Modeling State Agriculture: An Application and Some Implications

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A disaggregated econometric model of the agricultural sector at the state level is constructed. Using time series data on West Virginia agriculture and three-stage least squares in estimation, the model is employed to examine how various components of the state's agricultural sector adjust to changes in certain price and nonprice variables. Results reveal characteristics of the state's agricultural economy that are both unique and useful— characteristics that are usually masked in aggregate models but that have profound implications for modeling producer decision making and policy formulation.

A state's agricultural sector is often unique in its problems, commodity mixes, and producer characteristics. Thus, policies formulated at the national level based on a knowledge of aggregate producer behavior can be expected to have different impacts on agricultural-sector performance in different states. Further, producers' responses to changes in price and nonprice variables also can be expected to differ geographically, as Chavas and Kraus, for example, demonstrate to be the case in the dairy industry.

The agricultural sector in West Virginia (WV) is unique in many respects. Agriculture in this state is dominated by small and part-time fanners who engage primarily in forage-livestock production, although the state also has important commercial fruit, poultry, and grain production areas. While agriculture is a potentially important component of the state economy (D'Souza et al.), it has been relatively stagnant over the years in terms of total output as well as relative shares of commodities produced (WV Department of Agriculture). Producers are confronted by problems including a decline in profitability, an eroding competitive position, low levels of management, and difficulty in anticipating and responding to changes in prices, macrovariables, technology, and other factors. At the state level, policy makers are confronted by problems such as declining economic growth and high unemployment rates caused in part by the strong dependence of the state economy on an inherently unstable and a historically declining primary manufacturing sector. By virtue of its linkages with the nonfarm economy, growth in agriculture can contribute to state economic growth. Further, the agricultural sector can potentially act as a cushion to absorb a portion of the increased unemployment caused by the cyclical downturns that are characteristic of the state economy.

Whether or not policies can be designed and implemented that could improve producer response and increase the level of agricultural income, productivity, and competitiveness for the state while, in the process, contributing to its overall economic growth necessitates knowledge of how its agricultural sector operates and adjusts. In particular, knowledge about the impacts of specific variables on individual commodities or commodity groups and implications of certain unique relationships between the variables themselves, as well as the determination of how producers respond to changes in specific variables, is needed. The objective of this study is to provide some of this information for use by producers, researchers, and state policy makers, with attendant implications for other states with unique resource endowments and problems. To address this objective, a disaggregated econometric model of the WV agricultural sector is specified and estimated. The mode! is comprised of a system of output-supply, inventory, investment-demand, and employment-demand equations for major agricultural commodities produced in the state

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to explain how individual components of the state's agricultural sector adjust to changes in farm product prices, input costs, capital stocks, wages, interest rates, land tax rates, weather, and technology. While econometric models of the agricultural sector have been developed at the national level (Chen; Egbert; Freebairn, Rausser, and de Gorter) and to represent individual agricultural commodities and commodity groups (Houck and Gallagher; Lee and Helmberger; Martin and Heady; Ospina and Shum-way; Subotnik; Womack), the development of similar state-level models has not received much attention despite their potential usefulness.

Model Specification

In order to determine, and infer from, the specific interrelationships governing the individual agricultural commodities produced in WV, the state's agricultural sector is disaggregated into specific livestock (beef cattle, hogs, sheep, poultry, and fluid milk) and crop (field and fruit) commodities. Each commodity is represented in the model by a set of equations explaining changes in supply, inventory, and cash receipts. Since a determination of the agricultural sector's linkages with specific nonfarm input markets is one of the issues of interest, equations for the endogenous determination of capital-investment demand and the quantity of labor employed are included in the model (King; Popkin; Just). Producers' expectations regarding prices and quantities are incorporated into the model by specifying supply and inventory equations in forms consistent with Nerlove's partial-adjustment framework. Homogeneity conditions are imposed in the individual equations by expressing prices in ratio form or by deflating nominal values by appropriate price indices. The equations are specified in the double logarithmic functional form, allowing for direct observation of elasticities.

The model consists of seventy equations, with fifty-six behavioral equations and fourteen identities. It is specified as block-recursive (Pindyck and Rubinfeld), with the equations divided into (1) livestock production, (2) field crop production, (3) derived feed grain demand, (4) fruit crop production, (5) agricultural employment, (6) farm capital investment demand, and (7) farm receipts and expenditure blocks.

