REGIONAL IMPACTS OF FARM PROGRAMS: A TOP-DOWN CGE ANALYSIS

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Abstract–This paper analyzes the regional impacts of changing a major component of national farm policy. Using a national-level computable general equilibrium (CGE), we estimate the national impacts of removing deficiency payments, one of the primary components of U.S. farm programs. We then use two top-down methods of regionalization to analyze the regional impacts. While both top-down methods are easy to implement, the analysis demonstrates the importance of accounting for the presence of local linkages in assessing regional impacts of policy changes. The analysis indicates that elimination of the deficiency payment program would result in efficiency gains at the national level, but because of the reallocation of resources, nonmetropolitan regions would lose and metropolitan regions would gain.

Estimates of the regional impacts of national-level policies such as farm programs are essential in any comprehensive policy evaluation. Virtually all economic policies affect some industries and population groups more than others. Even if a policy is formulated without regard to location, the uneven spatial distribution of producing sectors and of factors of production means that regional differences can be quite large as some regions gain while others lose.

Farm programs are a good example of a group of policies that are national in scope but have very strong regional implications. During the past ten years, the federal government spent roughly $10 billion per year as direct payments to farmers under various farm programs. This is not a very large part of total government spending, so it is not surprising that a national-level model would not indicate large impacts from eliminating farm programs. However, because the crops and commodities for which government subsidies are available are by no means uniformly distributed across the country, removing government subsidies will have a far larger impact on some regions than on others. Using a national-level model to analyze these impacts would miss the regional variation altogether.

This paper analyzes the regional impacts of changing a major component of national farm policy. Using a national-level computable general equilibrium (CGE), we estimate the national impacts of removing deficiency payments, one of the primary components of U.S. farm programs. We then use two top-down methods of regionalization to analyze the regional impacts. These top-down methods are easy to construct and maintain, making the analysis of the regional impacts of national policy shocks feasible. While both top-down methods are easy

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to implement, the analysis demonstrates the importance of accounting for the presence of local linkages in assessing regional impacts of policy changes.

The analysis indicates that elimination of the deficiency payment program would result in efficiency gains at the national level, but because of the reallocation of resources, nonmetropolitan regions would lose and metropolitan regions would gain. Output and employment in rural areas would decline due to losses in farming, food processing, nondurable manufacturing, and services, but these losses are moderated by gains in rural durable manufacturing and construction. Rural areas in the North Central region are the most severely affected.

CONSISTENT MODELING OF NATIONAL AND REGIONAL ECONOMIES

Models useful for both regional and national impact analysis can be divided into two broad groups: bottom-up and top-down.[1] The bottom-up approach has a great deal of appeal, on theoretical grounds as well as from a policy perspective. From the perspective of model accuracy, a bottom-up model can, in principle, capture regional variation in economic structure such as differences in consumption patterns, production technology, and factor supplies, and interregional factor mobility. A bottom-up model also makes possible the analysis of region-specific policies. Unfortunately, the data required to construct a true bottom-up model with a high degree of spatial and sectoral detail are very demanding. Consequently, relatively few interregional CGE models have been implemented, and most of these are more limited either in regional coverage or in sectoral detail than is often desirable for comprehensive policy analysis.[2]

In contrast to the bottom-up approach, the primary modeling effort in a top-down model is at the national level. A top-down model begins with an estimate of national level impacts and constructs regional impacts by allocating the national impacts to regions. The advantage of the top-down approach is that it requires much less data and therefore allows for a high degree of detail, in terms of both the number of industries and the number of regions. In addition, data is more frequently updated at the national level than at the regional level, so a top-down model can be kept more current than a bottom-up model (Liew 1984). Top-down approaches have thus been commonly used in both forecasting and policy simulation work for many years (Bolton 1980). In particular, the top-down approach also has a long history in input-output analysis, beginning with Leontief et al.'s work in 1965 and continuing with recent analyses of defense spending cuts (Congressional Budget Office 1992). Two top-down approaches, the balanced model and the shared model, have been incorporated into a few CGE models. The

ORANI model of Australia (Higgs and Powell 1990, Higgs et al. 1988, Dixon et al. 1982) uses the balanced approach, and the model constructed by Stern et al. (1992) uses the shared approach. These two alternative top-down models, along with our improvements to the balanced model, are described in the remainder of this section.

