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An analysis of U.S. regional implications of tariff reductions under the Doha Round of negotiations

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Abstract

Simulated effects of tariff reductions under the Doha Round negotiations are analyzed with emphasis on their regional implications in the United States. The simulations are performed with an applied general equilibrium model of the U.S. economy, which has 13 single-output industries and 11 regions. Ten regions represent the U.S. economy; the eleventh region represents the rest of the world. The model is calibrated to recent data for domestic-world price gaps.

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1 Introduction

This draft analyzes simulated effects of tariff reductions under the Doha Round negotiations with emphasis on their regional implications in the United States. The simulations are performed with an applied general equilibrium (AGE) model of the U.S. economy. The AGE model has 13 single-output industries and 11 regions. Ten regions represent the U.S. economy; the eleventh region represents the rest-of-the-world (ROW). In each region, producers, consumers and governments trade with economic agents in all U.S. regions; they also engage in international trade with the ROW. The model is calibrated to recent data for domestic-world price gaps.

Preliminary results suggest that U.S. GDP and welfare increase due to the tariff removals. As expected, the percentage gains in GDP and welfare are small. U.S. exports increase by around 9 percent and U.S. imports increase by around 7 percent. The macro implications for the ROW are similar to those in the United States. Assumptions about labor and capital mobility in the United States do not affect macro results significantly. The tariff removals simulated in this paper cause an expansion in all U.S. industries except forestry, apparel; and services.

At the region level, gross region product (GRP) is not affected significantly by the policy change when U.S. factors of production can not relocate in the United States. When labor and capital are allowed to relocate, however, the GRP changes are larger. The simulated tariff removals create the conditions in the Northern Plains, Southern Plains, and Delta regions to attract primary factors from other U.S. regions.

The paper is organized as follows: the second section provides an overview of the methodology. The third section specifies the simulations. Section four presents some of the results of our simulations. The fourth section has summary and conclusions.

2 Methodology

The simulations are performed with an applied general equilibrium (AGE) model of the U.S. economy (see Tsigas, 1997; Canning and Tsigas, 2000; and Das *et al.*, 2005). The AGE model has 13 single-output industries and 11 regions. Ten regions represent the U.S. economy; the eleventh region represents the rest-of-the-world (ROW). In each region, producers, consumers and governments trade with economic agents in all U.S. regions; they also engage in international trade with the ROW. The model is calibrated to recent data for domestic-world price gaps from the GTAP modeling framework (Dimaranan and McDougall, 2005).

2.1 Structure of AGE model and data

The AGE model divides the U.S. economy into several regions; an ROW region represents all other economies. Each regional economy, including the ROW, is specified with demand and production structures. Subject to transportation costs, each U.S. region engages in commodity trade with other U.S. regions and the ROW region. Commodity prices are determined by market clearing through interregional and international trade.

Each regional economy consists of producing sectors, private households, regional governments (for U.S. regions and the ROW), and federal governments (for U.S. regions). All agents are price-takers and their demands for commodities and primary factors are based on cost minimizing or utility maximizing behavior. Cost minimizing sectors produce a single commodity, using as inputs primary factor services and intermediate products. Intermediate (and final demand) users of commodities are assumed to differentiate a commodity by its region of origin, i.e., the Armington specification is applied (Armington, 1969).

On the demand side of the model, in each region, households maximize utility subject to a regional budget constraint. They purchase commodities and they save part of their income, which consists of returns to primary factors and net tax collections. In each region, aggregate investment in new capital goods is represented by the output of a capital goods sector. Globally, the sum of household savings is equal to the sum of investment expenditures. The price index of global savings is the numeraire in the model.

Integrated into this model are U.S. and foreign policies, which induce changes in producer and consumer decisions in all regions and in economic efficiency.

The AGE model is solved using the GEMPACK suite of software (Harrison and Pearson, 1994; and Pearson, 1991).

Welfare and household demands. Figure 1 outlines a utility tree for households in each region of the model. The utility tree consists of a four-level utility tree of mostly Constant Elasticity of Substitution (CES) functions.