The livestock production block of the model consists of behavioral relationships explaining annual production of the individual livestock commodities. Included for each commodity are a supply equation and an inventory equation. The field crop production block contains equations explaining the annual production and carryover stocks of corn, oats, wheat, barley, and hay. Because of the simultaneous nature of acreage, yield, and production decisions (Houck and Gallagher), a set of behavioral equations for acreage and yield response, together with identity equations defining production as acreage planted times yield per harvested acre and total supply as the sum of current production and carryover stocks, are specified for each crop commodity. The feed grain demand block links the crop sector to the livestock sector. The fruit crop production block contains equations explaining the quantities supplied of fruits. The agricultural employment and farm capital investment demand blocks contain a single equation, each to represent the agricultural sector's linkages with the relevant input markets. Finally, the farm receipts and expenditure block contains accounting equations and definitional identities for the state agricultural sector.

The structural form of the supply component of

(1)

where $(3_0$ - $(A)b_O$, p, = (A)*,, $(3_2$ = (1-A), p_3 = (A)&$_2$> and V, — (A)«,; In is the logarithm operator; Y_t is a vector of endogenous variables at time *t;* p_0 is the intercept term; p/ (/ = 1, 2, 3) is a matrix of structural parameters; *A* is the partial-adjustment coefficient such that 0 < *A* < 1; P_t is a vector of lagged or expected prices; $F_{,\text{-}Y}$ is a vector of endogenous variables lagged *j* periods; *Z,* is a vector of predetermined nonprice variables; *V,* is a vector of error terms; b_f *(i* = 0, 1, 2) is a matrix of coefficients; and *u,* is a matrix of error terms of the stock-adjustment equations (Pindyck and Rubinfeld).

An illustration of the linkages among the variables and equations comprising the model is contained in Figure 1. The relationships depicted are based on the premises of economic theory and could therefore be applied to the analysis of agricultural sectors in other states or regions. Table 1 contains a list of the commodities and variables included in this analysis.

Data and Estimation

Annual time series data for the period 1949-83 were used for estimating the model. Data for the 1984-85 period were used in an ex ante simulation as part of the model validation process. These were the most recent data available for all variables when the analysis was conducted. The observation period