The Shared Model. The simplest method of regionalizing a national model is to allocate national-level sectoral impacts to regions according to fixed proportions. With t sectors and r regions in the economy, sectoral production can be denoted by the t element vector x, sectoral production for region r by x^r, and a diagonal matrix of industries shares for region r by S^r.[3] The shared model can be expressed by:

$$x^r = S^r x \tag{1}$$

Because the proportionate change in output for a given sector is the same for all regions in the shared model, regional variation in total output will depend only on differences in sectoral composition at the regional level.

The shared model is least reasonable when the assumption of truly national or international markets does not hold; that is, whenever regional or local demand is important. To understand this, consider the removal of subsidies to farmers. Removal of farm subsidies results in a decline in agricultural output and income. The assumption that a decline in agricultural production and income would be spread roughly proportionately across the major farming regions according to base year output or employment shares is relatively reasonable, at least as a first approximation. It is, however, much less reasonable to assume that all regions would experience proportionate changes in industries that depend largely on local economic conditions, such as retail trade and other service industries. Instead, one would expect retail and service industries to do relatively poorly in regions in which farm production is most important and relatively better in regions unaffected by the change in farming activity. Put another way, the shared model ignores the effects of local linkages by allocating sectoral impacts according to fixed proportions.

The Balanced Model. The balanced allocation is an attempt to account for the importance of local linkages within a region without incurring the substantial costs of estimating a complete interregional CGE model. A key assumption of the balanced model is that industries can be classified into two groups: national sectors that respond to national markets and local sectors which respond to local market conditions.[4] Local sector goods are not traded, so changes in local sector output are determined entirely by changes in intermediate and final demand within the region. Consequently, estimated regional impacts are upper bounds.

In the balanced model, the t sectors in the economy are divided into n national sectors and l local sectors (n + l = t) according to whether product markets are assumed to clear nationally or within a single region. The regional allocation of national goods is thus determined exactly as in equation (1), above.

The regional allocation of local goods and services production (x) is determined by regional demand, which can be broken down into two broad components: intermediate demand and final demand. Equation (2) shows how these two components are calculated in the model.

$$x_l^r = A_{ln}x_n^r + A_{ll}x_l^r + S_l^r F_l + w^r C_l \tag{2}$$

where A_{ln} and A_{ll} are sub-matrices of the interindustry technical coefficient matrix (A_{ln} consisting of the local-sector rows and the national-sector columns and A_{ll} the local-sector rows and local-sector columns), x_n^r is regional output of national-sector industries, S^r_l is a matrix of region r's shares of local sector output, F_l is the vector of all final demands except for household consumption expenditures, w^r is region r's share of total factor income, and C_l is the vector of national household demand for local sector output.

The first two terms of equation (2) show that intermediate demand for local-sector output is comprised of demand generated in the production of national-sector goods and demand generated by the production of local-sector goods themselves. The third term in equation shows that all final demand except for household consumption (e.g., investment, government purchases, net exports, and inventory accumulation) for local-sector output is allocated according to fixed proportions.

The fourth term of equation (2) indicates that regional household demand for local sector output is the product of the region's share of total factor income, w^r, and the vector of national household demand for local sector output, C_l. Previous CGE applications of the balanced allocation (e.g., Dixon et al. 1982, Higgs and Powell 1990) allocated household consumption demand according to each region's share of labor income, ignoring the role of capital income in determining regional demand for local production. The approach taken here improves on this previous work by allocating household demand according to the region's share of total factor income, as expressed in equation (3):

$$w^r = (k^r y_{labor} + s^r_{land} y_{land} + s^r_{corp} y_{corp} + k^r y_{non\text{-}corp}) \,/\, y_{total} \tag{3}$$

