Synthetic rubber manufacturing
154   ! Cellulosic organic fiber manufacturing
155   ! Noncellulosic organic fiber manufacturing
156   ! Nitrogenous fertilizer manufacturing
157   ! Phosphatic fertilizer manufacturing
158   ! Fertilizer  mixing only  manufacturing
159   ! Pesticide and other agricultural chemical manufact
160   ! Pharmaceutical and medicine manufacturing
161   ! Paint and coating manufacturing
162   ! Adhesive manufacturing
163   ! Soap and other detergent manufacturing
164   ! Polish and other sanitation good manufacturing
165   ! Surface active agent manufacturing
166   ! Toilet preparation manufacturing
167   ! Printing ink manufacturing
168   ! Explosives manufacturing
169   ! Custom compounding of purchased resins
170   ! Photographic film and chemical manufacturing
171   ! Other miscellaneous chemical product manufacturing
172   ! Plastics packaging materials  film and sheet
173   ! Plastics pipe  fittings  and profile shapes
174   ! Laminated plastics plate  sheet  and shapes
175   ! Plastics bottle manufacturing
176   ! Resilient floor covering manufacturing
177   ! Plastics plumbing fixtures and all other plastics
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178   ! Foam product manufacturing
179   ! Tire manufacturing
180   ! Rubber and plastics hose and belting manufacturing
181   ! Other rubber product manufacturing
182   ! Vitreous china plumbing fixture manufacturing
183   ! Vitreous china and earthenware articles manufactur
184   ! Porcelain electrical supply manufacturing
185   ! Brick and structural clay tile manufacturing
186   ! Ceramic wall and floor tile manufacturing
187   ! Nonclay refractory manufacturing
188   ! Clay refractory and other structural clay products
189   ! Glass container manufacturing
190   ! Glass and glass products  except glass containers
191   ! Cement manufacturing
192   ! Ready-mix concrete manufacturing
193   ! Concrete block and brick manufacturing
194   ! Concrete pipe manufacturing
195   ! Other concrete product manufacturing
196   ! Lime manufacturing
197   ! Gypsum product manufacturing
198   ! Abrasive product manufacturing
199   ! Cut stone and stone product manufacturing
200   ! Ground or treated minerals and earths manufacturin
201   ! Mineral wool manufacturing
202   ! Miscellaneous nonmetallic mineral products
203   ! Iron and steel mills
204   ! Ferroalloy and related product manufacturing
205   ! Iron  steel pipe and tube from purchased steel
206   ! Rolled steel shape manufacturing
207   ! Steel wire drawing
208   ! Alumina refining
209   ! Primary aluminum production
210   ! Secondary smelting and alloying of aluminum
211   ! Aluminum sheet  plate  and foil manufacturing
212   ! Aluminum extruded product manufacturing
213   ! Other aluminum rolling and drawing
214   ! Primary smelting and refining of copper
215   ! Primary nonferrous metal  except copper and alumin
216   ! Copper rolling  drawing  and extruding
217   ! Copper wire  except mechanical  drawing
218   ! Secondary processing of copper
219   ! Nonferrous metal  except copper and aluminum  shap
220   ! Secondary processing of other nonferrous
221   ! Ferrous metal foundaries
222   ! Aluminum foundries
223   ! Nonferrous foundries  except aluminum
224   ! Iron and steel forging
225   ! Nonferrous forging
226   ! Custom roll forming
227   ! All other forging and stamping
228   ! Cutlery and flatware  except precious  manufacturi
229   ! Hand and edge tool manufacturing
230   ! Saw blade and handsaw manufacturing
231   ! Kitchen utensil  pot  and pan manufacturing
232   ! Prefabricated metal buildings and components
233   ! Fabricated structural metal manufacturing
234   ! Plate work manufacturing
```

```
235   ! Metal window and door manufacturing
236   ! Sheet metal work manufacturing
237   ! Ornamental and architectural metal work manufactur
238   ! Power boiler and heat exchanger manufacturing
239   ! Metal tank  heavy gauge  manufacturing
240   ! Metal can  box  and other container manufacturing
241   ! Hardware manufacturing
242   ! Spring and wire product manufacturing
243   ! Machine shops
244   ! Turned product and screw  nut  and bolt manufactur
245   ! Metal heat treating
246   ! Metal coating and nonprecious engraving
247   ! Electroplating  anodizing  and coloring metal
248   ! Metal valve manufacturing
249   ! Ball and roller bearing manufacturing
250   ! Small arms manufacturing
251   ! Other ordnance and accessories manufacturing
252   ! Fabricated pipe and pipe fitting manufacturing
253   ! Industrial pattern manufacturing
254   ! Enameled iron and metal sanitary ware manufacturin
255   ! Miscellaneous fabricated metal product manufacturi
256   ! Ammunition manufacturing
257   ! Farm machinery and equipment manufacturing
258   ! Lawn and garden equipment manufacturing
259   ! Construction machinery manufacturing
260   ! Mining machinery and equipment manufacturing
261   ! Oil and gas field machinery and equipment
262   ! Sawmill and woodworking machinery
263   ! Plastics and rubber industry machinery
264   ! Paper industry machinery manufacturing
265   ! Textile machinery manufacturing
266   ! Printing machinery and equipment manufacturing
267   ! Food product machinery manufacturing
268   ! Semiconductor machinery manufacturing
269   ! All other industrial machinery manufacturing
270   ! Office machinery manufacturing
271   ! Optical instrument and lens manufacturing
272   ! Photographic and photocopying equipment manufactur
273   ! Other commercial and service industry machinery ma
274   ! Automatic vending  commercial laundry and dryclean
275   ! Air purification equipment manufacturing
276   ! Industrial and commercial fan and blower manufactu
277   ! Heating equipment  except warm air furnaces
278   ! AC  refrigeration  and forced air heating
279   ! Industrial mold manufacturing
280   ! Metal cutting machine tool manufacturing
281   ! Metal forming machine tool manufacturing
282   ! Special tool  die  jig  and fixture manufacturing
283   ! Cutting tool and machine tool accessory manufactur
284   ! Rolling mill and other metalworking machinery
285   ! Turbine and turbine generator set units manufactur
286   ! Other engine equipment manufacturing
287   ! Speed changers and mechanical power transmission e
288   ! Pump and pumping equipment manufacturing
289   ! Air and gas compressor manufacturing
290   ! Measuring and dispensing pump manufacturing
291   ! Elevator and moving stairway manufacturing
```

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292   ! Conveyor and conveying equipment manufacturing
293   ! Overhead cranes  hoists  and monorail systems
294   ! Industrial truck  trailer  and stacker manufacturi
295   ! Power-driven handtool manufacturing
296   ! Welding and soldering equipment manufacturing
297   ! Packaging machinery manufacturing
298   ! Industrial process furnace and oven manufacturing
299   ! Fluid power cylinder and actuator manufacturing
300   ! Fluid power pump and motor manufacturing
301   ! Scales  balances  and miscellaneous general purpos
302   ! Electronic computer manufacturing
303   ! Computer storage device manufacturing
304   ! Computer terminal manufacturing
305   ! Other computer peripheral equipment manufacturing
306   ! Telephone apparatus manufacturing
307   ! Broadcast and wireless communications equipment
308   ! Other communications equipment manufacturing
309   ! Audio and video equipment manufacturing
310   ! Electron tube manufacturing
311   ! Semiconductors and related device manufacturing
312   ! All other electronic component manufacturing
313   ! Electromedical apparatus manufacturing
314   ! Search  detection  and navigation instruments
315   ! Automatic environmental control manufacturing
316   ! Industrial process variable instruments
317   ! Totalizing fluid meters and counting devices
318   ! Electricity and signal testing instruments
319   ! Analytical laboratory instrument manufacturing
320   ! Irradiation apparatus manufacturing
321   ! Watch  clock  and other measuring and controlling
322   ! Software reproducing
323   ! Audio and video media reproduction
324   ! Magnetic and optical recording media manufacturing
325   ! Electric lamp bulb and part manufacturing
326   ! Lighting fixture manufacturing
327   ! Electric housewares and household fan manufacturin
328   ! Household vacuum cleaner manufacturing
329   ! Household cooking appliance manufacturing
330   ! Household refrigerator and home freezer manufactur
331   ! Household laundry equipment manufacturing
332   ! Other major household appliance manufacturing
333   ! Electric power and specialty transformer manufactu
334   ! Motor and generator manufacturing
335   ! Switchgear and switchboard apparatus manufacturing
336   ! Relay and industrial control manufacturing
337   ! Storage battery manufacturing
338   ! Primary battery manufacturing
339   ! Fiber optic cable manufacturing
340   ! Other communication and energy wire manufacturing
341   ! Wiring device manufacturing
342   ! Carbon and graphite product manufacturing
343   ! Miscellaneous electrical equipment manufacturing
344   ! Automobile and light truck manufacturing
345   ! Heavy duty truck manufacturing
346   ! Motor vehicle body manufacturing
347   ! Truck trailer manufacturing
348   ! Motor home manufacturing
```

```
  349   ! Travel trailer and camper manufacturing
  350   ! Motor vehicle parts manufacturing
  351   ! Aircraft manufacturing
  352   ! Aircraft engine and engine parts manufacturing
  353   ! Other aircraft parts and equipment
  354   ! Guided missile and space vehicle manufacturing
  355   ! Propulsion units and parts for space vehicles and
  356   ! Railroad rolling stock manufacturing
  357   ! Ship building and repairing
  358   ! Boat building
  359   ! Motorcycle  bicycle  and parts manufacturing
  360   ! Military armored vehicles and tank parts manufactu
  361   ! All other transportation equipment manufacturing
  362   ! Wood kitchen cabinet and countertop manufacturing
  363   ! Upholstered household furniture manufacturing
  364   ! Nonupholstered wood household furniture manufactur
  365   ! Metal household furniture manufacturing
  366   ! Institutional furniture manufacturing
  367   ! Other household and institutional furniture
  368   ! Wood office furniture manufacturing
  369   ! Custom architectural woodwork and millwork
  370   ! Office furniture  except wood  manufacturing
  371   ! Showcases  partitions  shelving  and lockers
  372   ! Mattress manufacturing
  373   ! Blind and shade manufacturing
  374   ! Laboratory apparatus and furniture manufacturing
  375   ! Surgical and medical instrument manufacturing
  376   ! Surgical appliance and supplies manufacturing
  377   ! Dental equipment and supplies manufacturing
  378   ! Ophthalmic goods manufacturing
  379   ! Dental laboratories
  380   ! Jewelry and silverware manufacturing
  381   ! Sporting and athletic goods manufacturing
  382   ! Doll  toy  and game manufacturing
  383   ! Office supplies  except paper  manufacturing
  384   ! Sign manufacturing
  385   ! Gasket  packing  and sealing device manufacturing
  386   ! Musical instrument manufacturing
  387   ! Broom  brush  and mop manufacturing
  388   ! Burial casket manufacturing
  389   ! Buttons  pins  and all other miscellaneous manufac
```

