

# Appendix D: U.S. Regional Agricultural Sector Model

As CRP acreage is released from conservation uses, crop production would increase with subsequent decreases in crop prices. The U.S. Regional Agricultural Sector Model (USMP; see House et al., 1999) simulates potential adjustments in production and prices to this policy. This model is a multi-commodity, spatial equilibrium approach of the type described in McCarl and Spreen (1980). The USMP model has been applied to various issues, such as the regional effects of trade agreements (Burfisher et al., 1992), climate change mitigation (Peters et al., 2001), water quality (Ribaud et al., 2001), ethanol production (House et al., 1993), wetlands policy (Claassen et al., 1998), and sustainable agriculture policy (Faeth, 1995).

USMP allocates production practices regionally based on relative differences in net returns by region. As such, USMP simulations of changes in farm programs are manifest as a spatial equilibrium across 10 main production regions ( $r$ ) and 45 subregions ( $u$ ) delineated by erosion class (highly erodible and non-highly erodible). Commodity price and production levels are simulated for 44 agricultural commodities and processed products at the regional level, which are integrated into the flow of final commodity demand and stock markets. USMP accounts for production of the major crop (corn, soybeans, sorghum, oats, barley, wheat, cotton, rice, hay, and silage) and confined livestock (beef, dairy, swine, and poultry) categories comprising approximately 75 percent of agronomic production and more than 90 percent of livestock production.

Production levels, land use, land-use management (e.g. crop mix, rotations, tillage, and fertilizer practices), and program participation are endogenously determined spatially according to a constrained optimization approach, maximizing consumer and producer welfare,  $\mathcal{L}$

(1)  $Max \mathcal{L}$

$$\equiv Z'A^d - \frac{Z'B^dZ}{2} - P'A^s - \frac{P'B^sP}{2} - Y'W_Y - INP'_V A^s - \frac{INP'_V B^s INP_V}{2} - INP'_F W_{INP};$$

subject to

(2)  $PP'_{cr} X_{cr} + PP'_{liv} X_{liv} + PP'_Y Y - Z \geq 0$  (commodity balancing);

(3)  $PP'_{inpcr} X_{cr} + PP'_{impliv} X_{liv} - INP_V \leq 0, \forall r$  (regional input balancing);

(4)  $\alpha_{p,u} \left( \sum_b \delta_{b,u} s_{p,b,u} RAC_{b,u}^{-p^{b,u}} \right)^{\frac{1}{p^{b,u}}} - C_{p,u} \leq 0, \forall p, u$  (regional crop balancing);

(5)  $\alpha_{b,u} \left( \sum_t \delta_{b,t,u} X_{b,t,u}^{-P^{b,u}} \right)^{\frac{1}{P^{b,u}}} - RAC_{b,u} \leq 0, \forall b, u$  (regional rotation balancing);

and

(6)  $Z, Y, X_{cr}, X_{liv}, INP_V, INP_F, RAC, C \geq 0$  (nonnegativity constraints).

Matrix  $\mathbf{Z}$  represents consumer demand for produced commodities, matrix  $\mathbf{P}$ , across markets and regions. Matrices  $\mathbf{A}$  and  $\mathbf{B}$  are the intercept and slope coefficients for product and market demand (superscripted “d”) and supply (superscripted “S”), respectively. Matrices  $\mathbf{X}_{\text{cr}}$  and  $\mathbf{X}_{\text{liv}}$  represent cropping and livestock activities across regions and management practices. Vectors  $\mathbf{Y}$  and  $\mathbf{W}_y$  represent processing activity levels and net costs of process, respectively. Matrix  $\mathbf{INP}$  represents variable (subscripted “V”) and fixed (subscripted “F”) inputs into production of primary and processed goods.  $\mathbf{W}_{\text{INP}}$  represents cost per unit of fixed inputs. The output parameters per share of crop, livestock, and processing activities are represented by matrices  $\mathbf{pp}_{\text{cr}}$ ,  $\mathbf{pp}_{\text{liv}}$ , and  $\mathbf{pp}_y$ , respectively. The input-output parameters for crop and livestock production activities are represented by matrices  $\mathbf{pp}_{\text{inpcr}}$  and  $\mathbf{pp}_{\text{inpliv}}$ , respectively.

Substitution among the cropping activities is represented using nested constant elasticity of transformation (CET) functions (4 and 5). The crop and rotation balancing equations ensures that the supply of land ( $C_{p,u}$ ) in subregion ( $u$ ) allocated to a crop ( $p$ ) is at least as great as the demand for it, given by the sum of rotational acres ( $RAC_{b,u}$ ) multiplied by the share of each crop grown in that rotation ( $s_{p,b,u}$ ) subject to nonlinear CET distribution ( $\delta_{b,u}$ ), shift ( $\alpha_{p,u}$ ), and substitution ( $\rho_{p,u}$ ) calibration parameters. Similarly, the allocation of land to various tillage practices ( $t$ ) used in a crop rotation ( $b$ ) must be no greater than the amount of land in that rotation, also subject to CET distribution ( $\delta_{b,t,u}$ ), shift ( $\alpha_{b,u}$ ), and substitution ( $\rho_{b,u}$ ) calibration parameters. The nonlinear CET equations imply that there is a declining marginal rate of transformation between land used in one crop rotation and land used to produce the same crop as part of another rotation, and between one tillage activity in a particular rotation and land used in other tillage activities used with the same rotation.

The initial crop production and price data for this analysis are calibrated to the 2001 agricultural baseline (USDA, 2001). Given the shortrun nature of the analysis, all land previously enrolled in the CRP is constrained to return to active crop production, which provides an upper bound on the price and production adjustments.<sup>90</sup> Moreover, because the livestock and poultry sectors are linked integrally to the crop sectors through the intermediate feed sector, decreases in crop commodity prices are expected to increase returns for the livestock sector. This would induce increases in livestock production and decreases in livestock commodity prices. Therefore, the impacts of removing the CRP are estimated for both the crop and animal production sectors.

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<sup>90</sup> The USMP does not explicitly include range or pasture lands. Consequently, the total quantity of cropland enrolled in CRP for 2001 in this model is approximately 20.6 million acres. If all of this returns to production, crop acreage would increase by 18.9 million acres with the remaining 1.7 million acres in a fallow rotation.