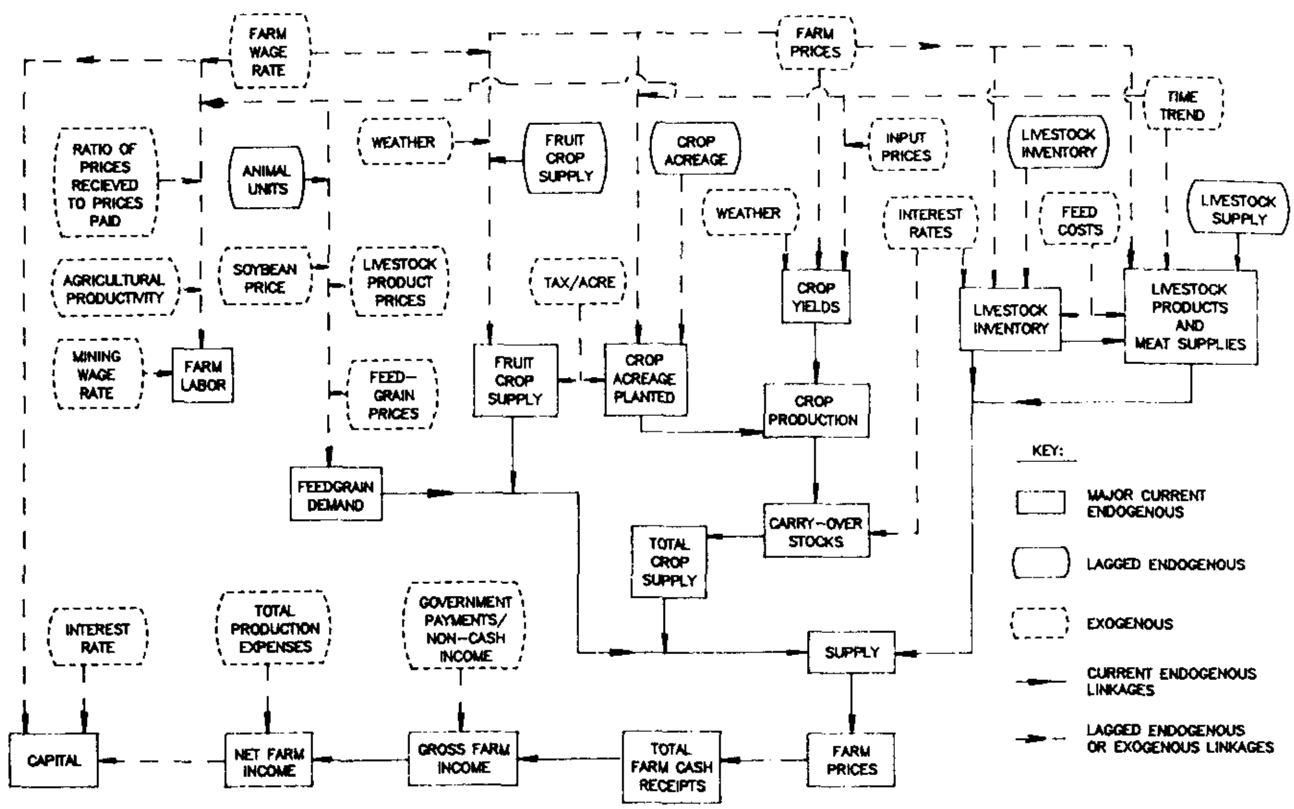

Figure 1. Flow Chart of the State Agricultural Sector Model

extends far enough to include adjustments brought about by changes in several important macrovariables. Oil prices, for example, increased through the mid- and late 1970s and peaked in 1980, as did inflation rates. Interest rates peaked a year later.

Several problems were encountered in obtaining appropriate state-level data for some variables. This limitation was overcome by using appropriate national or regional data as proxies for state data. For example, in the farm capital investment demand equation, time series data on farm machinery prices and quantities purchased annually by state fanners do not exist. Therefore, an implicit index of quantities purchased annually of farm machinery and equipment was computed using Fisher's weak reversal test (Diewert), and a national index of farm machinery prices was used as a proxy for state farm machinery prices. The lack of state-level data on individual crop input prices—one of the variables in the crop supply equations—also necessitated an adjustment. In this case, an index of fertilizer prices paid at the national level was selected as a proxy for state crop input prices. Data sources include the WV Department of Agriculture, the WV Department of Employment Security Research and Statistics, the U.S. Department of Agriculture, and Weiss, Whittington, and Teigen.

The livestock, fruit, field crop production, inventory, and farm income blocks of equations are estimated using three-stage least squares (3SLS). While 3SLS is sensitive to specification error, it is an appropriate method of estimation considering that many equations in the system are overidentified and given the expected contemporaneous correlation across equations. By explicitly accounting for the latter, 3SLS is asymptotically more efficient than, say, two-stage least squares (Intriligator). The feed grain demand, agricultural employment, and farm capital investment demand equations are recursive to the system and are estimated by ordinary least squares. Further details on model specification, data requirements, and estimation procedures can be found in Onafowora.

Results and Implications

Parameter estimates of the model are presented in Table 2. The coefficients are tested for significance at the 10% level. The discussion in this section centers primarily on some of the short-run impacts of causal factors; long-run impacts are addressed in the following section.

The results provide an explanation for some of the problems and potentials characterizing WV agriculture that were alluded to. Some of the findings suggest possible avenues for mitigation of these problems and capitalizing on the potentials. Others

Table 1. Commodities and Variables Comprising the State Agricultural Sector Model

Variable	Description	Variable	Description
AP	Apples	*MYT*	Deviation from mean May temperature (X)
BF	Beef	*MKFD*	Price ratio milk to dairy-cow feed cost (X)
BY	Barley	*NFI*	Net farm income (E)
C	Corn	*NLY*	Number of layers (E)
CK	Chickens	*PAP*	Real farm price of apples (X)
EG	Eggs	*PBF*	Real farm price of beef (X)
H	Hay	*PBY*	Real farm price of barley (X)
HG	Hogs and pigs	*PBYW*	Price ratio barley to wheat (X)
LS	Lambs and sheep	*PCN*	Real farm price of corn (X)
MK	Milk	*PCK*	Real farm price of chicken (X)
O	Oats	*PCO*	Price ratio corn to oats (X)
PH	Peaches	*PCV*	Real farm price of calves (X)
PK	Pork	*PEG*	Real farm price of eggs (X)
TK	Turkey	*PFG*	Weighted feed grain price (X)
W	Wheat	*PHY*	Real farm price of hay (X)
AC	Planted acreage (E)[a]	*PHW*	Price ratio hay to wheat (X)
BFFD	Price ratio beef to cattle feed cost (X)	*PKFD*	Price ratio pork to hog feed cost (X)
BRPL	Broiler placements (X)	*PLS*	Real farm price of lambs (X)
CKFD	Price ratio chickens to chicken feed cost (X)	*PLTFD*	Price ratio poultry to turkey feed (X)
CR	Cash receipts (E)	*PMH*	Farm machinery price index (X)
CS	Carryover stocks (E)	*PMK*	Real price of milk sold to wholesalers/retailers (X)
CVFD	Price ratio calves to cattle feed cost (X)	*PO*	Real farm price of oats (X)
DA	Farm debt/asset ratio (X)	*PPH*	Real farm price of peaches (X)
DFG	Feed grain demand (E)	*PSY*	Price of soybean meal (44% protein) (X)
DMH	Farm machinery demand (E)	*PW*	Real farm price of wheat (X)
EGFD	Ratio farm price of eggs to layer feed cost (X)	*PWO*	Price ratio wheat to oats (X)
EMP	Farm employment (E)		Supply (E)
FCR	Feed conversion ratio (X)	*OS*	Total supply (E)
FD	Feed cost (X)	*SPP*	Deviation from mean September precipitation (X)
FRC	Feed range condition index (X)	*SPT*	Deviation from mean September temperature (X)
FMZ	Average farm size (X)	*T*	Annual time trend (X)
HEF	Dairy-cow replacement heifers (> 500 Ibs.) (X)	*MKSY*	Price ratio milk to soybeans (X)
IN	Inventory (E)	*TCRALL*	Total cash receipts all farm commodities (E)
m	Real interest rate (X)	*TCRLK*	Total livestock cash receipts (E)
JYP	Deviation from mean July precipitation (X)	*TCRKRP*	Total crop cash receipts (E)
JYT	Deviation from mean July temperature (X)	*TKFD*	Ratio farm price of turkeys to turkey feed cost (X)
KR	Weighted crop price index (X)	*TX*	Index of taxes paid per acre of farmland in WV (X)
LKN	Livestock numbers on farms (X)	*UN*	Unemployment rate, WV (X)
LKPI	Weighted livestock price index (X)	*V*	Farm value of production (E)
LPI	Labor productivity index (poultry) (X)	*WFL*	Index of farm labor wage (X)
LSFD	Price ratio lambs to sheep feed cost (X)	*MPCW*	Milk production per cow (E)
MCW	Milk-cow numbers (E)	*WML*	Index of wage rate in WV coal mining industries (X)
		YD	Per acre yield (E)