SER Services

```
  391   ! Air transportation
  392   ! Rail transportation
  393   ! Water transportation
  394   ! Truck transportation
  395   ! Transit and ground passenger transportation
  396   ! Pipeline transportation
  397   ! Scenic and sightseeing transportation and support
  398   ! Postal service
  399   ! Couriers and messengers
  413   ! Newpaper publishers
  414   ! Periodical publishers
  415   ! Book publishers
  416   ! Database  directory  and other publishers
```

```
417   ! Software publishers
418   ! Motion picture and video industries
419   ! Sound recording industries
420   ! Radio and television broadcasting
421   ! Cable networks and program distribution
422   ! Telecommunications
423   ! Information services
424   ! Data processing services
425   ! Nondepository credit intermediation and  related a
426   ! Securities  commodity contracts  investments
427   ! Insurance carriers
428   ! Insurance agencies  brokerages  and related
429   ! Funds  trusts  and other financial vehicles
430   ! Monetary authorities and depository credit interme
431   ! Real estate
432   ! Automotive equipment rental and leasing
433   ! Video tape and disc rental
434   ! Machinery and equipment rental and leasing
435   ! General and consumer goods rental except video tap
436   ! Lessors of nonfinancial intangible assets
437   ! Legal services
438   ! Accounting and bookkeeping services
439   ! Architectural and engineering services
440   ! Specialized design services
441   ! Custom computer programming services
442   ! Computer systems design services
443   ! Other computer related services  including facilit
444   ! Management consulting services
445   ! Environmental and other technical consulting servi
446   ! Scientific research and development services
447   ! Advertising and related services
448   ! Photographic services
449   ! Veterinary services
450   ! All other miscellaneous professional and technical
451   ! Management of companies and enterprises
452   ! Office administrative services
453   ! Facilities support services
454   ! Employment services
455   ! Business support services
456   ! Travel arrangement and reservation services
457   ! Investigation and security services
458   ! Services to buildings and dwellings
459   ! Other support services
460   ! Waste management and remediation services
461   ! Elementary and secondary schools
462   ! Colleges  universities  and junior colleges
463   ! Other educational services
464   ! Home health care services
465   ! Offices of physicians  dentists  and other health
466   ! Other ambulatory health care services
467   ! Hospitals
468   ! Nursing and residential care facilities
469   ! Child day care services
470   ! Social assistance  except child day care services
471   ! Performing arts companies
472   ! Spectator sports
473   ! Independent artists  writers  and performers
```

```
  474   ! Promoters of performing arts and sports and agents
  475   ! Museums  historical sites  zoos  and parks
  476   ! Fitness and recreational sports centers
  477   ! Bowling centers
  478   ! Other amusement  gambling  and recreation industri
  479   ! Hotels and motels  including casino hotels
  480   ! Other accommodations
  481   ! Food services and drinking places
  482   ! Car washes
  483   ! Automotive repair and maintenance  except car wash
  484   ! Electronic equipment repair and maintenance
  485   ! Commercial machinery repair and maintenance
  486   ! Household goods repair and maintenance
  487   ! Personal care services
  488   ! Death care services
  489   ! Drycleaning and laundry services
  490   ! Other personal services
```

MISC Miscellaneous

```
  491   ! Religious organizations
  492   ! Grantmaking and giving and social advocacy organiz
  493   ! Civic  social  professional and similar organizati
  494   ! Private households
  496   ! Other Federal Government enterprises
  497   ! State and local government passenger transit
  499   ! Other State and local government enterprises
  500   ! Noncomparable imports
  501   ! Scrap
  502   ! Used and secondhand goods
  503   ! State & Local Education
  504   ! State & Local Non-Education
  505   ! Federal Military
  506   ! Federal Non-Military
  507   ! Rest of the world adjustment to final uses
  508   ! Inventory valuation adjustment
  509   ! Owner-occupied dwellings
```

