Model Exercise Answer Key

Model Exercise 2

B.2 REG = US, ROW are the regions in the database
B.3 TRAD_COM = AGR, MFG, and SER are the sectors in the database
B.4 END_COM = land, labor, capital are the factors of production in the database
C. An error message: "You cannot view more than two dimensions."
D. INCPAR("USA", "SER") = 1.0.

Table ME 2.1. *Elasticity Parameters for U.S. Agriculture (answer key)*

Elasticity	Value
Supply parameters	
Factor substitution (ESUBVA)	0.2
Intermediate input substitution (ESUBT)	0.0
Demand parameters	
Consumer income (INCPAR)	0.3
Consumer substitution (SUBPAR)	0.7
Import substitution (imports v. domestic good) (ESUBD)	3.8
Import substitution (among trade partners) (ESUBM)	10.1

Table ME 2.2. *Tax Rates for U.S. Agriculture (answer key)*

Tax rate	Name	Value
rTO	% ad valorem rate, output (or income) tax in region r	−1.0
rTF	% ad valorem rate, taxes on primary factors	−9.5
rTPD	% ad valorem rate, private domestic consumption taxes	4.1
rTPI	% ad valorem rate, private import consumption taxes	6.4
rTGD	% ad valorem rate, government domestic purchases taxes	0.0
rTGI	% ad valorem rate, government import purchases taxes	0.0
rTFD	% ad valorem rate, taxes on firms' domestic purchases	−4.0
rTFI	% ad valorem rate, taxes on firms' import purchases	−4.1
rTXS	% ad valorem rate, export taxes by destination	−0.0
rTMS	% ad valorem rate, import taxes by source	0.5

F.1 Variable definitions:

pm = market price of commodity *i* in region *r*
pop = regional population
ps = supply price of commodity *i* in region *r*
qfe = demand for endowment *i* for use in industry j in region *r*
qiw = aggregate imports of *i* in region s, CIF weights
qxw = aggregate exports of *i* from region *r*, FOB weights

F.2 Population is exogenous and all the rest of the variables listed in F.1 are exogenous.

Model Exercise 3

C2. *to* is defined as the output or income tax in region r.
C3. −.8017
C4. a tax

Table ME 3.1. *Results of a 5 percent Production Subsidy to U.S. Manufacturing, with Different Elasticities and Closures (answer key)*

	Definition of Variable	Base Results	High Factor Substitution Elasticity in MFG	Unemployment Closure
qo("MFG","USA")	Industry output of MFG in USA	2.98	2.95	23.91
qo("MFG","ROW")	Industry output of MFG in ROW	−0.23	−0.22	0.42
qfe("LABOR", "MFG", "USA")	Demand for LABOR in MFG in USA	2.91	2.76	33.25

Source: GTAP model, GTAP v.7.0 U.S. 3x3 database.

Table ME 3.2. *Welfare Decomposition of a 5 percent Production Subsidy to U.S. Manufacturing (answer key)*

Resource Allocation Effect	Endowment Effect	Technical Change	Population Growth	Terms of Trade	Investment–Savings Terms of Trade	Preference Change	Total
1 alloc_A1	2 endw_B1	3 tech_C1	4 pop_D1	5 tot_E1	6 IS_F1	7 pref_G1	
7,399.7	0	0	0	23,477	27,055	0	57,932

Source: GTAP model, U.S. 3x3 v.7.0 database.

a. *qo*("MFG", "USA") = 2.98
b. Mean = 2.96
c. Standard deviation = 0.14

Table ME 3.4. *Confidence Intervals for the Output Quantity Result with a 100 percent Variation in the Factor Substitution Elasticity (answer key)*

Confidence Interval	Mean (X)	Standard Deviation (sd)	Standard Deviation Multiplier (K)	Upper Limit (X + sdK)	Lower Limit (X − sdK)
75 percent	2.96	0.14	2	3.24	2.68
88.9 percent	2.96	0.14	3	3.38	2.54
95 percent	2.96	0.14	4.47	3.59	2.33
99 percent	2.96	0.14	10	4.36	1.56