The first term of the numerator is total labor income in region r, calculated as the product of the region's share of sectoral output (the row vector k^r) and national labor income by sector (the column vector y_{labor}). The elements in k^r for the national sectors are from the national share matrix S^r (equation 1). The elements of k^r for the local sectors are determined endogenously as the ratio of the regional output of local sectors (x in equation 2) divided by total local sector output. The next three terms are different types of capital income. Regional land and corporate income are fixed shares of the national totals, where s^r_{land} and s^r_{corp} are row vectors of region r's shares of land and corporate income by sector and yland and ycorp are the corresponding vectors of national capital income by sector. Fixed shares are used for allocating corporate income under the assumption that corporate ownership patterns are essentially national in scope. Fixed shares are also used to allocate land income because all of the crop and livestock production sectors are considered national sectors. In contrast, noncorporate capital income is allocated according to each region's share of noncorporate capital income under the assumption that a large proportion of noncorporate capital income accrues to local proprietors. Regional share of noncorporate income is calculated as the product of the region's share of local sector output (the row vector kr) and total noncorporate capital income. Note that the regional allocation of labor income, noncorporate capital income, household consumption, and regional output of local sectors are all interdependent, thus requiring either an iterative or a nonlinear solution procedure in order to ensure that all regional numbers add up to the national total.

NATIONAL LEVEL MODEL AND RESULTS

Model Description

We use a 32-sector general equilibrium model of the United States with a fair amount of detail in the agricultural sectors (See Appendix for a brief summary and Robinson et al. 1990 for more details). The model is based on 1986 data and includes 8 agricultural production sectors, 8 agricultural processing sectors, and 16 other manufacturing and service sectors. The model explicitly incorporates the deficiency payment program in the following way.

Under the deficiency payment program, qualifying producers are paid the difference between the market price and a target price. Deficiency payments apply to cotton, food grains, and feed crops. In 1986, our base year, total deficiency payments amount to \$10 billion: \$1 billion for cotton, \$4 billion for food grains, and \$5 billion for feed crops. Producers in the program crop sectors maximize profit subject to their production technology and available land. Revenue equals output times a producer incentive price, which is modeled as a weighted average of the target price and the market price, with the weights depending on the program participation rate. In effect, the producer incentive price equals the market price plus a subsidy rate which is not fixed, but instead is determined endogenously in the model (Kilkenny 1991).[5]

Impact of Removing Farm Programs

Tables 1 and 2 present some national level results from removing the $10 billion in deficiency payments. In the scenarios analyzed here, we assume that deficiency payments are eliminated unilaterally, with no change in farm or trade policy in other nations. We assume the reduction in government expenditures reduces the government deficit, which leads to an increase in fixed investment.[6] Over the long run the increased investment will lead to growth in the economy, but our analysis does not account for these growth effects on real GDP. The $1.3 billion increase in real GDP in our analysis is from efficiency gains due to the reallocation of factors of production from agriculture to the rest of the economy. These gains at the national level may be viewed by some as justification for removing farm programs, but as the following regional analysis shows, not all regions share in these gains.

TABLE 1
National Results from Removal of Farm Subsidies

	Base	Experiment	Change	Percent Change
Real GDP, bil $	3687.0	3688.3	1.3	0.0
Gov't budget surplus, bil$	-144.2	-137.6	6.6	4.6
Foreign savings, bil $	130.7	131.9	1.1	0.9
Investment, bil $	659.4	666.7	7.3	1.1
Farm Income, bil $	73.3	65.6	-7.7	-10.7
Farm labor, thous.	2033.0	1950.7	-82.3	-4.0

The farm sector sustains a 4 percent drop in employment (82 thousand jobs) and a $7.7 billion decline in farm income. Other sectors (e.g., food processing, nondurables production) also experience job losses totaling 42,000 full time jobs. Because of the full employment assumption, all 124,000 workers who lose jobs in sectors with declining employment find alternative employment in sectors with expanding employment. As will be shown below, this reallocation of labor leads