Appendix B: GAMS Model Code

```
* Regional CGE Model
*
* 17 AUGUST 2004
*
* Developed by Leroy Stodick, David Holland, and Stephen Devadoss
*
* Based on a model developed by Hans Lofgren
*
*
*
*************************************************************************
************

*************************************************************************
************
*
*
* PROGPATH is the folder where the SAM.GMS and REPORT.GMS programs
are located.*
* It is also the folder where the output report will be saved.
*
*
*
*************************************************************************
************

$SETGLOBAL PROGPATH C:\CGEUSTW\

$SETGLOBAL NAME CGEUSTW
$SETGLOBAL TXTNAME Results

*************************************************************************
************
*
*
* If the global variable LBR is set to NO, the employment data from
IMPLAN will*
* not be used. QFO will be set to the numbers in the SAM.
*
* If LBR is set to YES, the employment data from IMPLAY will be
used. QFO will *
* be set to the employment data extracted from IMPLAN. In this case,
QF        *
* represents actual number of jobs.
*
*
*
*************************************************************************
************

$SETGLOBAL LBR NO
```

```
* The following line assumes that the input file containing the SAM
data is
* named SAM.GMS

$INCLUDE "%PROGPATH%SAM.gms"

$ONEMPTY


SET FF(F)   Production Factors
   /
   LAB            Employee Compensation
   CAP            Proprietary Income
   /
;


SET H(I)   Households
   /
   HHD1
   HHD2
   HHD3
   HHD4
   HHD5
   HHD6
   HHD7
   HHD8
   HHD9
   /
;

SET G(I) Government units
   /
   FGOVND     Federal Govt Non-Defense
   FGOVD      Federal Govt Defense
   FGOVI      Federal Govt Investment
   SGOVNE     State Local Govt Non-Education
   SGOVE      State Local Govt Education
   SGOVI      State Local Govt Investment
   /
;

SET FG(G) Federal government units
   /
   FGOVND     Federal Govt Non-Defense
   FGOVD      Federal Govt Defense
   FGOVI      Federal GOvt Investment
   /
;

SET SG(G) State government units
   /
   SGOVNE     State Local Govt Non-Education
   SGOVE      State Local Govt Education
```

```
   SGOVI      State Local Govt Investment
   /
;


SET HG(I) Households and Government units;

HG(I) = H(I) + G(I);

ALIAS (FF,FFF),(C,CC),(H,HH),(G,GG),(FG,FGG),(SG,SGG);

* Parameters set by user
PARAMETERS
      CAPCLOS           Capital closure
      LABCLOS           Labor closure
      SICLOS            Savings investment closure
      ROWCLOS           Foreign savings closure
      RUSCLOS           RUS savings closure

      xed(C,T)          Elasticity of demand for world export
function
      esubp(A)          Elasticity of substitution for production
      esubd(C)          Elasticity of substitution (armington)
between regional output and imports
      esubs(C)          Elasticity of substitution (transformation)
between domestic (regional) and foreign demand
      esube(C)          Elasticity of substitution (transformation)
between row and rus for exports
      esubm(C)          Elasticity of substitution (armington)
between row imports and rus  imports
      ine(C,H)          Income elasticity
      frisch(C)         Consumption flexibility--determines minimum
subsistence level of consumption -1 imples zero minimum
      efac(FF)          Demand elasticity for capital and labor
;

* Set closure options here
      CAPCLOS = 1;
*         if CAPCLOS = 1, capital is mobile and supply is fixed
*         if CAPCLOS = 2, capital is mobile and supply is variable
*         if CAPCLOS = 3, capital is activity specific and fixed

      LABCLOS = 1;
*         if LABCLOS = 1, labor is mobile and supply is fixed
*         if LABCLOS = 2, labor is mobile and supply is variable
*         if LABCLOS = 3, labor is mobile. Unemployment is possible.

      SICLOS =1;
*         if SICLOS = 1, savings is investment driven
*         if SICLOS = 2, investment is savings driven
*         if SICLOS = 3, CPI changes

      ROWCLOS = 1;
*         if ROWCLOS = 1, exchange rate is variable
```

```
*         if ROWCLOS = 2, foreign savings (export - FSAVX) is
variable
*         if ROWCLOS = 3, foreign savings (import - FSAVM) is
variable

      RUSCLOS = 1;
*         if RUSCLOS = 1, RUS exchange rate is variable
*         if RUSCLOS = 2, RUS savings (export - DSAVX) is variable
*         if RUSCLOS = 3, RUS savings (import - DSAVM) is variable

* Set parameters here
      xed(C,T)   = -50;
      esubp(A)   = 0.99;
      esubd(C)   = 2;
      esubs(C)   = 2;
      esube(C)   = 2;
      esubm(C)   = 2;
      ine(C,H)   = 1;
      ine('SNAPFD-C',H)   = 0.53;
      ine('SINPROD-C',H)   = 0.65;
      ine('FDRTL-C',H)   = 0.65;
      ine('AGR-C',H)   = 0.57;
      ine('NATRES-C',H)   = 0.62;
      ine('CONST-C',H)   = 1.13;
      ine('UTIL-C',H)   = 1.16;
      ine('TRAD-C',H)   = 1.16;
      ine('MIN-C',H)   = 0.87;
      ine('MAN-C',H)   = 0.87;
      ine('SER-C',H)   = 1.19;
      frisch(C)  = -0.988864;
      efac(FF)   = 0.8;


SCALAR sgovbal State government budget balance;

PARAMETERS
      PMO(C)         Initial import price (domestic currency)
      XRO(T)         Initial exchange rate
      PEO(C)         Initial export price (domestic currency)
      PQO(C)         Initial composite commodity price
      PDO(C)         Initial domestic price of domestic output
      QQO(C)         Initial quantity supplied to domestic commodity
demanders
      QMO(C)         Initial quantity of imports
      QDO(C)         Initial quantity of domestic output sold
domestically
      PXO(C)         Initial producer price
      QXO(C)         Initial quantity of domestic output
      QEO(C)         Initial quantity of exports
      PAO(A)         Initial activity price
      PVAO(A)        Initial value added price
      QAO(A)         Initial activity level
      QFO(FF,A)      Initial quantity demanded of factor FF by
activity A
```

```
      QINTO(C,A)     Initial quantity of intermeditate use of
commodity C by activity A
      WFO(FF)        Initial average wage or rental rate of factor
FF
      YFO(I,FF)      Initial transfer of income to institution I
from factor FF
      YHO(H)         Initial gross household income
      NYHO(H)        Initial net household income
      QHO(C,H)       Initial household comsumption
      QINVO(C)       Initial investment demand
      QIINVO(I)      Initial institutional investment
      YFGO           Initial federal government revenue
      EFGO           Initial federal government expenditures
      YSGO           Initial state government revenue
      ESGO           Initial state government expenditures
      QFSO(FF)       Initial factor supply
      FSAVXO         Initial exports foreign savings
      DSAVXO         Initial exports RUS savings
      FSAVMO         Initial imports foreign savings
      DSAVMO         Initial imports RUS savings
      WFDISTO(FF,A)  Initial distortion factor for factor FF in
activity A
      INDTO(G)       Initial indirect taxes
      IMAKEQO(I,C)   Initial institutional make matrix (quantity)
      QMRO(T,C)      Initial regional imports
      PMRO(T,C)      Initial regional import price
      QERO(C,T)      Initial regional exports
      PERO(C,T)      Initial regional export price
      PWEO(C,T)      Initial world export price
      IADJO          Initial investment adjustment factor
      SADJO          Initial savings adjustment factor
      SGADJO         Initial state government adjustment factor for
quantity purchased
      SHIFTFFO(FF)   Factor supply equation shift variable
;

PARAMETERS
      theta(A,C)        Yield of output C per unit of activity A