Model Exercise 4

Table ME 4.1. *Elasticities in Two Scenarios of a 50 percent Increase in the World Agricultural Price (answer key)*

	Scenario 1		Scenario 2	
Elasticities	INCPAR	SUBPAR	INCPAR	SUBPAR
Agriculture	0.25	0.74	1	0
Manufacturing	0.87	0.24	1	0
Services	1.04	0.22	1	0

Table ME 4.2. *Household Budget Shares (answer key)*

	Base	Scenario 1	Scenario 2
Agriculture	.009	.010	.009
Manufacturing	.203	.203	.203
Services	.789	.786	.789

Table ME 4.3. *Effects of a 50 percent Increase in the World Price of Imported Agriculture (% change from base) (answer key)*

	Consumer Price	Consumer Commodity Quantity	Household Domestic Quantity	Household Import Quantity	Production Quantity	Household Expenditure	Welfare $U.S. Million
GTAP variable name	*pp*	*qp*	*qpd*	*qpm*	*qo*	*yp*	*EV*
CDE utility							
Agric.	25.24	−6.95	5.93	90.16	53.92	−0.72	−70,651.7
Mfg.	1.87	−2.24	−4.52	−3.94	−5.66		
Services	−0.73	−0.29	−0.27	−1.70	−.31		
Cobb-Douglas							
Agr.	24.79	−25.01	−11.86	−109.90	51.45	−0.22	−19,239.23
Mfg.	2.16	−2.38	−5.01	4.75	−6.26		
Services	−.22	0.0	0.00	0.43	−0.13		

1. The utility functions assume negative own-price elasticities. With income constant, as the price rises, demand should fall. In the CGE model, the demand quantity falls in both scenarios.
2. The CDE demand system is nonhomothetic. AGR is a necessity good, SER is a luxury good, and MFG is a necessity that is more responsive to income changes

than AGR. The CD function so, holding prices constant, demand quantities of all three goods changes by the same proportion as income.

3. AGR/MFG: $(-25.01 + 2.38)/(2.16 - 24.79) = 1$
   AGR/SER: $(-25.01 - .00001)/(-0.22 - 24.79) = 1$
   Both indifference curves would be relatively curved.
4. The CDE demand system allows flexible budget shares. In the CDE scenario, the agricultural budget share rises because the price rises, and the quantity demanded does not fall by enough to compensate. The CD utility function imposes fixed budget shares, so the change in quantity exactly offsets percentage changes in price and income.
5. Both scenarios describe a substantial decline in imports and increased consumer demand for the domestic variety of AGR. This causes U.S. agricultural output to increase. Higher agricultural output will exert a pull on the productive resources used in MFG and SER, so their output will decline.
6. The Armington assumption implies that consumers differentiate goods by country of origin, and consumers' willingness to substitute among the varieties is governed by an import substitution elasticity. Both models include import substitution elasticities for AGR of 3.75. Consumer demand shifts to the lower-priced domestic variety, so imports fall and consumption of the domestic good rises in both scenarios.
7. For scenario one, the elasticity of import substitution is:

$$(-90.16 - 5.93)/(21.80 - 47.42) = 3.75$$

   For scenario two, the elasticity of import substitution is:

$$(-109.90 + 11.86)/(21.29 - 47.43) = 3.75$$

8. A change in EV welfare measures the income equivalent of the change in utility due to changes in prices. U.S. welfare declines in both experiments; the magnitude is sensitive to the choice of utility function.
9. The income results do not differ much between the two scenarios because food is a small share of the U.S. budget.