TABLE 2
Sector Results from Removal of Farm Subsidies

	Labor	Output	Exports	Imports	Price	Value Added	Sector Income
	(Percent change from base)						
Total	0.0	0.1	-0.2	0.2	0.1	0.0	-0.2
Farm	-4.0	-1.5	-8.6	0.1	3.5	3.5	-10.7
Food processing	-0.8	-0.7	-3.0	0.1	0.5	-1.3	-1.5
Nondurable manufacturing	-0.2	-0.1	-0.2	-0.1	0.1	-0.2	-0.2
Other manufacturing	0.4	0.3	0.4	0.3	-0.0	0.2	0.2
Construction	1.0	0.8	0.9	0.0	-0.0	0.8	0.8
Services	-0.0	-0.2	0.1	-0.0	-0.1	-0.1	-0.1
Farm total	-4.0	-1.5	-8.6	0.1	3.5	3.5	-10.7
Livestock	-3.1	-1.0	-5.1	0.4	2.0	-4.6	-5.3
Food grains	-27.6	-8.1	-18.7	3.8	10.5	6.9	-43.0
Feed crops	-7.0	-2.0	-13.3	3.0	8.1	12.3	-11.7
Cotton	-18.7	-5.1	-21.7	7.4	13.9	26.1	-30.4
Other crops	-0.2	-0.1	0.3	-0.2	-0.2	-0.3	-0.3

to the result that many nonmetropolitan workers move to metropolitan areas to take jobs in growing sectors.

Looking at the aggregated sectoral results in the top panel of Table 2, we find the farm and food processing sectors are the big losers of output and employment. With increased demand for capital goods from new investment, the new jobs and increased output are in durable manufacturing and construction. The slightly negative impact on the service sectors at the national level is driven by the shift in final demand into investment goods.

Looking at the farm sector results in the lower panel of Table 2, we find a fall in production and employment for all sectors. For the program crop sectors (food grains, feed crops and cotton) eliminating deficiency payments lowers the incentive price to producers, leading to lower levels of production and demand for labor. The reduction in employment and output in the livestock sectors is a result of the higher costs of production due to the price increase caused by the lower supply of feed crops. The fall in employment and production of other crops is the result of a shift in final demand from consumption to investment and a decline in intermediate demand due to the reduction in livestock production. Corresponding to the lower supply of program crops is a higher market price and a $2.3 billion increase in value added (3.5 percent). Still, sector income falls $7.7 billion as the removal of $10 billion in deficiency payments exceeds the increase in value added.[7]

REGIONAL IMPLICATIONS FROM A TOP-DOWN APPROACH

Regional Data

We use employment data to construct the regional share matrices for each industry and region. For the balanced approach, we also use data on the regional share of sector-specific capital and land income, and the nationwide corporate/proprietor share of capital income.[8] National impacts are allocated to eight regions, consisting of the metropolitan and nonmetropolitan portions of four Census regions: Northeast, North Central, South, and West.

For the nonagricultural sectors, industry by region employment data are from *County Business Patterns* (U.S. Department of Commerce, Bureau of the Census 1987). Since the *County Business Patterns* data provides only detailed information for nonagricultural sectors, data on agricultural employment for the eight agricultural sectors must come from other sources. Total agricultural employment from *Employment and Earnings* (U.S. Department of Labor, Bureau of Labor Statistics 1987) is allocated to these eight agricultural sectors, using calculated farm production labor hours (U.S. Department of Agriculture 1988).[9] The percent of commodity cash receipts in each state is used to distribute national employment by commodity to the state level (U.S. Department of Agriculture 1987a,b). Finally, data on total farm earnings at the county level (U.S. Department of Commerce, Bureau of Economic Analysis 1991), are used for the metropolitan/nonmetropolitan split.

Regional employment shares for an aggregation of the model's 32 industries are presented in Table 3. For each industry, the regional employment shares sum to one. Overall, nonmetropolitan regions have 20 percent of total employment, but the range is 61 percent for the farm sector to 17 percent for services. Five of the 32 sectors are considered local sectors (dairy manufacturing; construction; trade and transportation; finance and insurance; and personal and professional services). Because local sectors are defined as sectors in which local demand determines local output levels, data on interregional trade flows are required in order to determine which sectors to include as local and which as national. Unfortunately, trade flow data at the county or metropolitan level is unavailable, so state level flow data from the 1977 Multiregional Input-Output accounts (U.S. Department of Health and Human Services 1984) were used as a guide in classifying industries.