      ica(C,A)          Quantity of C as intermediate input per unit
of activity A

      ad(A)             Production shift parameter
      del(F,A)          Production function share parameter
      rho(A)            CES production function exponent

      adel(C)           Armington commodity composite share
parameter for production
      aq(C)             Armington commodity composite shift
parameter
      arho(C)           Armington commodity composite exponent

      sdel(C)           Armington CET composite share parameter for
domestic sales
      srho(C)           Armington CET composite exponent
```

```
      as(C)             Armington CET composite shift parameter

      edel(C)           Armington composite share parameter foreign
exports
      erho(C)           Armington composite exponent for exports
      ae(C)             Armington composite shift parameter for
exports

      mdel(C)           Armington composite share parameter foreign
imports
      mrho(C)           Armington composite exponent for imports
      am(C)             Armington composite shift parameter for
imports

      tc(C)             Consumption tax (only paid by households)
      tq(C)             Sales tax
      tqs(C)            Sales tax on services not previously taxed
      tm(T,C)           Import taxes
      te(C,T)           Export tax rate
      tb(A)             Indirect business tax rate
      mps(H)            Marginal propensity to save
      ty(G,H)           Rate of household income tax
      trh(H,HH)         Interhousehold transfers
      pwm(T,C)          ROW and RUS import price
      cwts(C)           weight of commodity C in the cpi
      CPIO              initial consumer price index
      wfa(FF,A)         wage for factor FF in activity A
      xshift(C,T)       Shift parameter for world export demand
function
      lambda(C,H)       Subsistance level parameter
      beta(C,H)         Marginal budget share parameter
      engelwt(H)        Engel aggregation weight
      qg(C,G)           Government consumption
      shry(I,FF)        Instutional share of factor income
      tbshr(G)          Government unit share of indirect business
taxes
;

      tc(C)      = 0;
      tq(C)      = 0;
      tqs(C)     = 0;
      tm(T,C)    = 0;
      te(C,T)    = 0;

      PMO(C) = 1;
      XRO(T) = 1;
      PWEO(C,T) = 1;
      PEO(C) = 1;
      PQO(C) = 1 + tq(C)+ tqs(C);
      PDO(C) = PQO(C);

      PXO(C) = 1;
      PAO(A) = 1;
      QMO(C)     = SUM(T,SAM(T,C))/PMO(C);
```

```
      QXO(C)      = (SUM(A,SAM(A,C))+ SUM(I,SAM(I,C)))/PXO(C);
      QDO(C)      = (SUM(A,SAM(A,C)) + SUM(I,SAM(I,C)) -
SUM(T,SAM(C,T)))/PDO(C);
      QQO(C)      = (SAM('TOTAL',C) - SUM(T,SAM(C,T)))/PQO(C);
      QEO(C)      = SUM(T,SAM(C,T))/PEO(C);

      QAO(A)      = SAM('TOTAL',A)/PAO(A);

      QFO('CAP',A)  = SAM('CAP',A);
$IF %LBR% == "NO" $GOTO LW1
      QFO('LAB',A)  = EMPLOY(A);
$GOTO LW2
$LABEL LW1
      QFO('LAB',A)  = SAM('LAB',A);
$LABEL LW2
      WFO(FF) =    SUM(A, SAM(FF,A))/SUM(A, QFO(FF,A));
      QINTO(C,A) = SAM(C,A)/PQO(C);
      YFO(I,FF)  = SAM(I,FF);
      PVAO(A)    = SUM(FF,SAM(FF,A))/(SAM('TOTAL',A)/PAO(A));
      YHO(H)     = SUM(FF,SAM(H,FF)) + SUM(I,SAM(H,I)) +
SUM(T,SAM(H,T)) + SUM(C,PXO(C)*SAM(H,C));
      NYHO(H)    = SUM(C,SAM(C,H));
      QHO(C,H)   = SAM(C,H)/(PQO(C)*(1+tc(C)));
      QINVO(C)   = SAM(C,'INV')/PQO(C);
      QIINVO(I ) = SAM(I,'INV');

      YFGO       = SUM(FG,SAM(FG,'TOTAL'));
      EFGO       = SUM(FG,SAM('TOTAL',FG)) - SUM(FG,SAM('INV',FG));
      YSGO       = SUM(SG,SAM(SG,'TOTAL'));
      ESGO       = SUM(SG,SAM('TOTAL',SG)) - SUM(SG,SAM('INV',SG));
      QFSO(FF)   = SUM(A,SAM(FF,A)/WFO(FF));
      FSAVXO      = SAM('INV','FT')/XRO('FT');
      DSAVXO      = SAM('INV','DT')/XRO('DT');
      FSAVMO      = SAM('FT','INV')/XRO('FT');
      DSAVMO      = SAM('DT','INV')/XRO('DT');
      wfa(FF,A)     = SAM(FF,A)/QFO(FF,A);
      WFDISTO(FF,A) = wfa(FF,A) / WFO(FF);

      INDTO(G)   = SAM(G,'INDT');
      IMAKEQO(I,C) = SAM(I,C)/PXO(C);
      IADJO       = 1;
      SADJO       = 1;
      SGADJO      = 1;

      ty(G,H)    = SAM(G,H)/SAM('TOTAL',H);
      tb(A)      = SAM('INDT',A)/SAM('TOTAL',A);
      pwm(T,C)   = 1;
      trh(H,HH)  = SAM(H,HH) /((1-SUM(G,ty(G,HH)))*SAM('TOTAL',HH));
      mps(H)     = SAM('INV',H)/((1-SUM(G,ty(G,H)))*SAM('TOTAL',H));
      qg(C,G)    = SAM(C,G)/PQO(C);

      PMRO(T,C) = pwm(T,C)*(1+tm(T,C))*XRO(T);
      QMRO(T,C)  = SAM(T,C)/PMRO(T,C);
      PERO(C,T) = PWEO(C,T)*XRO(T)*(1-te(C,T));
```

```
      QERO(C,T)  = SAM(C,T)/PERO(C,T);

      xshift(C,T) = QERO(C,T)/(PWEO(C,T)**xed(C,T));
      SHIFTFFO(FF) = QFSO(FF)/(WFO(FF)**efac(FF));

SET CM(C),CE(C),CNM(C),CNE(C);
SET CM1(C),CE1(C),CM2(C),CE2(C);

      CM(C) = YES$QMO(C);
      CE(C) = YES$QEO(C);
      CNM(C) = YES$(QMO(C) = 0);
      CNE(C) = YES$(QEO(C) = 0);
      CM1(C) = YES$((QMRO('FT',C) AND QMRO('DT',C) = 0) OR
(QMRO('FT',C) = 0 AND QMRO('DT',C)));
      CE1(C) = YES$((QERO(C,'FT') AND QERO(C,'DT') = 0) OR
(QERO(C,'FT') = 0 AND QERO(C,'DT')));
      CM2(C) = YES$(QMRO('FT',C) AND QMRO('DT',C));
      CE2(C) = YES$(QERO(C,'FT') AND QERO(C,'DT'));

      theta(A,C) = (SAM(A,C)/PXO(C)) / QAO(A);
      ica(C,A)   = QINTO(C,A)/QAO(A);

      rho(A)=1/esubp(A)-1;

      del(FF,A) =
(WFDISTO(FF,A)*WFO(FF)*QFO(FF,A)**(rho(A)+1))/SUM(FFF,WFDISTO(FFF,A)
*WFO(FFF)*QFO(FFF,A)**(rho(A)+1));
      ad(A) = (QAO(A)*(1-tb(A)-SUM(C,ica(C,A))))/(SUM(FF,
del(FF,A)*QFO(FF,A)**(-rho(A))))**(-1/rho(A));

      arho(CM)=1/esubd(CM)-1;
      adel(CM)=(QMO(CM)**(1+arho(CM)))*PMO(CM)
           /(QMO(CM)**(1+arho(CM))*PMO(CM) +
QDO(CM)**(1+arho(CM))*PDO(CM));
      aq(CM) =  QQO(CM)/(
           adel(CM)*QMO(CM)**(-arho(CM))+(1-adel(CM))*QDO(CM)**(-
arho(CM)))
          **(-1/arho(CM));

      srho(CE)=1/esubs(CE)+1;



      sdel(CE)=(QEO(CE)**(1-srho(CE)))*PEO(CE)
           /(QDO(CE)**(1-srho(CE))*PDO(CE)+QEO(CE)**(1-
srho(CE))*PEO(CE));
      as(CE) = QXO(CE)/(sdel(CE)*QEO(CE)**(srho(CE))+
               (1-sdel(CE))*QDO(CE)**(srho(CE)))
                  **(1/srho(CE));

      erho(CE2) = 1/esube(CE2) + 1;
      edel(CE2)=(QERO(CE2,'FT')**(1-erho(CE2)))*PERO(CE2,'FT')
           /(QERO(CE2,'FT')**(1-erho(CE2))*PERO(CE2,'FT')
               +QERO(CE2,'DT')**(1-erho(CE2))*PERO(CE2,'DT'));
```

```
      ae(CE2) = QEO(CE2)/
               (edel(CE2)*QERO(CE2,'FT')**(erho(CE2))
                         +(1-edel(CE2))*QERO(CE2,'DT')**(erho(CE2)))
                        **(1/erho(CE2));

      mrho(CM2) = 1/esubm(CM2) - 1;
      mdel(CM2)=(QMRO('FT',CM2)**(1+mrho(CM2)))*PMRO('FT',CM2)
           /(QMRO('FT',CM2)**(1+mrho(CM2))*PMRO('FT',CM2)
               +QMRO('DT',CM2)**(1+mrho(CM2))*PMRO('DT',CM2));
      am(CM2) = QMO(CM2)/
                (mdel(CM2)*QMRO('FT',CM2)**(-mrho(CM2))
                         +(1-mdel(CM2))*QMRO('DT',CM2)**(-
mrho(CM2)))
                        **(-1/mrho(CM2));



      engelwt(H) =
1/SUM(C,(QHO(C,H)*PQO(C)*(1+tc(C)))/NYHO(H)*ine(C,H));
      ine(C,H) = engelwt(H)*ine(C,H);
      beta(C,H)=(QHO(C,H)*PQO(C)*(1+tc(C)))/NYHO(H)*ine(C,H);

lambda(C,H)=(QHO(C,H)*PQO(C)*(1+tc(C))+beta(C,H)*NYHO(H)/frisch(C))/
(PQO(C)*(1+tc(C)));

      cwts(C) = SUM(H,SAM(C,H))/SUM((CC,H),SAM(CC,H));
      CPIO = SUM(C,cwts(C)*PDO(C));
      shry(I,FF)   = SAM(I,FF) / (SAM('TOTAL',FF)-SUM(T,SAM(T,FF)));
      tbshr(G)  = SAM(G,'INDT')/SUM(GG,SAM(GG,'INDT'));

      sgovbal = SUM(SG,SAM('INV',SG));



VARIABLES
      PM(C)          Import price (domestic currency)
      XR(T)          Exchange rate
      PWE(C,T)       World export price
      PE(C)          Export price (domestic currency)