Demanders of commodities are assumed to treat imports from different sources as imperfect substitutes. Thus, demands reflect cost minimization across *within-region* and *out-of-region* sources of supply. At level 4, in figure 1, the elasticity of substitution σ_L>0 determines the degree of substitution which occurs between within-region and out-of-region composite commodities. Within-region commodities are produced in the region. Out-of-region composite commodities are aggregates of imports from all other U.S. regions. Out-of-region and within-region varieties of the same commodity are aggregated to a domestic composite commodity. At level 3, the elasticity of substitution σ_D determines the degree of substitution which occurs between the domestic composite variety and its foreign counterpart. This yields composite commodities for each commodity in the model. Substitutions at levels 4 and 3 implement the Armington assumption at the household level. At level 5, the elasticity of substitution σ_S determines the degree of substitution which occurs across other regional sources of supply for each commodity. Substitutions at level 5 apply for the regional economy as a whole, when commodities enter the region. Elasticities σ_D, σ_L, and σ_S are commodity specific.

Substitution at levels 3, 4, and 5, in figure 1, contain elasticities the values of which are important for model results on regional impacts of policies. Elasticities of substitution between foreign imports and the domestic composite commodity (i.e., elasticity σ_D) largely determine the U.S. national import price elasticities of demand for each commodity. These elasticities determine the extent to which policies cause changes in the composition between foreign and U.S. domestic sources of supply, and thus they influence the national terms-of-trade. The values of elasticities of substitution between within-region and out-of-region varieties (i.e., elasticity σ_L) largely determine the extend to which a region's terms-of-trade improve or deteriorate due a policy change.

The utility tree is different for the ROW region. First, in the ROW, the elasticity σ_S (at level 5 in figure 1) determines substitution across U.S. regional sources of supply for each commodity. This yields a composite foreign commodity for each commodity in the model. Substitutions at level 5 apply for the ROW as a whole, when commodities enter its border. Second, the elasticity σ_L (at level 4 in figure 1) is not relevant for the ROW because there are not any sub-regions in the ROW.

At the top of the utility tree, in figure 1, regional welfare is derived from private household expenditures, government expenditures, and savings. In particular, each household maximizes utility subject to a regional income constraint. In the U.S. regions of the model, there are two types of government expenditures: state and federal. Currently, there is no economic mechanism that links federal government expenditures in U.S. regions. In the ROW there is only one type of government.

It is assumed that the simulations do not change the distribution of regional income across private and government expenditures, and savings. This assumption is implemented by applying a Cobb-Douglas function to describe substitutions between the four components of welfare (in this case the elasticity of substitution, σ, is equal to 1, and budget shares are constant).

Household demands for composite commodities are specified with two functional forms. First, it is assumed that substitutions between composite commodities for government demands can be described with Cobb-Douglas functions. Second, private household (i.e., consumer) demands for composite commodities are based on the Constant *Differences* of Elasticities (CDE) expenditure function (Hanoch 1975 and 1978; Surry 1989 and 1993; Hertel *et al.*, 1991 and Hertel, 1997).

Sectoral demands. Producing sectors demand two types of inputs: primary factors and intermediate inputs. The primary factor composite is a CES aggregate of land (where appropriate), labor, and capital. There is no substitution between the primary factor composite and intermediate inputs (i.e., a Leontief technology is assumed). Producer demands for foreign, out-of-region, and within region varieties of commodities have the same structure as those for households (i.e., substitutions as in levels 3, 4, and 5, in figure 1, apply to producers too).

Interregional and international trade. The main features of the model treatment of trade are the Armington assumptions discussed earlier. In addition, a global sector demands services from each regional transportation services sector, to provide a composite service which is used for shipping commodities across regions. A second global sector intermediates between regional savings and regional investment. This global sector has a portfolio of regional net investments which are offered to regional households to satisfy their demand for savings. Regarding the regional composition of net investment, a negative relationship between the expected regional rate of return on capital and the amount of investment undertaken in a region is assumed.

Primary factor mobility. Each region has an endowment of land, labor, and capital. Labor and capital are assumed to be intersectorally perfectly mobile. This implies that all sectors, in a region, face the same market price for labor and the same market price for capital. Land rents are allowed to be different across sectors.[1]

To explore the implications of factor mobility across U.S. regions, the assumption of fixed endowments in a region can be relaxed and allow labor and capital to relocate to other regions. This assumption is implemented with a system of regional labor and capital supplies functions which are derived from Constant Elasticity of Transformation (CET) functions, with elasticities of transformation, $\sigma_i^{US} < 0,\ \ i \in \{\text{Labor}, \text{Capital}\}$.