TABLE 3
Regional Employment Shares

		Total	Farm	Food Processing	Manufacturing: Nondurable	Manufacturing: Durable	Construction	Services
Nonmetro	Northeast	0.02	0.02	0.02	0.03	0.03	0.01	0.02
	N.Central	0.07	0.27	0.10	0.05	0.07	0.04	0.06
	South	0.08	0.21	0.12	0.20	0.09	0.08	0.07
	West	0.03	0.10	0.04	0.01	0.02	0.03	0.03
Metro	Northeast	0.20	0.04	0.15	0.26	0.20	0.14	0.21
	N.Central	0.19	0.08	0.21	0.13	0.23	0.14	0.19
	South	0.25	0.11	0.21	0.23	0.20	0.38	0.26
	West	0.17	0.16	0.16	0.10	0.16	0.18	0.18
Total	U.S.	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Nonmetro	0.20	0.61	0.28	0.28	0.20	0.16	0.17
	Metro	0.80	0.39	0.72	0.72	0.80	0.84	0.83

Note: Sums may not equal totals due to rounding.

Balanced Model Results

Output and employment decline in nonmetropolitan areas and increase in metropolitan areas. The balanced model allocates the $3.6 billion increase in national output as a loss of $1.7 billion (1982 constant dollars) in nonmetropolitan areas and a $5.3 billion gain in metropolitan output (Table 4). The largest decline in total output occurs in the nonmetropolitan North Central region and the largest increase in the metropolitan Northeast, followed closely by the South and North Central metro regions. Output declines in farm, food processing, and nondurable goods in both metropolitan and nonmetropolitan regions. The nonmetropolitan decline in farm output is more than twice as large as the metropolitan decline but the reverse holds true for food processing and nondurables. There are also large differences among nonmetropolitan regions. Because farm program crops are concentrated in the North Central region, 54 percent of the decline in nonmetropolitan farm output occurs in this region, even though it accounted for only 27 percent of base-year farm employment.

Services (trade and transportation; finance and insurance; and personal and professional services) output falls $690 million nationally. However, all services are local sectors, so the regional impacts are determined by local linkages rather than being spread proportionally across regions. Thus, nonmetropolitan areas experience a loss of $681 million in services output, virtually all (99 percent) of the national decline. Furthermore, the nonmetropolitan North Central region accounts for over half the nonmetropolitan decline in services output because it accounts for a disproportionate share of losses in national-sector industries, especially farming. In contrast, the combination of relatively large gains in durable manufacturing and small losses in farming results in a very small decrease in metropolitan services output. In the metropolitan Northeast, service output actually increases because of the relatively low reliance on farming and food processing.

Changes in regional employment, presented in Table 5, are derived from the changes in regional output and labor productivity ratios. The full employment assumption of the national CGE model means that total employment does not change, so the net loss of 55,220 full-time nonmetropolitan jobs is exactly offset by an equal gain in metropolitan jobs. The reallocation of labor is even greater, however, because a total of 79,000 nonmetropolitan jobs are lost in farming, food-processing, nondurable manufacturing, and services. Nonmetropolitan durable manufacturing and construction gain only 23,500 jobs, requiring at least 55,500 nonmetropolitan workers to leave nonmetropolitan areas to find jobs in metropolitan areas.

The model indicates that many of the displaced rural workers would be from the North Central region. Metropolitan areas in the North Central region ex-

TABLE 4
Change in Regional Output Using Balanced Approach, Millions of 1982 $

		Total	Farm	Food Processing	Manufacturing: Nondurable	Manufacturing: Durable	Construction	Services
Nonmetro	Northeast	146	-39	-29	-11	139	85	1
	N.Central	-1144	-1094	-257	-17	360	223	-359
	South	-446	-577	-303	-73	389	341	-223
	West	-243	-285	-47	-4	81	112	-100
Metro	Northeast	1529	-59	-254	-96	1077	818	43
	N.Central	1312	-288	-456	-48	1361	743	0
	South	1404	-215	-381	-86	962	1149	-25
	West	1046	-271	-238	-37	897	722	-27
Total	U.S.	3604	-2828	-1965	-372	5266	4193	-690
	Nonmetro	-1687	-1995	-636	-105	969	761	-681
	Metro	5291	-833	-1329	-267	4297	3432	-9

Note: Sums may not equal totals due to rounding.