      PQ(C)          Composite commodity price
      PD(C)          Domestic price of domestic output
      PMR(T,C)       Regional price of imported commodities
      PER(C,T)       Regional price of exported commodities
      PA(A)          Activity price
      PVA(A)         Value added price
      PX(C)          Producer price

      QQ(C)          Quantity supplied to domestic commodity
demanders
      QM(C)          Quantity of imports
      QD(C)          Quantity of domestic output sold domestically
      QMR(T,C)       Regional imports
      QER(C,T)       Regional exports
```

```
      QX(C)          Quantity of domestic output
      QE(C)          Quanitity of exports
      QA(A)          Activity level

      QF(FF,A)       Quantity demanded of factor FF by activity A
      QINT(C,A)      Quantity of intermeditate use of commodity C by
activity A
      WF(FF)         Average wage or rental rate of factor FF
      YF(I,FF)       Factor income
      YH(H)          Gross household income
      NYH(H)         Net household income
      QH(C,H)        Household consumption
      QINV(C)        Investment demand
      QIINV(I)       Investment demand by institutions
      YFG            Federal government revenue
      EFG            Federal government expenditure
      YSG            State government revenue
      ESG            State government expenditure
      QFS(FF)        Factor supply

      WALRAS         Dummy variable
      IADJ           Investment adjustment variable
      SADJ           Savings adjustment variable
      SGADJ          State government spending adjustment variable
for quantity purchased

      WFDIST(FF,A)   Wage distortion factor
      INDT(G)        Total indirect taxes
      IMAKEQ(I,C)    Make matrix (quantity)
      SHIFTFF(FF)    Factor supply equation shift variable
      FSAVX          Exports foreign savings
      DSAVX          Exports RUS savings
      FSAVM          Imports foreign savings
      DSAVM          Imports RUS savings
      CPI            Consumer Price Index
;

EQUATIONS

      PMDEFF(T,C)    Regional foreign import price equation
      PEDEFF(C,T)    Regional foreign export price equation
      PMDEFD(T,C)    Regional domestic import price equation
      PEDEFD(C,T)    Regional domestic export price equation
      WEXDEM(C,T)    World export demand function
      ARMIMP(C)      Armington import composite equation
      ROWRUSM(C)     ROW-RUS import ratio
      ROWRUSE(C)     ROW-RUS export ratio
      IMPVAL(C)      Import output value
      EXPVAL(C)      Export output value
      ARMEXP(C)      Armington export composite equation
      EQMRUS(C)      Absorption equation for one imported commodity
      EQERUS(C)      Absorption equation for one exported commodity
      EPERUS(C)      Price for one exported destination
      EPMRUS(C)      Price for one imported destination
```

```
      ABSORP(C)     Absorption equation
      DOMOUT(C)     Domestic Output Value
      PADEF(A)      Activity price equation
      PVADEF(A)     Value added price
      PRODN(A)      Leontief-CES Production Functions
      FACDEM(FF,A)  Factor demand equation
      INTDEM(C,A)   Intermediate input demand equation
      ALLOC(C)      Output function
      ARMCOMS(C)    Armington commodity composite supply equation
      IMPDEM(C)     Import-Domestic demand ratio
      SUPNON(C)     Composite supply for nonimported commodities
      ARMCET(C)     Output transformation CET equation
      EXPDOM(C)     Export-domestic supply ratio
      OUTNON(C)     Output transformation for nonexported
commodities
      FACINC(I,FF)  Factor income
      HOUSINC(H)    Household income
      NYHINCOME(H)  Net household income
      HOUSDEM(C,H)  Household consumption demand
      INVDEM(C)     Investment demand equation
      FGOVREV       Federal government revenue equation
      FGOVEXP       Federal government expenditure equation
      SGOVREV       State government revenue equation
      SGOVEXP       State government expenditure equation
      SGOVBUD       State government budget balanced
      FACMKT(FF)    Factor market equation
      COMPMKT(C)    Composite commodity market equation
      CURACCF       ROW current account balance
      CURACCD       RUS current account balance
      SAVBAL        Savings investment balance
      NORM          Price normalization equation
      INDTCALC(G)   Indirect tax calculation
      FACSUP(FF)    Factor supply equation
;


* Regional foreign import price equation
    PMDEFF('FT',CM)..
       PMR('FT',CM) =E= pwm('FT',CM)*(1+tm('FT',CM))*XR('FT');

* Regional domestic import price equation
    PMDEFD('DT',CM)..
       PMR('DT',CM) =E= pwm('DT',CM)*(1+tm('DT',CM))*XR('DT')*CPI;

* Regional foreign export price equation
    PEDEFF(CE,'FT')$QERO(CE,'FT')..
       PER(CE,'FT') =E= PWE(CE,'FT')*XR('FT')*(1-te(CE,'FT'));

* Regional foreign export price equation
    PEDEFD(CE,'DT')$QERO(CE,'DT')..
       PER(CE,'DT') =E= PWE(CE,'DT')*CPI*XR('DT')*(1-te(CE,'DT'));

* World export demand function
    WEXDEM(CE,T)..
```

```
        QER(CE,T)$QERO(CE,T) =E=
xshift(CE,T)*(PWE(CE,T)**xed(CE,T));

* Armington import composite equation
    ARMIMP(CM2)..
        QM(CM2) =E=
           am(CM2)* (mdel(CM2)*QMR('FT',CM2)**(-mrho(CM2))
                   +(1-mdel(CM2))*QMR('DT',CM2)**(-mrho(CM2)))
                 **(-1/mrho(CM2));

* ROW-RUS import ratio
    ROWRUSM(CM2)..
       QMR('FT',CM2)/QMR('DT',CM2) =E=
          ((PMR('DT',CM2)/PMR('FT',CM2))*(mdel(CM2)/((1-
mdel(CM2)))))**(1/(1+mrho(CM2)));

* Equilibrium for non ROW imported commodity
    EQMRUS(CM1)..
       QM(CM1) =E= QMR('DT',CM1)$QMRO('DT',CM1) +
QMR('FT',CM1)$QMRO('FT',CM1);

* Price for one imported commodity
    EPMRUS(CM1)..
       PM(CM1) =E= PMR('DT',CM1)$QMRO('DT',CM1) +
PMR('FT',CM1)$QMRO('FT',CM1);

* Import output value
    IMPVAL(CM2)..
        PM(CM2)*QM(CM2) =E= SUM(T,PMR(T,CM2)*QMR(T,CM2));

* Armington export composite equation
    ARMEXP(CE2)..
        QE(CE2) =E=
           ae(CE2)* (edel(CE2)*QER(CE2,'FT')**(erho(CE2))
                   +(1-edel(CE2))*QER(CE2,'DT')**(erho(CE2)))
                 **(1/erho(CE2));

* ROW-RUS export ratio
    ROWRUSE(CE2)..
       QER(CE2,'DT')/QER(CE2,'FT') =E=
          ((PER(CE2,'DT')/PER(CE2,'FT'))*(edel(CE2)/((1-
edel(CE2)))))**(1/(erho(CE2)-1));

* Export output value
    EXPVAL(CE2)..
        PE(CE2)*QE(CE2) =E= SUM(T,PER(CE2,T)*QER(CE2,T));

* Quantity for one exported commodity
    EQERUS(CE1)..
       QE(CE1) =E= QER(CE1,'DT')$QERO(CE1,'DT') +
QER(CE1,'FT')$QERO(CE1,'FT');

* Price for one exported commodity
    EPERUS(CE1)..
```

```
       PE(CE1) =E= PER(CE1,'DT')$QERO(CE1,'DT') +
PER(CE1,'FT')$QERO(CE1,'FT');

* Absorption equation
    ABSORP(C)..
       PQ(C)*QQ(C) =E= (1+tq(C))*PM(C)*QM(C)$CM(C) +
(1+tq(C)+tqs(C))*PD(C)*QD(C);

* Domestic Output Value
    DOMOUT(C)..
       PX(C)*QX(C) =E= PD(C)*QD(C) + PE(C)*QE(C)$CE(C);

* Activity price equation
     PADEF(A)..
        PA(A) =E= SUM(C, PX(C)*theta(A,C));

* Value added price
     PVADEF(A)..
        PVA(A) =E= PA(A)*(1 - tb(A)) - SUM(C, PQ(C)*ica(C,A));

* Leontief-CES Production Functions
     PRODN(A)..
        QA(A) =E=
         (ad(A)/(1 - tb(A) - SUM(C, ica(C,A))))
         * (SUM(FF, del(FF,A)*QF(FF,A)**(-rho(A))))**(-1/rho(A));

* Factor demand equation
     FACDEM(FF,A)..
        WFDIST(FF,A)*WF(FF) =E=
            PVA(A) * (ad(A)/(1-tb(A)-SUM(C, ica(C,A))))
             * (SUM(FFF, del(FFF,A)*QF(FFF,A)**(-rho(A))))**((-
1/rho(A))-1)
             * del(FF,A)*QF(FF,A)**(-rho(A)-1);

* Intermediate input demand equation
     INTDEM(C,A)..
        QINT(C,A) =E= ica(C,A)*QA(A);

* Output function
    ALLOC(C)..