The database. The 1987 input-output (IO) table of the U.S. economy (Bureau of Economic Analysis) and State-level employment statistics (Bureau of Census, *County Business Patterns*) are the building blocks in assembling regional economic accounts.

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[1] This assumption is implemented with a system of land supply functions which are derived from a Constant Elasticity of Transformation (CET) function, with an elasticity of transformation σ_T<0.

To derive producer accounts for each U.S. State, statistics on employment, by State were used and the assumptions that: (1) for each industry/commodity, average output per employee is the same across States; (2) for each industry/commodity, cost shares are the same across States. Private household expenditures for the U.S. as a whole are pro-rated across states using statistics on total personal income, by State (Bureau of Economic Analysis, "Personal Income, by State"). National federal government expenditures (for the two aggregates of defense and other) and U.S.-aggregate State government expenditures (for the three aggregates of education, hospitals, and other) are pro-rated across U.S. States using federal government expenditures, by State (Consolidated Federal Funds Report, U.S. Census Bureau), and State government expenditures, by State (State Government Finance Summary Tables, by State, U.S. Census Bureau). The U.S. national gross investment, by industry, was pro-rated across the U.S. States using the computed State-level sectoral output.

The IO table provides import and export statistics for the U.S. economy as whole. Two additional sources of information were used to describe trade linkages between U.S. States and those between U.S. States and the ROW. One of them is the Commodity Flow Survey on inter-state trade flows for commodities (Bureau of Transportation Statistics) and the other is the State Merchandise Export statistics (International Trade Administration). This data, along with information on U.S. industry expenditures on transportation costs (from the IO table), allow construction of transportation cost information by commodity, and trade route. Percentage transportation costs for international trade were obtained from the GTAP database (Gehlhar *et al.*).

The State Merchandise Export statistics provide the data for exports from U.S. States to the ROW. For commodity aggregates for which the State Export data do not have information, U.S. national exports were pro-rated across States.

Values for model parameters have been adopted from the GTAP (Huff *et al*.) modeling framework.

3 Specification of simulation and closures

Our data has 3 primary factors: land, labor, and capital. The industry and region specification is shown in Table 1 and Figure 2. There are 13 industries, and 11 regions; 10 of the regions are U.S. regions; the 11th region is the rest of the world.

The policy change that is simulated in this paper is removal of the import tariffs in the model (see Table 2 for the import tariffs in the model). Four different simulations of the policy change are discussed in this paper. In the first simulation, it is assumed that labor and capital are not mobile across the 10 U.S. regions, that is the two CET elasticities (σ_i^{US}, $i \in \{Labor, Capital\}$), which regulate intra-U.S. factor mobility, are zero. In the second simulation, labor is assumed to be partially mobile across U.S. regions (with $\sigma_{Labor}^{US} = -5.0$). In the third simulation, capital is assumed to be partially mobile across U.S. regions, with labor impartially mobile across regions (with $\sigma_{Capital}^{US} = -5.0$ and $\sigma_{Labor}^{US} = 0$). In the fourth simulation, both labor and capital are assumed to be partially mobile across U.S. regions (with $\sigma_i^{US} = -5.0$, $i \in \{Labor, Capital\}$).

4 Implications of tariff removals

This section discusses the macro and regional implications of global tariff removals. First, the macro and sectoral implications are discussed. The next section discusses the U.S. regional implications of tariff removals.

4.1 Macro and sectoral implications

Table 3 shows selected macro and sectoral results from the four simulations. U.S. GDP and welfare increase due to the tariff removals. As expected, the percentage gains in GDP and welfare are small. U.S. exports increase by around 8.6 percent and U.S. imports increase by around 6.5 percent. The macro implications for the ROW are similar to those in the United States. The percentage gains in GDP are small; welfare declines slightly. ROW exports increase by around 6.5 percent and ROW imports increase by around 8.6 percent.

Assumptions about the mobility of labor and capital among U.S. regions do not affect the results significantly, although there trade increases by slightly more when labor and when both labor and capital are partially mobile across U.S. regions. When only capital is partially mobile across U.S. regions, there is larger increase in U.S. imports and a smaller increase in U.S. exports.