Model Exercise 5

1. See the technology tree in Figure 5.1. Your tree will look similar, with a value-added nest containing K, L, and Land, governed by a factor substitution elasticity of 0.2 and an intermediate input bundle that contains AGR, MFG, and SER inputs, governed by an intermediate input substitution elasticity of zero. The two bundles are combined to produce AGR governed by an aggregate input substitution elasticity of zero.
2. Price changes could lead to factor substitution in the CGE model, but no substitution among intermediates, or between the intermediate and value-added bundles.
3. AGR becomes more land intensive and less intensive in the use of labor and capital. This is consistent with land rents that are falling relative to wage and

Table ME 5.1. *Base and Updated Subsidy Rates (answer key)*

	Base Rate	Updated Rate
Production subsidy rto ("AGR", "USA") (negative value = tax)	−1.0	0
Land subsidy rtf ("LAND", "AGR", "USA") (negative value = subsidy)	−9.5	0
Intermediate input subsidy on domestic input rtfd ("AGR", "AGR", "USA") (negative value = subsidy)	−4.0	0
Intermediate subsidy on imported input rtfi ("AGR", "AGR", "USA") (negative value = subsidy)	−4.1	0

Table ME 5.2. *Effects of U.S. Agricultural Subsidy Elimination (% change from base) (answer key)*

		Base ESUBVA Factor Substitution Elasticity				
		Subtotals				
	Variable Name in GTAP	Total	Output Tax/ Subsidy Effect	Land Tax/ Subsidy Effect	Intermediate Input Tax/ Subsidy Effect	ESUBVA = 2 TOTAL
Agricultural output quantity	*qo* (AGR,USA)	−0.37	0.97	0	−1.34	−0.59
Agricultural producer price	*ps*(AGR,USA)	1.25	0.42	0.01	0.82	1.33
Land rent	*ps*(LAND,USA)	−11.31	5.07	−9.38	−7	−9.83
Labor wage	*ps*(LABOR,USA)	−0.02	0.09	0.01	−0.12	−0.04
Capital rent	*ps*(CAPITAL,USA)	−0.03	0.12	0.01	−0.16	−0.05
Household consumption	*qp* (AGR,USA)	−0.06	0.16	0	−0.22	−0.09
Export quantity	*qxw*(AGR,USA)	−1.61	4.19	0	−5.8	−2.57

capital rents. Intermediate input-output ratios are unchanged, consistent with the Leontief intermediate input technology in the U.S. 3x3 model.

4. The loss of the land subsidy effect has little impact except on land rents. The other two reforms have offsetting effects in many instances. Policy makers may want to select reforms with different impacts, or phase them all in together, knowing that they have off-setting impacts on AGR.
5. The total effects are only slightly larger when ESUBVA is higher. In this case, L and K more readily exit agriculture as farmers substitute toward the lower-cost land input.
6. Agriculture accounts for only 1 percent of U.S. household spending so U.S. consumers are not likely to be substantially affected by an agricultural reform program.

Table ME 5.3. *Change in Input-Output Coefficients due to U.S. Agricultural Policy Reform (% change from base)*

Output and Inputs	Output and Input Quantities	Change in Input-Output Coefficients (*qfe-qo*) or (*qf-qo*)
AGR output (*qo*)	−0.37	Not applicable
Land (*qfe*)	0.0	0.37
Labor (*qfe*)	−0.43	−0.6
Capital (*qfe*)	−0.43	−0.6
AGR intermediate (*qf*)	−0.37	0.0
MFG intermediate (*qf*)	−0.37	0.0
SER intermediate (*qf*)	−0.37	0.0

8. Land cannot be employed elsewhere, so a change in land use tax has no effect on quantity of land demanded, and therefore on AGR output levels. In the our simple 3x3 model, land is employed only in agriculture, whereas labor and capital are fully mobile across all three sectors; and all factors are fully employed.