[a] The letter "E" enclosed in parentheses indicates current or lagged endogenous variables; exogenous variables are indicated by the letter "X"

suggest that WV agriculture is indeed unique with respect to producer behavior. The declining competitive position of WV agriculture can partially be explained by the results obtained for the commodity that dominates state agricultural production— beef cattle. Nonprice variables, such as forage availability, are found to be more important determinants of herd-size decisions than price variables such as interest rates (Table 2, equation 2.1). While this is consistent with the forage-based nature of WV's agriculture, it also suggests that a sluggish response to price variables can compromise producers' abilities to be competitive. This result is consistent with that or the feed grain demand equation (equation 2.39), included to link the crop and livestock sectors, which indicates that feed grain prices are not a significant determinant of feed grain demand. While many producers grow their own feed, logic would dictate that feed be purchased when unit market prices are lower than individual unit variable production costs. For this to occur, producers need to track market prices and their production costs, and make adjustments as necessary.

Some of the results for certain other commodities, however, are more consistent with ' 'normative

Table 2. Estimated Coefficients for the Equations Comprising the Model[a]

Livestock: Beef Cattle

(Eq. 2.1) *BFIN* = .21 + *.S1BFIN.*, + *.\4BFFD* , + *AHQH* + .03/tf - *A2PKFD.* , - *.\1CVFD_*,
(.41) (.05) (.06) (.03) (.01) (.02) (.05)

(Eq. 2.2) *QBF* = -.48 + .09QBF_, + .0047 + *A6BFIN* + *.25PBF-t* - *A4PCV* - *.Q6BFFD_t*
(3.0) (.06) (.001) (.09) (.03) (.03) (.04)

Hogs

(Eq. 2.3) *HGIN* = -.47 + .83//G/AL. + *.3\PKFD.t* - *A4IR* - .09BFFD-.
(.91) (.08) (.11) (.06) (.07)

(Eq. 2.4) *QPK* = 25.01 + *.51QPK_t* + .0147 - *AlPKFD* + *.54HGIN*
(5.49) (.05) (.008) (.06) (.06)

Lamb and Sheep

(Eq. 2.5) *LSIN* = 18.37 + .82LS//V_, - .0107 + *A9LSFD* + *.09QH* - .04BFFD
(5.25) (.06) (.002) (.04) (.03) (.03)

(Eq. 2.6) *QLS* = 5.23 + .18015-, + *.69LSIN* - .16L5FD
(.61) (.09) (.08) (.04)

Milk

(Eq. 2.7) *MCW* = 93.79 + *.24IR* - .09BFfD , + *.\3FRC.i* - .0537 + *MHEF* 2 + *.\5MKFD.t*
(6.43) (.04) (.04) (.08) (.003) (.04) (.08)

(Eq. 2.8) *MPCW* = 16.14 + *.13MPCW^* + *.MMKSY* + .0097
(2.93) (.05) (.02) (.002)

(Eq. 2.9) *QMK* = *MCW* * *MPCW*

Poultry: Turkeys

(Eq. 2.10) *QTK* = 4.12 + *.63QTK-t* + *39FCR* + *.\5LPI* - *\.\4PLTFD-i* + *.ttTKFD.j*
(1.22) (.08) (.18) (.08) (.24) (.24)