       QX(C) =E= SUM(A,theta(A,C)*QA(A)) + SUM(I,IMAKEQ(I,C));

* Armington commodity composite supply equation
    ARMCOMS(CM)..
       QQ(CM) =E=
          aq(CM)*(adel(CM)*QM(CM)**(-arho(CM))
           +(1-adel(CM))*QD(CM)**(-arho(CM)))
            **(-1/arho(CM));

* Import-Domestic demand ratio
    IMPDEM(CM)..
       QM(CM)/QD(CM) =E=
          ((adel(CM)/(1-
adel(CM)))*(PD(CM)/PM(CM)))**(1/(1+arho(CM)));
```

```
* Composite supply for nonimported commodities
    SUPNON(CNM)..
       QQ(CNM) =E= QD(CNM);

* Output transformation CET equation
    ARMCET(CE)..
       QX(CE) =E=
          as(CE)* (sdel(CE)*QE(CE)**(srho(CE))+(1-
sdel(CE))*QD(CE)**(srho(CE)))
                **(1/srho(CE));

* Export-domestic supply ratio
    EXPDOM(CE)..
       QE(CE)/QD(CE) =E=
          (PE(CE)/PD(CE)*(1-sdel(CE))/sdel(CE))**(1/(srho(CE)-1));

* Output transformation for nonexported commodities
    OUTNON(CNE)..
        QX(CNE) =E= QD(CNE);

* Factor income
    FACINC(I,FF)..
        YF(I,FF) =E=
shry(I,FF)*(SUM(A,WFDIST(FF,A)*QF(FF,A)*WF(FF))-
CPI*SUM(T,SAM(T,FF)));

* Household income
    HOUSINC(H)..
        YH(H)
          =E= SUM(FF,YF(H,FF)) + SUM(C,PX(C)*IMAKEQ(H,C)) +
CPI*SUM(G,SAM(H,G))
              + QIINV(H) + SUM(HH,trh(H,HH)*(1-
SUM(G,ty(G,HH)))*YH(HH)) + CPI*SUM(T,SAM(H,T));

* Net household income
   NYHINCOME(H)..
        NYH(H) =E= YH(H) - SUM(HH,trh(HH,H)*(1-
SUM(G,ty(G,H)))*YH(H))
                     - SADJ*mps(H)*(1-SUM(G,ty(G,H)))*YH(H) -
SUM(G,ty(G,H))*YH(H)
                   - CPI*SUM(T,SAM(T,H));

* Household consumption demand
    HOUSDEM(C,H)..
        QH(C,H) =E=
         lambda(C,H)+(beta(C,H)*(NYH(H)-
SUM(CC,lambda(CC,H)*(PQ(CC)*(1+tc(C))))))
         /(PQ(C)*(1+tc(C)));

* Investment demand
    INVDEM(C)..
        QINV(C) =E= IADJ*QINVO(C);
```

```
* Federal government revenue
    FGOVREV..
        YFG =E= SUM((H,FG),ty(FG,H)*YH(H)) +
CPI*SUM((T,FG),SAM(FG,T))
                + SUM((C,FG),PX(C)*IMAKEQ(FG,C)) + SUM(FG,QIINV(FG))
                + CPI*SUM((FG,FGG),SAM(FG,FGG)) +
SUM((FG,FF),YF(FG,FF)) + SUM(FG,INDT(FG));

* Federal government expenditures
   FGOVEXP..
        EFG =E= CPI*SUM((FG,I),SAM(I,FG)) +
CPI*SUM((FG,T),SAM(T,FG)) + SUM((FG,C),PQ(C)*qg(C,FG)) -
CPI*SUM(FG,SAM('INV',FG));

* State government revenue
    SGOVREV..
        YSG =E= SUM((H,SG),ty(SG,H)*YH(H)) +
CPI*SUM((T,SG),SAM(SG,T)) + CPI*SUM((SG,FG),SAM(SG,FG))
                + SUM((C,SG),PX(C)*IMAKEQ(SG,C)) + SUM(SG,QIINV(SG))
                + CPI*SUM((SG,SGG),SAM(SG,SGG)) +
SUM((SG,FF),YF(SG,FF)) + SUM(SG,INDT(SG))
                + SUM(C,(PM(C)*QM(C)$CM(C) + PD(C)*QD(C))*tq(C))
                + SUM((H,C),PQ(C)*tc(C)*QH(C,H))
                + SUM(C,PD(C)*QD(C)*tqs(C));

* State government expenditures
   SGOVEXP..
        ESG =E= CPI*SUM((SG,I),SAM(I,SG)) +
CPI*SUM((SG,T),SAM(T,SG)) + SGADJ*SUM((SG,C),PQ(C)*qg(C,SG)) -
CPI*sgovbal;

* State government budget balanced
   SGOVBUD..
        YSG =E= ESG + CPI*sgovbal;

* Factor market equation
   FACMKT(FF)..
        SUM(A,QF(FF,A)) =E= QFS(FF);

* Composite commodity market equation
   COMPMKT(C)..
        QQ(C) =E= SUM(A,QINT(C,A)) + SUM(H,QH(C,H)) +
SUM(FG,qg(C,FG)) + SGADJ*SUM(SG,qg(C,SG)) + QINV(C);

* ROW current account balance
   CURACCF..
        SUM(CE,PER(CE,'FT')*QER(CE,'FT')$QERO(CE,'FT')) +
CPI*SUM(H,SAM(H,'FT')) + CPI*SUM(G,SAM(G,'FT')) + XR('FT')*FSAVX
               =E=
              SUM(CM,PMR('FT',CM)*QMR('FT',CM)$QMRO('FT',CM)) +
CPI*SUM(FF,SAM('FT',FF)) + CPI*SUM(HG,SAM('FT',HG))
               + XR('FT')*FSAVM;

* RUS current account balance
```

```
   CURACCD..
        SUM(CE,PER(CE,'DT')*QER(CE,'DT')$QERO(CE,'DT')) +
CPI*SUM(H,SAM(H,'DT')) + CPI*SUM(G,SAM(G,'DT'))
             + CPI*XR('DT')*DSAVX =E=
             SUM(CM,PMR('DT',CM)*QMR('DT',CM)$QMRO('DT',CM)) +
CPI*SUM(FF,SAM('DT',FF)) + CPI*SUM(HG,SAM('DT',HG))
             + CPI*XR('DT')*DSAVM;

* Savings investment balance
    SAVBAL..
       SUM(C,PX(C)*IMAKEQ('INV',C)) + SADJ*SUM(H,mps(H)*(1-
SUM(G,ty(G,H)))*YH(H)) + (YFG - EFG) + CPI*sgovbal + XR('FT')*FSAVX
            + CPI*XR('DT')*DSAVX + SUM(FF,YF('INV',FF))
          =E= SUM(C,PQ(C)*QINV(C)) + SUM(HG,QIINV(HG))
              + CPI*XR('DT')*DSAVM + XR('FT')*FSAVM + WALRAS;

* Price normalization equation
    NORM..
       SUM(C,(1+tc(C))*PQ(C)*cwts(C)) =E= CPI;

* Indirect taxes calculation
     INDTCALC(G)..
        INDT(G) =E= tbshr(G)*SUM(A,tb(A)*PA(A)*QA(A));

* Factor supply equation
     FACSUP(FF)..
        QFS(FF) =E= SHIFTFF(FF)*WF(FF)**efac(FF);


OPTION MCP=PATH;
*OPTION MCP=PATHNLP;

MODEL CGEMODEL
    /
    ALL
    /
;
CGEMODEL.HOLDFIXED = 1;

* Initialize the variables

      PM.L(C)       = PMO(C);
      PWE.L(C,T)    = PWEO(C,T);
      PE.L(C)       = PEO(C);
      PQ.L(C)       = PQO(C);
      PD.L(C)       = PDO(C);
      QQ.L(C)       = QQO(C);
      QM.L(C)       = QMO(C);
      QD.L(C)       = QDO(C);
      PX.L(C)       = PXO(C);
      QX.L(C)       = QXO(C);
      QE.L(C)       = QEO(C);
      PA.L(A)       = PAO(A);
      PVA.L(A)      = PVAO(A);
```

```
       QA.L(A)        = QAO(A);

       QF.L(FF,A)     = QFO(FF,A);
       QINT.L(C,A)    = QINTO(C,A);
       WF.L(FF)       = WFO(FF);
       YF.L(I,FF)     = YFO(I,FF);
       YH.L(H)        = YHO(H);
       NYH.L(H)       = NYHO(H);
       QH.L(C,H)      = QHO(C,H);
       QINV.L(C)      = QINVO(C);

       YFG.L          = YFGO;
       EFG.L          = EFGO;
       YSG.L          = YSGO;
       ESG.L          = ESGO;
       WALRAS.L       = 0;
       SGADJ.L        = SGADJO;
       INDT.L(G)      = INDTO(G);
       QMR.L(T,C)     = QMRO(T,C);
       QER.L(C,T)     = QERO(C,T);
       PMR.L(T,C)     = PMRO(T,C);
       PER.L(C,T)     = PERO(C,T);


       IMAKEQ.FX(I,C)  = IMAKEQO(I,C);
       QIINV.FX(I)     = QIINVO(I);

IF(CAPCLOS EQ 1,
*Capital is fully employed and mobile. WF('CAP') is the market-
clearing
*variable for the unified capital market.

     WFDIST.FX('CAP',A) = WFDISTO('CAP',A);

     SHIFTFF.LO('CAP') = -INF;
     SHIFTFF.L('CAP') = SHIFTFFO('CAP');
     SHIFTFF.UP('CAP') = +INF;

     WF.LO('CAP')       = -INF;
     WF.UP('CAP')       = +INF;
     WF.L('CAP')        = WFO('CAP');


     QF.LO('CAP',A)     = -INF;
     QF.UP('CAP',A)     = +INF;
     QF.L('CAP',A)      = QFO('CAP',A);

     QFS.FX('CAP')       = QFSO('CAP');

);

IF(CAPCLOS EQ 2,

     WFDIST.FX('CAP',A) = WFDISTO('CAP',A);
```

```
     SHIFTFF.FX('CAP') = SHIFTFFO('CAP');

     WF.LO('CAP')       = -INF;
     WF.UP('CAP')       = +INF;
     WF.L('CAP')        = WFO('CAP');

     QF.LO('CAP',A)     = -INF;
     QF.UP('CAP',A)     = +INF;
     QF.L('CAP',A)      = QFO('CAP',A);

     QFS.LO('CAP')      = -INF;
     QFS.UP('CAP')      = +INF;
     QFS.L('CAP')       = QFSO('CAP');
);

IF(CAPCLOS EQ 3,
*Capital is fully employed and activity-specific.
*WFDIST('CAP',A) is the market-clearing variable, one for
*each segment of the capital market.

     WFDIST.LO('CAP',A) = -INF;
     WFDIST.UP('CAP',A) = +INF;
     WFDIST.L('CAP',A)  = WFDISTO('CAP',A);
     SHIFTFF.FX('CAP') = SHIFTFFO('CAP');

     WF.LO('CAP')       = -INF;
     WF.UP('CAP')       = +INF;
     WF.L('CAP')        = WFO('CAP');

     QF.FX('CAP',A)     = QFO('CAP',A);

     QFS.LO('CAP')      = -INF;
     QFS.UP('CAP')      = +INF;
     QFS.L('CAP')       = QFSO('CAP');
);

IF(LABCLOS EQ 1,
*Labor is fully employed and mobile. WF('LAB') is the market-
clearing
*variable for the unified capital market.

     WFDIST.FX('LAB',A) = WFDISTO('LAB',A);

     SHIFTFF.LO('LAB') = -INF;
     SHIFTFF.UP('LAB') = +INF;
     SHIFTFF.L('LAB') = SHIFTFFO('LAB');

     WF.LO('LAB')       = -INF;
     WF.UP('LAB')       = +INF;