Model Exercise 6

Table ME 6.1. *Effects of 10 percent Increase in the U.S. Supply of Unskilled Labor (answer key)*

	Factor Price (*pfe*)		Demand for Labor (*qfe*)		
			Unskilled	Skilled	Output (*qo*)
BORJAS – 10 percent increase in unskilled labor supply with high factor substitution					
Unskilled	−1.18	Agriculture	12.85	2.61	5.28
Skilled labor	−0.39	Manufactures	9.80	−0.16	4.42
Capital	−0.38	Services	9.99	−0.11	3.95
OTTA1 – 10 percent increase in unskilled labor supply with low factor substitution					
Skilled	−9.53	Agriculture	−2.19	−5.98	−4.91
Skilled labor	10.19	Manufactures	6.99	−3.06	1.49
Capital	9.28	Service	10.91	0.5	4.53
OTTA2 – 10 percent increase in unskilled labor, 6 percent increase in capital, low factor substitution					
Unskilled	−8.33	Agriculture	9.95	5.83	8.58
Skilled labor	10.93	Manufactures	10.34	0.30	6.42
Capital	−1.06	Services	9.92	−0.07	5.33

1. See Figures 6.2a and 6.2b in Chapter 6.
2. Change the factor substitution elasticities. A larger parameter value describes a more flexible production technology, with a relatively large substitution in factor input quantities given a percentage change in the inverse of their relative prices.
3. When firm technologies are assumed to allow easy substitution of among factors, a fall in the price of unskilled workers will lead to a fall in demand for and prices of the other two factors.

Table ME 6.2. *Real GDP Effects of a 10 percent Increase in U.S. Unskilled Labor Supply*

Scenario	% Change in Real GDP
BORJAS	4.04
OTTA1	3.90
OTTA2	5.56

4. See Figures 6.2c and 6.2d in Chapter 6.
5. Producers must hire more skilled labor and capital to complement their increased use of unskilled workers, which increases demand for and prices of skilled labor and capital.
6. An increase in the capital stock will shift the demand curves for both unskilled and skilled labor outward, if factors are assumed to be relatively complementary. Wages of both labor types will increase relative to the results of OTTO1.
7. The price of capital falls because the supply of capital increases.
8. AGR output declines in OTTA1 but expands in OTTA2. The difference between them is that the capital stock increases in OTTA2. AGR is the most capital-intensive U.S. sector. It expands because the factor cost share of capital is high in AGR, therefore an increase in capital that reduces rents lowers the production costs and price of AGR, compared to other sectors.
9. Real GDP grows because the endowment of productive resources grows. Real GDP growth is larger when the production technology is more flexible, allowing producers to better take advantage of an increase in an endowment and a fall in its price.

Model Exercise 7

Table ME 7.3. *Base Tax Rates in U.S. 3x3 Model (answer key)*

	Tax Rate					
	United States			Rest-of-World		
Tax type	Agr.	Mfg.	Services	Agr.	Mfg.	Services
Taxes on domestic intermediates used in agricultural production (rTFD)	−4.0	−1.0	−3.7	−1.4	2.2	−0.7
Taxes on imported intermediates used in agricultural production (rTFI)	−4.1	−2.0	−2.8	−1.5	0.4	−0.4
Export taxes (rTXS)	0	−0.3	0	−.4	−.8	0
Import tariffs (rTMS)	0.5	1.9	0	8.5	2.9	0

Source: GTAP v.7.0.

Table ME 7.4. *Welfare Effects of Trade Liberalization by Region and by Policy, $U.S. Millions (answer key)*

	Total	U.S. Agricultural Policy Reform	U.S. Nonagricultural Policy Reform	Rest-of-World Agricultural Policy Reform	Rest-of-World Nonagricultural Policy Reform
United States	14,565.39	−1,516.94	−10,632.93	7,860.50	18,854.70
ROW	−13,481.11	1,161.59	11,773.62	−6441.43	−19,974.88
World	1,084.29	−355.35	1,140.69	1,419.07	1,120.18

Note: Welfare is equivalent variation measure.
Source: GTAP model, GTAP v.7.0 U.S. 3x3 database.

Table ME 7.5. *Decomposition of the Total Welfare Effect, $U.S. Millions (answer key)*

	Total	Allocative Efficiency	Terms of Trade in Goods and Services	Terms of Trade in Savings-Investment
United States	14,565.39	1,030.0	11,909.5	1,625.9
ROW	−13,481.11	90.1	−11,941.0	−1,630.2
World	1,084.29	1,121.1	−31.5	−4.3

Note: Welfare is equivalent variation measure.
Source: GTAP model, GTAP v.7.0 U.S. 3x3 database.