The tariff removals simulated in this paper favor all U.S. industries except forestry, apparel; and services; in the ROW, minerals and fuels, textiles, leather, apparel and other manufactures expand. Assumptions about the mobility of labor and capital among U.S. regions do not affect the industry output results significantly.

4.2 U.S regional implications

Figures 2 and 3 present some the regional implications from the removal of import tariffs. Gross region product (GRP) does is not affected significantly by the policy change when U.S. factors of production can not relocate in the United States (Sim1 in Figure 2). When labor (Sim2) and when capital (Sim3) are allowed to relocate, however, the GRP changes are larger.

If labor were partially mobile, it would relocate from the North East, Appalachia, Corn Belt, and Pacific regions to the South East, Lake, Delta, Northern Plains, Southern Plains and Mountain regions. As a result, GRP in the former group of regions would decline and GRP in the latter group of regions would expand (Sim2 in Figure 2). GRP would expand the most in the Northern Plains, Southern Plains, and Delta regions.

If capital were partially mobile, it would relocate from the North East, South East, Lake, Corn Belt, Mountain, and Pacific regions to the Appalachia, Delta, Northern Plains, and Southern Plains regions. As a result, GRP would expand in the latter group of regions (Sim3 in Figure 2). GRP would expand the most in the Southern Plains, Northern Plains, and Delta regions.

If both labor and capital were partially mobile, their relocation patterns would be the same as if only one of the factors could relocate, except in the case of the Appalachia region which would attract labor instead of losing labor. GRP would expand the most in the Northern Plains, Southern Plains and Delta regions. GRP would decline more than expected in the North East.

Figure 3 shows the regional implications of tariff removal for labor wages, and capital and land rents. As expected, labor wages would increase in the Northern Plains, Southern Plains, and the Delta region (Sim1 in the Labor wages panel in Figure 3). Wages in those three regions would increase by less when labor is partially mobile across U.S. regions (Sim2 in the Labor wages panel in Figure 3). Capital and land rents increase by more when labor is partially mobile across U.S. regions (Sim2 in the Capital rents and Land rents panels in Figure 3).

5 Summary and conclusions

This paper analyzed simulated effects of tariff reductions under the Doha Round negotiations with emphasis on their regional implications in the United States. The simulations were performed with an applied general equilibrium (AGE) model of the U.S. economy. The AGE model has seven single-output industries and eleven regions. Ten regions represent the U.S. economy; the eleventh region stands for the rest-of-the-world (ROW).

Simulation results suggest that U.S. GDP and welfare increase due to the tariff removals. As expected, the percentage gains in GDP and welfare are small. U.S. exports increase by around 9 percent and U.S. imports increase by around 7 percent. The macro implications for the ROW are similar to those in the United States. Assumptions about labor and capital mobility in the United States do not affect macro results significantly. The tariff removals simulated in this paper cause an expansion in all U.S. industries except forestry, apparel; and services.

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This work applied the so-called “bottoms-up” approach to regional modeling. The bottoms-up methodology begins with economic models of several regions which are then linked via various interregional flows of commodities, labor, and capital. The bottoms-up approach explicitly models the behavior of economic agents at the regional level. The so-called "tops-down" approach obtains effects at the region level by distributing effects obtained from a national model to regions (Leontief *et al.* and Dixon *et al.*). The revised paper would examine the consequences of the "tops-down" approach for tariff removal analysis.

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Table 1. Industry and region specification

Number	Industry	Number	Region
1	Food grains		**U.S. regions**
2	Feed grains	1	North East
3	Other crops	2	Appalachia
4	Livestock	3	South East
5	Forestry	4	Lake
6	Minerals and fuels	5	Corn Belt
7	Meat and dairy	6	Delta
8	Other foods	7	Northern Plains
9	Textiles and leather products	8	Southern Plains
10	Lumber, wood and paper products	9	Mountain
11	Apparel	10	Pacific
12	Other manufactures	11	Rest of world (ROW)
13	Services		

Note: U.S. regions are specified in Figure 1.