TABLE 5
Change in Regional Employment Using Balanced Approach, Thousands of Full-Time Jobs

		Total	Farm	Food Processing	Manufacturing: Nondurable	Manufacturing: Durable	Construction	Services
Nonmetro	Northeast	1.2	-1.2	-0.2	-0.2	1.7	1.2	-0.1
	N.Central	-33.0	-31.2	-1.7	-0.3	4.3	3.3	-7.4
	South	-15.1	-16.7	-2.2	-1.3	5.2	5.0	-5.0
	West	-8.6	-8.8	-0.4	-0.1	1.2	1.6	-2.2
Metro	Northeast	19.0	-1.7	-1.7	-1.7	13.2	11.7	-0.9
	N.Central	12.6	-8.1	-2.9	-0.8	15.1	10.7	-1.3
	South	15.2	-6.1	-2.6	-1.5	11.4	16.5	-2.5
	West	8.7	-8.4	-1.6	-0.6	10.8	10.4	-1.9
Total	U.S.	0.0	-82.3	-13.3	-6.5	62.9	60.5	-21.3
	Nonmetro	-55.5	-57.9	-4.5	-1.9	12.4	11.1	-14.7
	Metro	55.5	-24.4	-8.8	-4.7	50.5	49.3	-6.5

Note: Sums may equal totals due to rounding.

perience a net gain of only 12,600 jobs, not nearly enough to offset nonmetropolitan losses of 33,000 jobs (0.5 percent). Thus, the model indicates not only a reallocation of labor from nonmetropolitan to metropolitan areas but also a reallocation of labor between regions, with workers moving from the North Central region to the three other regions, primarily the South and Northeast.

Shared Model Results

Changes in regional production using a shared approach are presented in Table 6. The only difference between these results and the balanced results is the treatment of local sectors: dairy processing, construction, and services. The net decline in service output at the national level means that services decline in each region under the shared model (Table 6). The loss of $95 million in nonmetropolitan service sector output under the shared model is proportional to their base-year share of service-sector employment. In comparison, there is a $681 million loss under the balanced model. Local linkages in the balanced model magnify the regional impacts of policy-induced changes in national-sector output.

SUMMARY AND CONCLUSIONS

This study shows how a relatively simple procedure can be used to model the regional impacts of national policy changes in the absence of a bottom-up regional CGE model. It shows that the removal of deficiency payments would lead to a slight increase in national output, but the impacts would be very uneven across regions. Nonmetropolitan areas experience a net loss of both output and jobs as losses in agriculture, food processing, nondurable manufacturing, and services exceed gains in durable manufacturing and construction by a wide margin. Furthermore, these losses occur primarily in the North Central region. In contrast, all metropolitan areas gain with the elimination of the deficiency payment program. Overall, 124,000 workers change jobs (0.1 percent), a large proportion (45 percent) being nonmetropolitan workers who find jobs in metropolitan areas.

Our model assumes that labor is perfectly mobile between regions, but total labor supply is fixed. This assumption is a key difference between this study and other interregional CGE models. For example, Kraybill et al. (1992) assume an exogenous labor supply growth rate and do not allow labor to move between regions. Buckley (1992) and Morgan et al. (1989) take intermediate positions regarding spatial mobility, assuming partial labor mobility among regions. Finally, Kilkenny's (1993) model assumes no labor mobility between metropolitan and nonmetropolitan areas, but, unlike the other models, relaxes the assumption of a