Chickens

(Eq. 2.11) *OCK* = -1.20 + *.12OCK-t* + *.35FCR* + *.2\LPl* + .28CKF£> , + *.2ZBRPL*
(.58) (.05) (.13) (.04) (.08) (.04)

Eggs

(Eq. 2.12) *NLY* = .79 + *X&NLY^* + *.26FCR* ~ .16F.GFD-.
(.22) (.03) (.05) (.05)

(Eq. 2.13) *QEG* = -18.48 + .(WfiEG-, + *.95NLY* + .0091 - *.Q9BRPL* - *AQEGFD*
(6.47) (.05) (.06) (.003) (.02) (.03)

Field Crops: Corn

(Eq. 2.14) *ACC* - 41.16 + .79ACC_, + .657X. , + *.23PCO.t* - .027
(15.40) (.06) (.23) (.09) (.01)

(Eq. 2.15) *YDC* - -52.24 + .06ACC + *.Q2MYP* + .047KP - *.Q2JYT* + .037
(2.87) (.03) (.006) (.005) (.007) (.001)

(Eq. 2.16) *QC* - *ACC* * *YDC*

(Eq. 2.17) *CCS* = -49.94 + .29CCS_(- .31//J + -SSfiC + *.2iPCN*
(13.36) (.07) (.11) (.08) (.12)

(Eq. 2.18) *QSC* = *QC* + *CCS*

Oats

;Eq. 2.19) *AGO* - 56.88 + *A9ACO.t* + -15POVV., - .037
(8.52) (.07) (.07) (,004)

;Eq. 2.20) *YOO* = -25.66 + .02SP7 - .047X7 - .037KP + .0257
(2.61) (.01) (.01) (.008) (.001)

Table 2. *{continued)*

Oats

(Eq. 2.21) *QO = ACO * YDO*

(Eq. 2.22) *OCS* = 6.59 + *.09OCS.* , - *. 5 11R + 2%QO + 21PO*
(1.20) (.11) (.11) (.13) (.11)

(Eq. 2.23) *QSO = QO + OCS*

Wheat

(Eq. 2.24) *ACW* = 13.59 + *A6ACW_t* - .077 + *.\4PWO. t* + 1.307X_,
(2.38) (.09) (.01) (.06) (.25)

(Eq. 2.25) *YDW* = 27.57 - *.Q9ACW* + .0277 - .017MK7 - *.Q29MHT*
(4.97) (.04) (.003) (.008) (.008)

(Eq. 2.26) *QW = ACW * YDW*

(Eq. 2.27) *WCS* = 2.26 + .52WC5_i - *.23IR* + *.21QW* + .79/W-, - *.18PW*
(.74) (.07) (.09) (.08) (.16) (.13)

(Eq. 2.28) *QSW = QW + WCS*

Barley

(Eq. 2.29) *ACBY* = .99 + *.69ACBY.,* - .367X,, + *.33PBYW.t*
(.20) (.07) (.08) (.12)

(Eq. 2.30) *YDBY* = 26.45 - *.Q6ACBY* + .027 - *.Q2MYT* - .033W//7
(3.41) (.04) (.002) (.009) (.008)

(Eq. 2.31) *QBY = ACBY * YDBY*

(Eq. 2.32) *BYCS* = -1.44 + *.51BYCS-1 - . 12IR + .54QBY - .69PBY* + .34PSK.,
(.76) (.07) (.06) (.09) (.18) (.17)

(Eq. 2.33) *QSBY = QBY + BYCS*

Hay

(Eq. 2.34) *ACH* = 13.01 + .79AO/-, + .187X_, - .0067 + *.OOSPHW^*
(5.45) (.08) (.07) (.003) (.013)

(Eq. 2.35) *YDH* - -8.94 + ,05M>T - .038SW + *.032SPT - .03UYT* + .0057
(2.99) (.01) (.011) (.Oil) (.013) (.002)

(Eq. 2.36) *QH = ACH * YDH*

(Eq. 2.37) *HCS* - 2.43 - .002WC5., - *A6IR + .63QH - .55PHY_t*
(1.01) (.09) (.06) (.13) (.13)

(Eq. 2.38) *QSH - QH + HCS*

Feed Grain Demand

(Eq. 2.39) *DFG* - 9.23 + *\.36LKN - .\SPSY + .35PFG + .34LKP1*
(10.46) (.71) (.12) (.25) (.24)
(R^2 = .53, *DW* - 1.578)

Fruit Crops: Apples

(Eq. 2.40) *QAP* = 23.38 - *.29QAP.t + 2ZPAP + .22PAP_2*
(21.42) (.17) (.16) (.16)

- *A9WFL* .07I7VT + .0415P7 + .0247
(.30) (.001) (.026) (.Oil)