Table 2. Import tariffs in model

	Import tariffs on	
Industry	**Imports from ROW into U.S. regions**	**Imports from U.S. regions into ROW**
	------ *percent* ---------	
Food grains	0.49	35.90
Feed grains	0.02	43.19
Other crops	1.47	20.69
Livestock	0.09	4.35
Forestry	0.05	0.54
Minerals and fuels	0.19	2.03
Meat and dairy	5.11	32.22
Other foods	2.68	17.07
Textiles and leather products	9.70	5.50
Lumber, wood and paper products	0.21	2.24
Apparel	9.90	11.15
Other manufactures	1.02	2.71
Services	0.00	0.00

Source: GTAP database.
Note: There is no intra-ROW trade in this paper.

Table 3. Macro and sectoral implications of tariff removals

	Sim1	Sim2	Sim3	Sim4
	-------------- *percent* ---------------			
United States				
GDP, volume	0.02	0.02	0.02	0.02
Welfare	0.12	0.12	0.12	0.11
Exports, volume	8.68	8.69	8.67	8.71
Imports, volume	6.54	6.55	6.56	6.58
Industry supply				
Food grains	19.97	20.02	20.04	20.18
Feed grains	3.93	3.96	3.95	4.04
Other crops	6.70	6.72	6.75	6.83
Livestock	3.51	3.55	3.58	3.70
Forestry	-1.50	-1.48	-1.50	-1.43
Minerals and fuels	4.40	4.46	4.65	4.88
Meat and dairy	3.02	3.05	3.06	3.13
Other foods	2.42	2.44	2.48	2.54
Textiles and leather products	2.92	2.94	3.00	3.10
Lumber, wood and paper products	0.51	0.52	0.52	0.55
Apparel	-2.65	-2.63	-2.59	-2.50
Other manufactures	-0.89	-0.87	-0.89	-0.86
Services	-0.22	-0.21	-0.21	-0.20
Rest of world				
GDP, volume	0.17	0.17	0.17	0.17
Welfare	-0.02	-0.01	-0.02	-0.01
Volume of exports	6.54	6.55	6.56	6.58
Volume of imports	8.68	8.69	8.67	8.71
Industry supply				
Food grains	-7.24	-7.25	-7.24	-7.25
Feed grains	-16.10	-16.11	-16.10	-16.11
Other crops	-5.51	-5.51	-5.50	-5.51
Livestock	-2.94	-2.94	-2.94	-2.95
Forestry	-0.46	-0.47	-0.46	-0.47
Minerals and fuels	0.32	0.33	0.32	0.33
Meat and dairy	-6.10	-6.11	-6.11	-6.13
Other foods	-1.06	-1.06	-1.06	-1.06
Textiles and leather products	7.06	7.06	7.07	7.07
Lumber, wood and paper products	-0.21	-0.21	-0.21	-0.21
Apparel	10.72	10.72	10.73	10.72
Other manufactures	0.58	0.58	0.58	0.57
Services	0.03	0.03	0.03	0.04

Note: Column "Sim1" shows simulation results under the assumption that primary factors are not mobile across U.S. regions; "Sim2" shows simulation results under the assumption that labor is partially mobile across U.S. regions; "Sim3" shows simulation results under the assumption that capital is partially mobile across U.S. regions; "Sim4" shows simulation results under the assumption that both labor and capital are partially mobile across U.S. regions.