Table ME 7.6. *Effect of Trade Liberalization on Exports (% change from base)*

	U.S.	Rest-of-World
Agriculture (*qxw*)	61.93	−0.77
Manufacturing (*qxw*)	8.07	0.71
Services (*qxw*)	−1.98	0.64

Source: GTAP model, GTAP v.7.0 U.S. 3x3 database.

1. The total world welfare effect is positive. The equivalent variation measure the income equivalent of the increase in utility due to the change in prices.
2. The main source is the benefit to the United States from ROW's non-agricultural policy reforms. A win-win strategy balances policies that benefit one country with policies that benefit its trade partner.
3. Export quantities increase most in sectors in which import tariffs are highest.
4. Both regions benefit from efficiency gains, but these are relatively small.
5. Terms-of-trade effects measure the price of a country's exports relative to its imports, or the import purchasing power of its exports. In this experiment, they are the most important component of each country's total welfare effect. The effects on USA and ROW offset each other, because in this two-region model, an increase in one country's import price is the same as an increase in the other's export price.

6. The import substitution elasticity has the most direct effect on terms of trade, because it influences the quantities of imports demanded when a country removes its tariffs, and therefore the supply quantity of its exports.
7. The toy 3x3 model's welfare effects are smaller because it is static, whereas theirs is a recursive dynamic model in which the economies have grown in size. Their model has more countries and commodities, and therefore more scope for efficiency gains.
8. Their tariff and subsidy rates are generally higher than in the 3x3 model, which may contribute to their higher welfare gains from reforms.

Model Exercise 8

10 a. Base tax revenue = 3,567,950
   b. Updated tax revenue = 3,690,278
   c. Change in government tax revenue = 122,328.

13 a. EV = −7,970.95
   b. Mean = −7,852.53
   c. Standard deviation = 935.67

Table ME 8.4. *Welfare Effects of a 1 percent Increase in U.S. Taxes, $U.S. Millions (answer key)*

Allocative Efficiency	Endowment	Technology	Population	Terms of Trade in Goods and Services	Terms of Trade in Investment-Savings	Preference	Total Welfare Cost	Change in Government Tax Revenue	Welfare Cost Per Dollar of Revenue
−3,509.1	0	0	0	−6,720.5	2,258.6		−7,970.9	122,328	−6.5

Source: GTAP model, U.S. 3x3 v.7.0 database.

Table ME 8.5. *Welfare Decomposition of the Allocative Efficiency Effect, $U.S. Million (answer key)*

Tax Type	Welfare Cost
Factor tax (pfattax)	−258.0
Output tax (prodtax)	−567.6
Input tax (inputtax)	−737.6
Consumption tax (contax)	−692.2
Government tax (govtax)	0.0
Export tax (etax)	−182.9
Import tax (mtax)	−1,070.7
Total	−3,509.1

Source: GTAP model, U.S. 3x3 v.7.0 database.
Experiment is a 1 percent increase in all U.S. taxes.

1. The direct burden is the increase in tax revenue of $122,328 million; its excess burden is an efficiency loss of $3,509.1 million.

2. Import tariffs have the most distorting effect and export taxes have the least effect.
3. The marginal welfare cost is the welfare change per additional dollar of tax revenue. This loss is 6.5 cents per dollar, so the government should be advised that its project must return at least 106.5 percent of its costs, or welfare will decline.
4. Terms of trade measures the price of exports relative to imports. It measures the import purchasing power of exports, so it is included in the EV welfare measure, which reflects the effect of price changes on utility.
5. The marginal welfare cost per dollar is lower than the Ballard, et al. finding. One reason is that the model has only three sectors. Taxes lead to allocative inefficiency by changing relative prices of goods such as groceries and autos. The more aggregated the model, the smaller is the scope for a tax to change relative prices. Another reason is that the GTAP model does not capture dynamic effects of income taxes on savings and capital accumulation or the supply of labor.
6. The U.S. 3x3 model's taxes are reported gross of the tax. Even so, sales tax and labor factor taxes are higher than in Ballard, et al. but the capital factor tax is lower. The effects of differences in tax rates on model results are therefore not clear.
7. EV mean value: −7,852.53
8. EV standard deviation: −935.67
9. 75% confidence range = −7,852.53 + / − 2 * − 935.67 = −9,723.87 to − 5,981.19
10. 95% confidence range = −3,670.09 to −12,035.95.