Peaches

(Eq. 2.41) *QPH* - 4.26 + *.56QPH.., + .19PPH + A1PPH_2 - [22WFL.,* + .0257X., + *.Q61SPT*
(3.11) (.20) (.39) (.29) (.50) (.002) (.025)

Table 2. *(continued)*

Agricultural Employment

(Eq. 2.42) *EMP* = 14.59 + *3\\WFL* + 1.34PM// - *.96WML* + .33CW - .077
(5.58) (.16) (.46) (.58) (-17) (.03)
$(R^2 = 0.96, DW = 2.398)$

Capital Investment Demand

(Eq. 2.43) *DMH* = 3.45 - .2J£W - .14/tf - *\.22FMZ* + *.O4KRPMH* + *.26TCRKPP* - *.52WFL* + .0157
(14.03) (.07) (.05) (.43) (.07) (.06) (.39) (.011)
(*² = 0.98, *DW* = 2.87)

Farm Income Components

(Eq. 2.44) *VBF* = 1.98 + .12PBF + *\.Q4QBF*
(6.58) (.18) (.56)
;Eq. 2.45) *CRBF* = 15.73 + 1.06VW + .023V5F , - .0087
(2.28) (.03) (.02) (.001)
;Eq. 2.46) *VPK* = 3.85 + *.\6PPK* + *.5\QPK*
(.77) (.09) (.08)
* ;Eq. 2.47) *CRPK* = 31.94 + *1.29VPK - MVPK,₁* + .0177
(4.64) (.09) (.09) (.002)
;Eq. 2.48) *VLS* = 8.41 + *.61PLS* + *.Q2QLS*
(.67) (.08) (.06)
;Eq. 2.49) *CRLS* = 1.39 + 1.01 VLS - .02VLS_, - .00077
(.15) (.04) (.04) (.00008)
Eq. 2.50) *VCK* = 2.29 + *.23PCK* + *l.l&QCK*
(.67) (.07) (.05)
* Eq. 2.51) *CRCK* = 4.44 + .99VCA: - .005VCK., + .00237
(.19) (.003) (.003) (.0001)
Eq. 2.52) *VEG* = 14.21 + *MPEG - A4QEG*
(.50) (.06) (.05)
Eq. 2.53) *CREG* - 10.64 + *.97VEG* - .06VEG_, + .0067
(1.31) (.01) (.01) (.001)
* Eq. 2.54) *VMK* - 3.73 + *\.3%PMK* + *.59QMK*
(.60) (.16) (.06)
Eq. 2.55) *CRMK* - 31.67 + *MVMK* + *.03VMK.ₜ* + ,0177
(.71) (.03) (.02) (.001)
Eq. 2.56) VC - .38 + *.1QPCN* + .860C
(.95) (.15) (.09)
+ Eq. 2.57) *CRC* = .94 + .49VC + 1.05VC_, + .0027
(.56) (.03) (.59) (.001)
iq. 2.58} *VO* = .34 + *.55PO* + *1.Q3QO*
(.18) (.03) (.03)
Eq. 2.59) *CRO* = 42.22 + .82VO + .10VO_, + .027
(9.94) (.123) (.113) (.005)
iq. 2.60) *VW* = 4.94 + *.38PW* + *.51QW*
(.51) (.09) (.06)
•q. 2.61) *CRW* = 18.98 + *.69VW* + .35VW.., + .0097
(7.33) (.09) (.09) (.003)

Table 2. *(continued)*

Farm Income Components

(Eq. 2.62) *VBY* = 2.46 + *.34PBY* + *MOBY*

(.79) (.19) (.11)

(Eq. 2.63) *CRBY* = 2.83 + \.*03VBY* + .16V»y_, - .003F

(5.69) (.08) (.07) (.003)

(Eq. 2.64) *VH* = 7.11 - .83/W + *A3QH*

(.75) (.09) (.11)

(Eq. 2.65) *CRH* = 25.27 + .30V// + ,67V//., + .0127

(5.20) (.11) (.11) (.003)

(Eq. 2.66) *CRAP* = 2.99 + *.&3QAP* + *A2PAP*

(1-19) (.19) (.13)

(Eq. 2.67) *CRPH* = 5.87 + *.89QPH* + *.91PPH*

(.64) (.06) (.11)

(Eq. 2.68) *TCRLK = CRBF + CRPK + CRLS + CRCK + CREG + CRMK + CRTK*

(Eq. 2.69) *TCRKRP = CRO + CRW + CRC + CRBY + CRH + CRAP + CRPH*

(Eq. 2.70) *TCRALL = TCRLK + TCRKRP*

Note: Standard errors are enclosed in parentheses below the coefficients. The R^2 and Durbin-Watson (DW) statistics are also included in parentheses below those equations estimated by OLS.