     WF.L('LAB')        = WFO('LAB');

     QF.LO('LAB',A)     = -INF;
     QF.UP('LAB',A)     = +INF;
     QF.L('LAB',A)      = QFO('LAB',A);
```

```
     QFS.FX('LAB')       = QFSO('LAB');
);

IF(LABCLOS EQ 2,
*Labor is fully employed and mobile. WF('LAB') is the market-
clearing
*variable for the unified capital market.

     WFDIST.FX('LAB',A) = WFDISTO('LAB',A);
     SHIFTFF.FX('LAB') = SHIFTFFO('LAB');

     WF.LO('LAB')       = -INF;
     WF.UP('LAB')       = +INF;
     WF.L('LAB')        = WFO('LAB');

     QF.LO('LAB',A)     = -INF;
     QF.UP('LAB',A)     = +INF;
     QF.L('LAB',A)      = QFO('LAB',A);

     QFS.LO('LAB')      = -INF;
     QFS.UP('LAB')      = +INF;
     QFS.L('LAB')       = QFSO('LAB');
);

IF(LABCLOS EQ 3,
*Labor is unemployed and mobile. For each activity, the wage,
*WFDIST('LAB',A)*WF('LAB'), is fixed. QFS('LAB') is the market-
clearing
*variable for the unified labor market.

     WFDIST.FX('LAB',A) = WFDISTO('LAB',A);

     SHIFTFF.LO('LAB') = -INF;
     SHIFTFF.UP('LAB') = +INF;
     SHIFTFF.L('LAB') = SHIFTFFO('LAB');

     WF.FX('LAB')       = WFO('LAB');

     QF.LO('LAB',A)     = -INF;
     QF.UP('LAB',A)     = +INF;
     QF.L('LAB',A)      = QFO('LAB',A);

     QFS.LO('LAB')      = -INF;
     QFS.UP('LAB')      = +INF;
     QFS.L('LAB')       = QFSO('LAB');
);

*SAVINGS-INVESTMENT BALANCE

IF(SICLOS EQ 1,
*Investment-driven savings -- MPS('U-HHD') is flexible, permitting
*the savings value to adjust.
     IADJ.FX     = IADJO;
```

```
     CPI.FX      = CPIO;
     SADJ.LO     = -INF;
     SADJ.UP     = +INF;
     SADJ.L      = SADJO;
 );

IF(SICLOS EQ 2,
*Savings-driven investment -- IADJ is flexible, permitting
*investment quantities and the investment value to adjust.
     SADJ.FX   = SADJO;
     CPI.FX    = CPIO;
     IADJ.LO   = -INF;
     IADJ.UP   = +INF;
     IADJ.L    = IADJO;
 );

IF(SICLOS EQ 3,
* Savings and investment are not linked.
* All investment except federal govt is fixed.
* Federal govt investment adjusts.
     SADJ.FX    = SADJO;
     IADJ.FX    = IADJO;
     CPI.LO     = -INF;
     CPI.UP     = +INF;
     CPI.L      = CPIO;
 );

*THE FOREIGN EXCHANGE MARKET

IF(ROWCLOS EQ 1,
*Foreign savings is fixed. A flexible exchange rate clears
*the current account of the balance of payments.
       FSAVX.FX = FSAVXO;
       FSAVM.FX = FSAVMO;
       XR.LO('FT')  = -INF;
       XR.UP('FT')  = +INF;
       XR.L('FT')   = XRO('FT');
 );

IF(ROWCLOS EQ 2,
*The exchange rate is fixed. Flexible foreign savings clears
*the current account of the balance of payments.
      XR.FX('FT')   = XRO('FT');
      FSAVM.FX = FSAVMO;
      FSAVX.LO  = -INF;
      FSAVX.UP  = +INF;
      FSAVX.L   = FSAVXO;
 );

IF(ROWCLOS EQ 3,
*The exchange rate is fixed. Flexible foreign savings clears
*the current account of the balance of payments.
      XR.FX('FT')   = XRO('FT');
      FSAVX.FX = FSAVXO;
```

```
      FSAVM.LO  = -INF;
      FSAVM.UP  = +INF;
      FSAVM.L   = FSAVMO;
 );

*THE RUS EXCHANGE MARKET

IF(RUSCLOS EQ 1,
*Foreign savings is fixed. A flexible RUS exchange rate clears
*the current account of the balance of payments.
       DSAVM.FX = DSAVMO;
       DSAVX.FX = DSAVXO;
       XR.LO('DT')  = -INF;
       XR.UP('DT')  = +INF;
       XR.L('DT')   = XRO('DT');
 );

IF(RUSCLOS EQ 2,
*The exchange rate is fixed. Flex RUS savings clears
*the current account of the balance of payments.
      XR.FX('DT')   = XRO('DT');
      DSAVM.FX = DSAVMO;
      DSAVX.LO  = -INF;
      DSAVX.UP  = +INF;
      DSAVX.L   = DSAVXO;
 );

IF(RUSCLOS EQ 3,
*The exchange rate is fixed. Flex RUS savings clears
*the current account of the balance of payments.
      XR.FX('DT')   = XRO('DT');
      DSAVX.FX = DSAVXO;
      DSAVM.LO  = -INF;
      DSAVM.UP  = +INF;
      DSAVM.L   = DSAVMO;
 );

* Set counterfactual

*income tax transfer
ty('FGOVND','HHD1')=-4.92*ty('FGOVND','HHD1');
ty('FGOVND','HHD2')=-4.92*ty('FGOVND','HHD2');
ty('FGOVND','HHD3')=-4.92*ty('FGOVND','HHD3');
ty('FGOVND','HHD4')=0.92*ty('FGOVND','HHD4');
ty('FGOVND','HHD5')=0.92*ty('FGOVND','HHD5');
ty('FGOVND','HHD6')=0.92*ty('FGOVND','HHD6');
ty('FGOVND','HHD7')=0.92*ty('FGOVND','HHD7');
ty('FGOVND','HHD8')=0.92*ty('FGOVND','HHD8');
ty('FGOVND','HHD9')=0.92*ty('FGOVND','HHD9');

SOLVE CGEMODEL USING MCP;


PARAMETERS
```

```
         UTO(H)       Base household utility
         UT(H)        Household Utility
         EV(H)        Equivalent Variation
         IMPORTSO(T)  Base imports
         IMPORTS(T)   Counterfactual imports
         EXPORTSO(T)  Base exports
         EXPORTS(T)   Counterfactual exports
         GDPFCO       Base total wage and capital bill (GDP at
factor cost)--  all the following based on Kendrick notes
         GDPFC        Counterfactual wage and capital bill (GDP at
factor cost)-- Kendrick notes
         GDPMCO1      Base state  GDP (c + i + g + e - m)  (GDP at
market prices--Kendrick notes
         GDPMC1       Counterfactual  state  GDP (c + i + g + e - m)
(GDP at market prices--Kendrick notes
         GDPMCO2      Base value added for economy (wage and capital
bill plus indirect business taxes)--also = GDP at market prices?
         GDPMC2       Counterfactual value added for economy (wage
and capital bill plus indirect business taxes) --also = GDP at
market prices
         GDPMCO3      Total activity output minus intermediate cost
minus (ibt) equals total wage and capital bill
         GDPMC3       Counterfactual Total activity output minus
intermediate cost minus (ibt) equals total wage and capital bill
*         GSIMPO       Base Value added + net remissions from
foriegn countrie to hh - net interest and profits to foreigners--
accounts for labor and income from outside the region
*         GSIMP        Counterfactual  Base Value added + net
remissions from foriegn countrie to hh - net interest and profits to
foreigners--national income
*         DGSIMPO      Base Disposable Gross State Income at market
prices
*         DGSIMP       Disposable Gross State Income at market
prices
;

* Calculate some descriptive parameters based upon the output of the
model

UTO(H) = SUM(C,beta(C,H)*LOG(QHO(C,H)-lambda(C,H))$(QHO(C,H)-
lambda(C,H) GT 0));
UT(H) = SUM(C,beta(C,H)*LOG(QH.L(C,H)-lambda(C,H))$(QH.L(C,H)-
lambda(C,H) GT 0));
EV(H) = (NYH.L(H) -
SUM(C,lambda(C,H)*PQ.L(C)*(1+tc(C))))*PROD(C,(PQO(C)/(PQ.L(C)*1+tc(C
)))**beta(C,H))
         - (NYHO(H) - SUM(C,lambda(C,H)*PQO(C)));
IMPORTSO(T) = SUM(C,QMRO(T,C));
IMPORTS(T) = SUM(C,QMR.L(T,C));
EXPORTSO(T) = SUM(C,QERO(C,T));
EXPORTS(T) = SUM(C,QER.L(C,T));
GDPFCO = SUM(FF,SAM(FF,'TOTAL'));
GDPFC = SUM((FF,A),QF.L(FF,A)*WFDIST.L(FF,A)*WF.L(FF));
GDPMCO2 = SUM(F,SAM(F,'TOTAL'));
```

```
GDPMC2 = GDPFC + SUM(A,tb(A)*PA.L(A)*QA.L(A));
GDPMCO1 = SUM((C,I),SAM(C,I)) + SUM((C,T),SAM(C,T)) -
SUM((T,C),SAM(T,C));
GDPMC1 = SUM((C,HH),PQ.L(C)*QH.L(C,HH)) + SUM((C,G),PQ.L(C)*qg(C,G))
         + SUM(C,PQ.L(C)*QINV.L(C)) +
SUM((C,T),PER.L(C,T)*QER.L(C,T))
         - SUM((T,C),PMR.L(T,C)*QMR.L(T,C));

GDPMCO3 = SUM(A,SAM(A,'TOTAL')) - SAM('INDT','TOTAL') -
SUM((C,A),SAM(C,A));
GDPMC3 = SUM((C,A),theta(A,C)*PX.L(C)*QA.L(A)) -
SUM(A,tb(A)*PA.L(A)*QA.L(A)) - SUM((C,A),PQ.L(C)*QINT.L(C,A));

* not really sure about the accounting for the parameters below

*GSIMPO = GDPMCO2 + SUM((H,T),SAM(H,T)) - SUM(T,SAM(T,'CAP'));
*GSIMP = GDPMC2 + SUM((H,T),SAM(H,T)) - SUM(T,SAM(T,'CAP'));

*DGSIMPO = GSIMPO - SUM((G,T),SAM(G,T));
*DGSIMP = GSIMP - SUM((G,T),SAM(G,T));

* Call the report generator (User should change the filename)

$SETGLOBAL MONTHDEF NO
$BATINCLUDE "%PROGPATH%REPORT.GMS"  %TXTNAME%
$BATINCLUDE "%PROGPATH%CSVREPORT.GMS"  %TXTNAME%
* DISPLAY IINCOMEO,IINCOME.L;

*$BATINCLUDE "%PROGPATH%XLSGEN.GMS"
```