Figure 1. Regional welfare and household demands

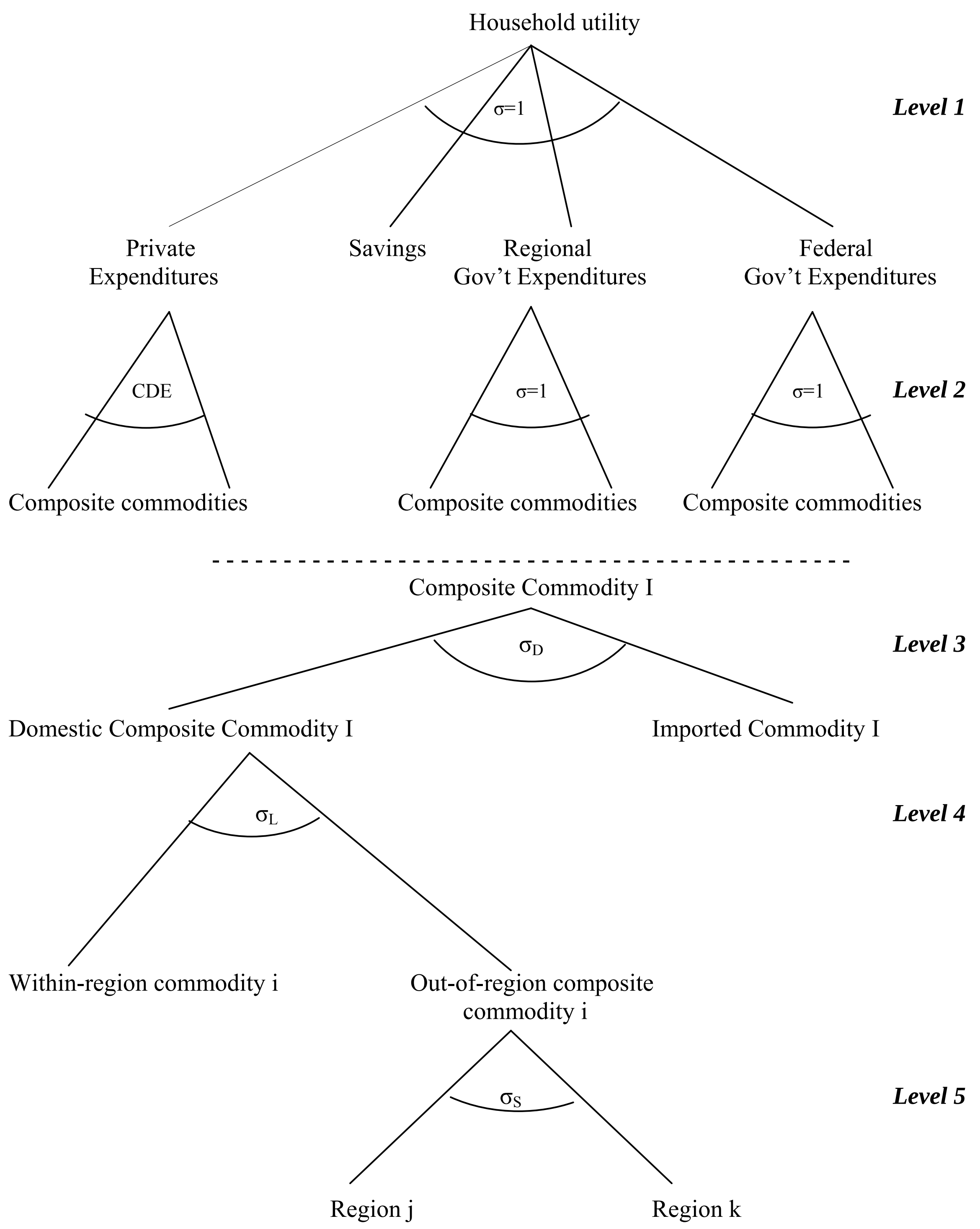