[a] Table 1 contains a description of the variables. Some variable names in Table 2 are derived by combining a commodity with one of the variables listed in Table 1. For example, the variable *BFIN* (beef inventory) in equation 2.1 is a combination of commodity *BF* (beef) and variable *IN* (inventory).

expectations," even though many of these commodities represent only a small proportion of farm receipts. For example, interest rates are found to be one of the key determinants of hog inventories (equation 2.3). For milk production, the results (equation 2.8) suggest that producers have taken advantage of technological advances (proxied by a time trend variable) to increase milk yields. Further, while milk producers are not as sensitive to interest rates as, say, hog producers, they do respond in the "expected" manner to changes in other price variables such as milk prices and feed costs.

Apple producers also appear to have reaped the benefits of technological advances over the study period (equation 2.40). Fruit crop producers, in general, appear to respond in the expected manner to changes in most price variables. This is especially significant since apple production accounts for a major proportion of crop receipts.

The poultry production sector (represented by equations 2.10 to 2.13) also is found to exhibit desired responses to changes in variables, potentially making this sector more competitive in the process. Together with the fruit production sector, state policy makers could target the poultry sector for expansion. In addition to the strong demand for poultry and fruit products, WV could have a production advantage in that its hilly terrain acts as a natural barrier to the spread of disease outbreaks, the latter comprising a major component of production risk in the poultry industry. The finding that commodities such as milk, fruit, and poultry have benefited from technological advances over the study period suggests the continued importance of technology to effect future increases in productivity for these commodities, with implications for others where technological adoption lags behind.

The positive relationship between agricultural employment and state unemployment (equation 2.42) indicates that the agricultural sector, as hypothesized, does indeed absorb some "excess" labor when unemployment rises, a problem occurring with some frequency in this state. Results also indicate that as opportunity wages in the nonfarm sector increase, farm employment decreases. The potentially adverse consequences of such cyclical labor outmigration from agriculture should be tempered somewhat by the fact that labor and machinery are found to be substitutes.

Overall, the results reveal that the problems, commodity mixes, and other characteristics of WV agriculture are indeed unique in many respects, a uniqueness that implies, among other things, that policies formulated at the national level based on a knowledge of aggregate producer behavior are not likely to have the desired impacts on the state's agriculture. Thus, the finding that livestock producers are more sensitive to changes in forage availability than feed grain prices suggests that policy intervention in the form of drought assistance, for example, could have a greater impact on WV producers. Likewise, the positive relationship between property taxes paid and production of some feed and fruit crops (equations 2.14, 2.24, 2.34, 2.40, and 2.41) could lead to the formulation and implementation of policies by state and local government officials, which would result in the creation of additional rents to boost government revenues. Analyses such as this could be a first step in the process of ultimately gaining knowledge of the extent to which responses to price and nonprice changes differ geographically—knowledge that could be used in adapting national farm policies to explicitly account for such differences.

The validation statistics (R^2 and Durbin-Watson test statistic, Table 2) suggest that the model adequately captures the interrelationships and adjustments in WV agriculture over the study period, thereby increasing the confidence that can be attached to the preceding results. The validation process included simulating the model over two time periods: first over the entire estimation period of 1949-83 (historical simulation), and subsequently for the beyond-sample period of 1984-85 (ex ante simulation). The simulations were performed with the SIMLIN procedure of SAS/ETS (Statistical Analysis Systems). Validation statistics for the historical simulation are summarized by the values of the root mean square percentage error (RMS%E), presented in Table 3 for selected endogenous variables. Less than 13% of the variables are associated with a RMS%E exceeding 10%. Evaluation statistics for the ex ante simulation for selected endogenous variables (Table 4) reveal that an equally small proportion of variables is predicted with errors exceeding 10%. Dynamic multipliers also were estimated as part of the validation process, and these suggest that the model is stable, as fluctuations in the endogenous variables from their equilibrium values diminish geometrically over time following an exogenous shock. The validation results suggest that the model performs well enough to make it potentially useful for policy analysis.

Long-Run Impacts

Further insights into state agriculture are provided by additional simulations of the model. Three such simulations were conducted and used to evaluate the long-run impacts of changes in (1) interest rates and (2) real estate tax rates on agricultural production decisions, and (3) selected exogenous variables on the poultry subsector.