The negative sign of the EV result is robust with respect to the factor substitution elasticity.

Model Exercise 9

Table ME 9.2. *Cumulative Growth Rates (answer key)*

	Labor Force
USA	16
ROW	15
	Capital stock
USA	46
ROW	46
	TFP
USA	13
ROW	27

1. INCPAR is a parameter related to the income elasticity of demand, which describes the percentage change in quantity demanded given a percentage change in income. The model experiments introduce long-term income growth. Reducing

Table ME 9.3. *Role of Tobacco in Economywide Production (answer key)*

	USA	ROW
Share of tobacco in total activity output	0.55	.009

Source: GTAP v.7.0 3x3 tobacco database.

Table ME 9.4. *Base and Updated INCPAR Parameter Values (answer key)*

	Base Parameter Values		Updated Parameter Values
	USA	ROW	ROW only
Tobacco	0.7	0.7	0.4
Agr./Mfg.	0.8	0.8	*No change*
Services	1.0	1.1	*No change*

Table ME 9.5. *Private Household Budget Shares Under Alternative Scenarios (answer key)*

	Base		Income Growth		Income Growth with ROW nonsmoking Preferences	
	USA	ROW	USA	ROW	USA	ROW
Tobacco	.013	.029	.013	.027	.013	.025
Agr./Mfg.	.198	.387	.196	.373	.196	.374
Services	.789	.584	.791	.600	.791	.602
Total	1.000	1.00	1.00	1.00	1.00	1.00

Table ME 9.6. *Change in Rest-of-World Budget Shares for Tobacco (% change from base) (answer key)*

	Income Growth	Income Growth with Preference Change in ROW
Tobacco	−6.90	−13.79
Agr./Mfg.	−3.62	−3.36
Services	2.74	3.08

Table ME 9.7. *Industry Output with and Without Changes in ROW Smoking Preferences (% change from base) (answer key)*

	Income Growth		Income Growth with No-Smoking Preferences	
	USA	ROW	USA	ROW
Tobacco (*qo*)	39.38	56.38	38.98	48.46
Agr./Mfg. (*qo*)	44.03	57.91	44.02	57.93
Services (*qo*)	38.86	64.12	38.87	64.16

Table ME 9.8. *Systematic Sensitivity Analysis of Preference Change on Tobacco Quantities in ROW (answer key)*

	Point Estimate	Mean	Standard Deviation	95 Percent Confidence Interval	
				Upper	Lower
Production (*qo*)	48.46	48.53	4.03	66.55	30.51
Private consumption (*qp*)	43.93	44.00	5.57	68.91	19.09

Source: GTAP CGE model and v.7.0 3x3 tobacco database.

ROW's INCPAR means that the same growth in income will result in a smaller increase in its consumer demand for tobacco.

2. The INCPAR for tobacco and AG/MFG are less than one, and that for services is greater than one. All else equal, this means that demand for tobacco and AG/MFG will increase by proportionately less than the increase in income, whereas consumption of services will increase by proportionately more than the change in income. Therefore, the services budget share are expected to expand while the shares of tobacco and AG/MFG will decline in both scenarios.
3. Given consumer preferences for services as incomes grow, all else equal, services production will increase by proportionately more than other industries as their economies grow. However, other factors also influence output.
4. Economic growth causes the equilibrium demand and supply, and the tobacco price, to increase from the initial equilibrium. Antismoking preferences will cause the equilibrium quantities and price to fall.
5. The share of tobacco in both countries' total activity output is less than 1 percent, so economywide effects, such as effects on production in other industries, employment, and macrovariables like the wage and exchange rate, are likely to be minimal.