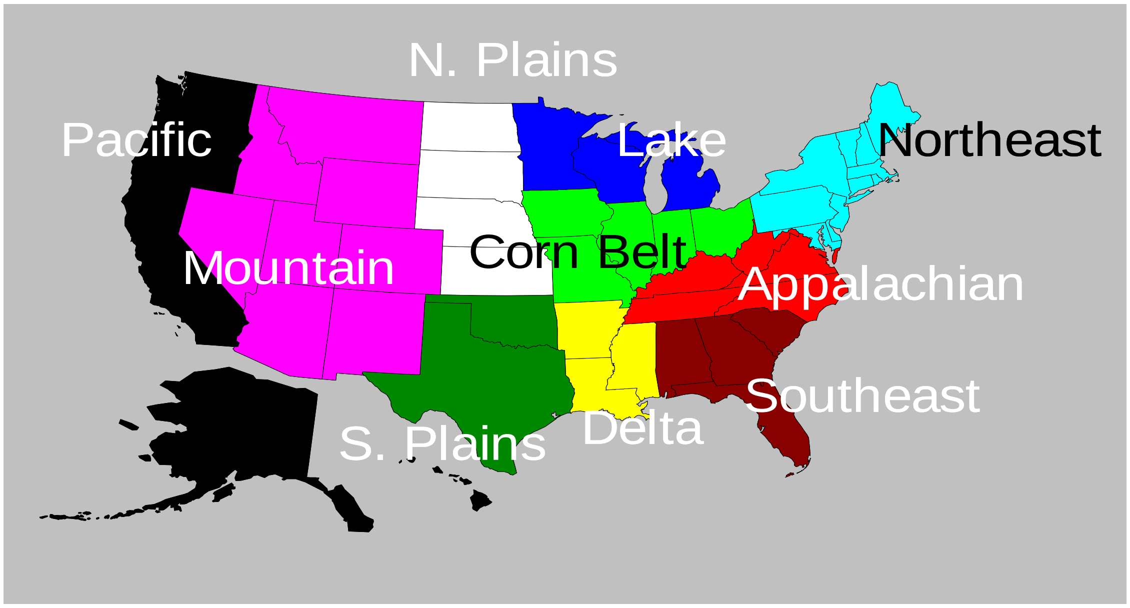
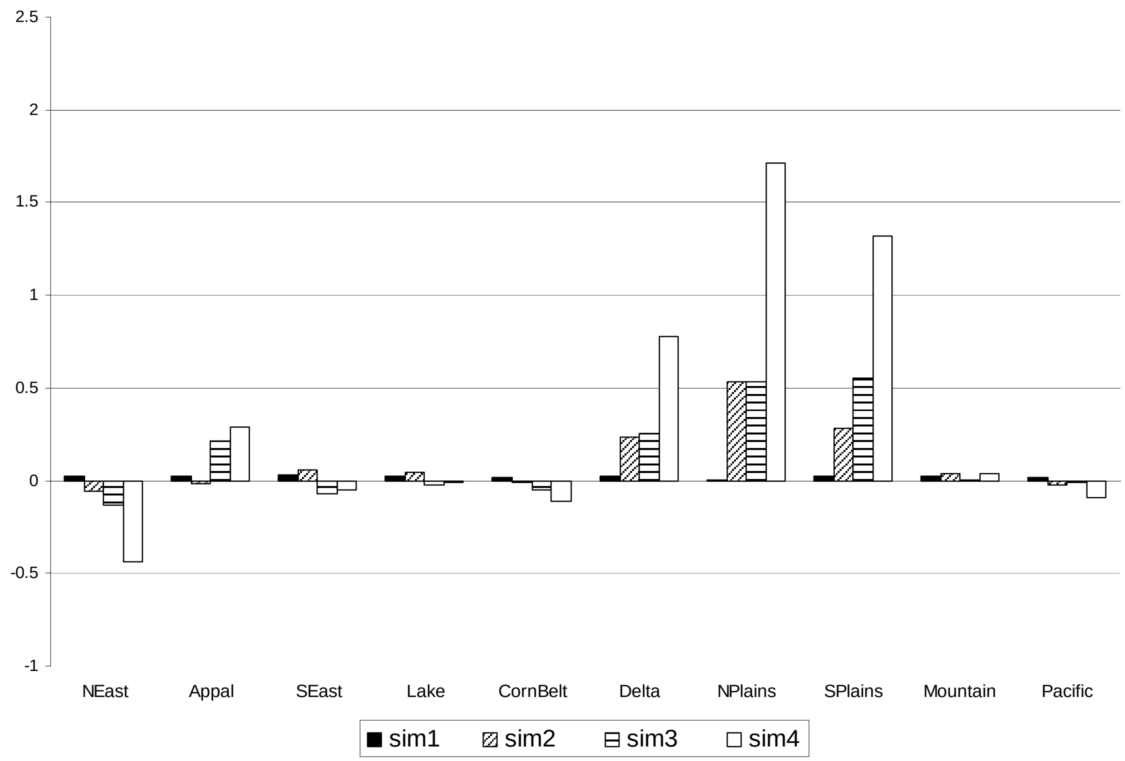