Appendix C: Sensitivity Analysis

To examine the sensitivity of the policy experiment results the experiment is replicated using different labor and capital closures. The labor and capital closure to the model directly affects the primary factor markets in the model. Thus, the sensitivity in the results of returns to primary factors and the supply and demand for primary factors is displayed in this analysis. The analysis compares results from 3 different labor and capital closure scenarios to the results of the policy experiment. The labor and capital closure scenarios are displayed in Table 1.

Table 1. Closure Scenarios

Scenario	Capital Closure	Labor Closure
Policy Experiment	mobile and supply fixed sector specific and supply	mobile and unemployment possible
Scenario 1	fixed	mobile and unemployment possible
Scenario 2	mobile and supply variable	mobile and supply variable
Scenario 3	mobile and supply fixed	mobile and supply fixed

The sensitivity analysis finds slight changes in the labor and capital markets as a result of the labor and capital closure specifications. However, the overall effect on the labor and capital market from the policy experiment is so small that virtually no change was made in supply, demand, and returns to factors. There is a redistribution of labor and capital across commodity sectors, but that is expected based on the redistribution of output and value that occurs. Overall, these results reinforce the fact that the policy experiment only impacts demand; it has very little supply side effects. Results for the 4 scenarios are compared in Tables 2 through 5 below.

Table 2. Change in Returns to Primary Factors

Scenario	Wage Rate	Rental Rate
Policy Experiment	-0.0181%	0.0000%
Scenario 1	0.0000%	0.0000%
Scenario 2	-0.0042%	0.0057%
Scenario 3	-0.0077%	0.0105%

Table 3. Change in Labor Demand

Sector	Policy Experiment	Scenario 1	Scenario 2	Scenario 3
SNAPFD	-0.12%	-0.17%	-0.11%	-0.10%
SINPROD	0.06%	0.08%	0.07%	0.08%
FDRTL	0.02%	0.03%	0.04%	0.04%
AGR	-0.10%	-0.19%	-0.09%	-0.08%
NATRES	-0.03%	-0.02%	-0.02%	-0.01%
CONST	-0.02%	-0.03%	-0.01%	-0.01%
UTIL	-0.20%	-0.37%	-0.19%	-0.18%
TRAD	0.13%	0.15%	0.15%	0.15%
MIN	-0.01%	0.01%	0.00%	0.00%
MAN	0.02%	0.03%	0.04%	0.04%
SER	-0.07%	-0.08%	-0.06%	-0.06%

Table 4. Change in Capital Demand

Sector	Policy Experiment	Scenario 1	Scenario 2	Scenario 3
SNAPFD	-0.12%	0.00%	-0.12%	-0.12%
SINPROD	0.06%	0.00%	0.06%	0.06%
FDRTL	0.02%	0.00%	0.03%	0.02%
AGR	-0.10%	0.00%	-0.10%	-0.10%
NATRES	-0.03%	0.00%	-0.03%	-0.03%
CONST	-0.02%	0.00%	-0.02%	-0.03%
UTIL	-0.20%	0.00%	-0.20%	-0.20%
TRAD	0.13%	0.00%	0.14%	0.14%
MIN	-0.01%	0.00%	-0.01%	-0.01%
MAN	0.02%	0.00%	0.03%	0.02%
SER	-0.07%	0.00%	-0.07%	-0.07%

Table 5. Change in Supply of Primary Factors

Scenario	Labor	Capital
Policy Experiment	-0.0181%	0.0000%
Scenario 1	-0.0164%	0.0000%
Scenario 2	-0.0034%	0.0045%
Scenario 3	0.0000%	0.0000%