TABLE 6
Change in Regional Output Using National Shares, Millions of 1982 $

				Food	Manufacturing:			
		Total	Farm	Processing	Nondurable	Durable	Construction	Services
Nonmetro	Northeast	93	-39	-34	-11	139	49	-11
	N.Central	-895	-1094	-277	-17	360	164	-31
	South	-250	-577	-295	-73	389	341	-35
	West	-153	-285	-48	-4	81	121	-18
Metro	Northeast	1113	-59	-242	-96	1077	598	-165
	N.Central	995	-288	-476	-48	1361	579	-133
	South	1718	-215	-370	-86	962	1596	-169
	West	983	-271	-223	-37	897	746	-129
Total	U.S.	3604	-2828	-1965	-372	5266	4193	-690
	Nonmetro	-1205	-1995	-654	-105	969	675	-95
	Metro	4809	-833	-1311	-267	4297	3519	-596

Note: Sums may not equal totals due to rounding.

fixed labor supply. Clearly, there is no consensus on the most appropriate assumption concerning labor market flexibility. The assumption taken here, however, is supported by the work of Greenwood and Hunt (1984), who found significant interregional labor mobility in response to job opportunities.

Given the very limited availability of data on regional economies, it is clear that top-down models such as the one presented here will continue to be useful in assessing the regional distribution of national-level policy changes. As the comparison between the balanced model and the even simpler shared model shows, it is important to account for the effects of linkages within the regional economy. Further improvements in the model are possible. Greater sectoral detail would permit better measurement of local sector linkages. Incorporating at least partial endogeneity to the allocation of nation-sector output, perhaps using the method proposed by Silvers (1989) or making use of the research on the relationship between employment opportunities and migration, might also be feasible.

ENDNOTES

1. The distinction between the two lies in the level at which the primary modeling effort takes place. In the bottom-up model, the primary modeling effort is regional. Regions are modeled separately in the sense that region-specific data on production, factor supplies, and interregional flows of goods, services, and factors of production are used in constructing each regional model. National impacts are estimated from a bottom-up model by summing the regional impacts. See Liew (1984) for further discussion.

2. Recent examples include Buckley (1992), Morgan et al.(1989) , Kilkenny (1993), and Rickman (1992). See Kraybill (1993) for a discussion of regional CGE modeling.

3. A superscript indicates a regional variable; no superscript indicates a national variable.

4. In addition to the ORANI model, cited above, a recent model that uses the local-national sector distinction is Shao and Treyz (1993).

5. A number of agricultural models simulate the deficiency payment program by using a fixed *ad valorem* price wedge. We follow Kilkenny and Robinson, who argue that this approach is often inadequate, failing to capture the effect of policy changes on program costs and producer incentives.

6. The alternative closure of transferring the savings due to the removal of the deficiency payment program directly to households leads to an increase in household expenditures. Thus, the sectoral pattern of impacts differs because industries producing goods and services for household consumption would tend to

gain more than under the deficit reduction scenario. However, the regional impacts are essentially unchanged because the regions that experienced the negative impacts of the loss of deficiency payments remain the same, while the shift in demand from investment to consumption at the national level does not result in major regional shifts in production. Regional shares of consumption and investment goods are similar.

7. The removal of deficiency payments in a unilateral framework as analyzed in this study leaves the farm sector worse off, because foreign demand does not increase, as is likely under multilateral trade liberalization, and thus exports fall. This result contrasts with a number of other studies in which U.S. farm programs are removed under assumptions of multicountry trade liberalization. See, for example, Kilkenny and Robinson (1990); and Robinson et al. (1991).

8. The shares for land income were constructed from data on farmland values by state (U.S. Department of Agriculture 1990). Corporate and proprietors' income shares were constructed from state personal income estimates, U.S. Department of Commerce, 1989.

9. Further disaggregation of the agricultural sectors can be carried out using detailed data on commodity cash receipts (U.S. Department of Agriculture, 1987a and 1987b).