Figure 2. Specification of U.S. regions



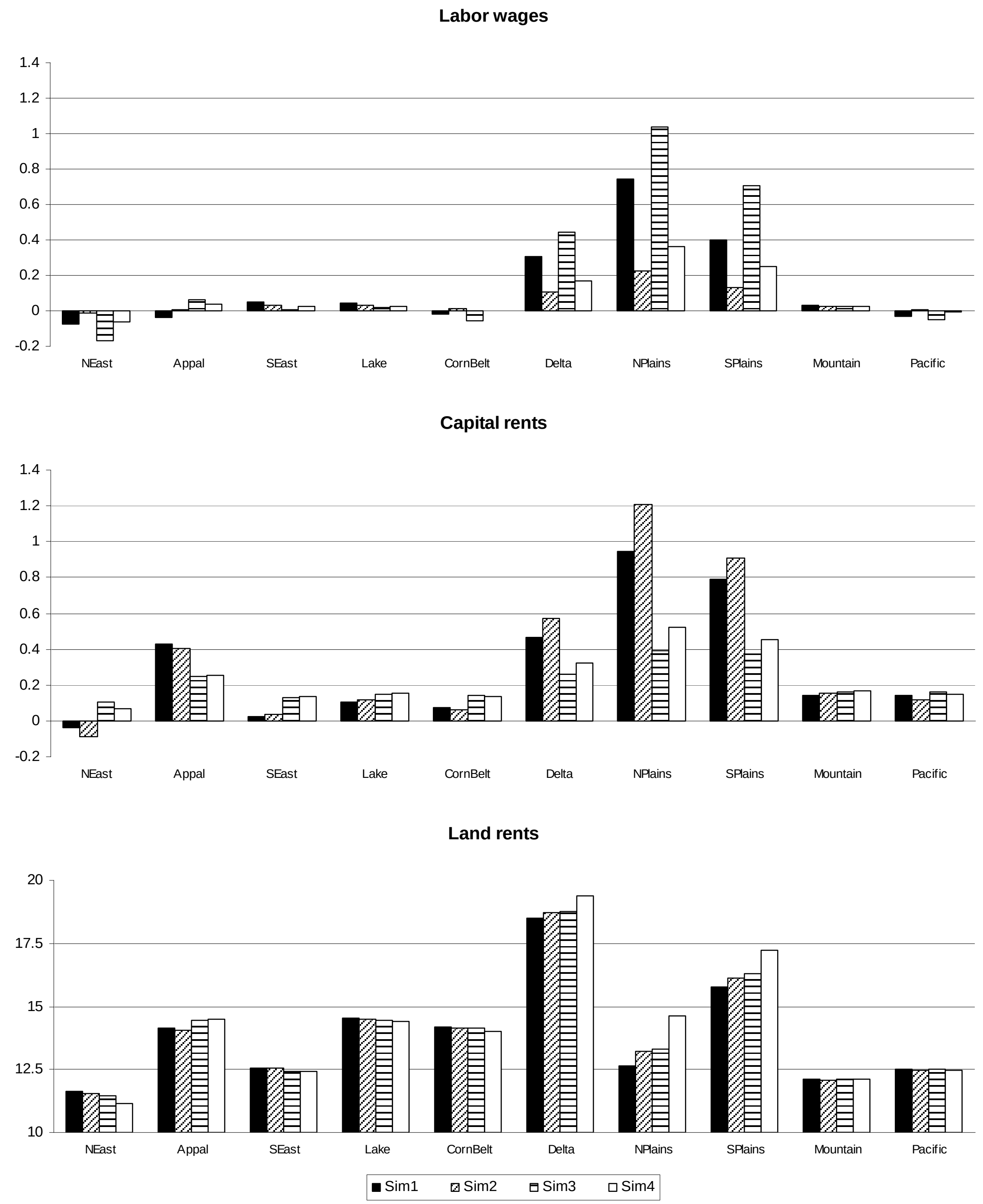
Note: Regions have the following number of states: Northeast, 12; Appalachian, 5; Southeast, 4; Lake, 3; Corn Belt, 5; Delta, 3; Northern Plains, 4; Southern Plains, 2; Mountain, 8; and Pacific, 5.

Figure 2. Impacts on gross region product, percent change in volume



Note: "sim1" shows simulation results under the assumption that primary factors are not mobile across U.S. regions; "sim2" shows simulation results under the assumption that labor is partially mobile across U.S. regions; "sim3" shows simulation results under the assumption that capital is partially mobile across U.S. regions; "sim4" shows simulation results under the assumption that both labor and capital are partially mobile across U.S. regions.

Figure 3. Impacts on primary factor wages and rents, percent change



Note: "sim1" depicts simulation results under the assumption that primary factors are not mobile across U.S. regions; "sim2" depicts simulation results under the assumption that labor is partially mobile across U.S. regions; "sim3" depicts simulation results under the assumption that capital is partially mobile across U.S. regions; "sim4" depicts simulation results under the assumption that both labor and capital are partially mobile across U.S. regions.