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APPENDIX: Model Description

We use a modified version of the U.S. Department of Agriculture, Economic Research Service, Computable General Equilibrium model. The model is for 1986 with 32 sectors, including 8 agricultural production sectors, 8 agricultural processing sectors, and 16 other manufacturing and service sectors. Each sector's output is produced according to a constant elasticity of substitution (CES) production function using the primary inputs–labor, capital, and land (for the crop sectors only). The CES elasticity of substitution for the agricultural sectors is set at 0.5, while for the nonagricultural sectors it is set at 2.0. Intermediate inputs are used in fixed proportions to output. Sectoral input demands are derived from first-order conditions for profit maximization.

The aggregate supplies of land, labor and capital are exogenous. The economywide wage/rental rates adjust to clear the factor markets. We assume labor is mobile across sectors, while capital and land are sector specific. For the sector–specific factors the sectoral rental rates vary in equilibrium. While our analysis of land use and the return to land is simplified, sensitivity analysis indicates that changing the assumption regarding land use in the absence of deficiency payments does not substantially alter the relative regional results reported here.

The commodity produced in each sector is a composite commodity that can be transformed, according to a constant elasticity of transformation (CET) function, into an export good or a good sold on the domestic market. The CET elasticities are set at 4, which is quite high, making it easy for producers to shift the use of a commodity from exports to domestic markets. Consequently, the output supply response to removing the farm programs will be more evenly shared by the export and domestic markets.

The model also incorporates imperfect substitution between imports and domestic goods, using the Armington assumption. Domestic demand is for a "composite commodity," which consists of imports and domestically produced goods. They are combined according to a constant elasticity of substitution (CES) aggregation function. For the agricultural crop sectors the CES import demand elasticity was set at 0.5, while for the livestock sectors it was set at 0.7. Since imports of program crops are small, this assumption plays a minor role in the analysis.

This treatment of imports and exports partially insulates the domestic price system from changes in world prices of sectoral substitutes. The model also makes the "small country" assumption on the import side, assuming that the United States cannot affect world prices of its imports. On the export side, we assume downward-sloping world demand functions for four U.S. agricultural exports: cotton, food grains, feed crops, and oilseed crops. All other exports have exogenous world prices.

Aggregate domestic demand has four components: consumption, intermediate demand, government, and investment (including inventory accumulation). Household expenditure functions are derived from a Cobb-Douglas utility function, yielding fixed nominal expenditure shares. Each household pays income taxes to the government and saves a fixed proportion of after-tax income. Intermediate demand is calculated from sectoral output, using fixed input-output coefficients. For the government, real aggregate spending on goods and services is fixed and its sectoral composition is given by fixed shares. Inventory demand by sector is a fixed proportion of domestic output.

Aggregate investment is "savings driven." The difference between aggregate savings and inventory demand represents the funds available for purchasing new capital goods (fixed investment). Expenditure on investment goods by sector is a fixed share of the total funds available for investment, giving investment demand by sector of destination. Investment demand by sector of origin is translated from investment demand by sector of destination by using a capital composition matrix.

Aggregate savings is the sum of household saving, enterprise-retained earnings plus capital consumption allowance, government saving, and foreign saving. Household saving is a fixed fraction of after-tax income. Enterprise retained earnings is a fixed fraction of after-tax income, while the capital consumption allowance is a fixed fraction of capital stocks. Government saving is the difference between government revenue (the sum of the household income tax, enterprise profit tax, social security tax, tariffs, and excise taxes) less government spending on goods and services and transfer payments. Foreign saving is the balance of trade in goods and nonfactor services.

The model contains a balance-of-trade constraint in that the value of imports at world prices must equal the value of exports at world prices plus foreign savings, net remittances, and net foreign borrowing by the U.S. Government. In the CGE model, two alternative equilibrating mechanisms are specified. First, the real exchange rate adjusts to achieve equilibrium given an exogenously specified balance of trade. Second, the exchange rate is exogenous, and foreign savings adjust to achieve equilibrium. We assume foreign savings adjust while the exchange rate is fixed.

The CGE model solves only for relative prices. We choose as the numeraire price index the gross domestic product (GDP) price deflator, so all nominal values are relative to a fixed GDP deflator. Given the choice of numeraire, the model solves for all factor returns, prices, and the real exchange rate that clear the markets for factors and products and equilibrates the balance of trade. See Robinson et al. (1990) for more details.