The dynamic multipliers of an interest rate "shock" on selected endogenous variables over a ten-year period are presented in Table 5. A sustained 1% increase in interest rates *(IR)* is found to reduce hog inventories *(HGIN)* by 0.78% in the

Table 3. Validation Statistics for the Historical Simulation of the Model

Variable	RMS%E	Variable	RMS%E	Variable	RMS%E
*BFIN**	0.654	*QBF*	0.442	*HGIN*	2.933
OPK	1.604	*SIN*	1.044	*OLS*	0.862
MCW	1.677	*MPCW*	0.346	*QMK*	100.000
QTK	2.455	*QCK*	0.676	*NLY*	2.150
QEG	2.952	*CRBF*	3.983	*CRPK*	4.280
CRMK	56.263	*CRCK*	2.883	*CREG*	40.002
TCRLK	371.924	*OBY*	1.384	*OH*	0.880
VC	3.659	*VO*	1.243	*VW*	4.027
VBY	4.434	*VH*	1.839	*CRCN*	6.229
CRO	5.605	*CRW*	5.710	*CRBY*	8.476
CRH	3.013	*TCRK*	4.489	*QAP*	2.361
QPH	13.119	*CRAP*	3.979	*CRPH*	14.595
DFG	2.965	*EMP*	8.334	*DMH*	4.750
VBF	3.629	*VPK*	3.889	*VLS*	6.582
VMK	64.154	*VCK*	2.843	*VEG*	43.565
ACC	2.343	*AGO*	4.691	*ACW*	3.049
ACB	7.026	*ACH*	0.345	*YDC*	1.838
YDO	2.099	*YDW*	2.395	*YDB*	2.403
YDH	2.211	*CCS*	2.165	*OCS*	2.032
WCS	3.701	*BCS*	2.700	*HCS*	1.787
QC	1.088	*QO*	1.055	*QW*	1.849

[a] See Table I for **a description of** the variables.

Table 4. Actual and Forecasted Values for Selected Endogenous Variables for the Ex Ante Simulation

Variable	Actual	Forecast	% Error
ACfi[a]	1.792	1.622	9.490
ACC	4.745	4.854	2.303
ACH	6.446	6.432	0.225
ACO	2.398	2.553	6.461
ACW	2.485	2.321	6.590
BCS	5.710	6.209	8.740
BFIN	6.380	6.430	0.781
CCS	9.289	9.529	2.582
CRAP	4.325	4.522	4.555
CRBF	10.929	11.197	2.457
CRBY	4.419	4.820	9.075
CRC	8.170	8.396	2.774
CRCK	10.494	10.449	0.433
CREG	9.160	9.031	1.415
CRH	8.537	8.453	0.981
CRLS	8.110	8.288	2.190
CRO	4.094	4.374	6.843
CRPH	2.230	2.358	6.073
CRPK	8.113	9.445	16.426
CRW	6.701	6.808	1.601
DFG	8.398	8.562	2.010
DMH	4.465	4.589	2.770
EMP	3.269	3.256	0.398
HCS	6.889	6.736	2.224
HGIN	3.611	3.887	7.645
MCW	3.526	3.449	2.181
MPCW	9.292	9.281	0.122
VPK	8.696	9.824	12.971
NLY	6.349	6.256	1.462
OCS	6.914	6.941	0.390
OAP	5.416	5.460	0.812
OBF	11.784	11.786	0.024
WCS	5.545	6.III	10.217
YDO	3.932	3.937	0.122
QCK	11.509	11.443	0.573
QEG	4.867	4.807	1.233
VW	7.383	7.421	0.515
OLS	8.663	8.735	0.830
QMK	5.911	5.821	1.524
VPK	8.696	9.824	12.971
OPH	2.833	2.972	4.906
OPK	9.261	10.303	11.255
QTK	10.726	10.721	0.054
VO	6.889	7.137	3.599
SIN	4.511	4.561	1.100
TCRK	31.921	32.850	2.910
VBF	11.110	11.344	2.106
VBY	6.658	6.685	0.375
VC	10.380	10.676	2.852
VCK	0.495	10.451	0.419
VEG	9.216	9.079	1.487
VH	11.276	10.062	10.766
VLS	8.154	8.328	2.134
VMK	10.813	10.969	1.443
YDH	0.582	0.331	43.138
YDC	4.605	4.638	0.723
YDB	3.970	3.938	0.815

* See Table I for a description of the variables.

long run, compared to a reduction of 0.14% in the short run. The large estimated long-run effect on hog inventories obviously has an adverse effect on long-run pork supplies, as indicated by the -0.98 coefficient for pork supply *(QPK)*. Interest-rate multipliers for corn and wheat carryover stocks *(CCS* and *WCS,* respectively) suggest that the willingness to hold large crop inventories decreases with increases in inventory holding costs (interest rates). In the case of corn, the multiplier effect declines rapidly, converging to zero by the end of the sixth-year lag. For wheat, the multiplier effect of a 1% sustained increase in interest rates is shown to have measurable effects, even at the end of the ten-year lag period. The initial effect of an increase in interest rates on farm machinery demand (DA///) is shown to be larger than the long-run (total-multiplier) effect. Machinery investment decisions can be delayed for some years, but eventually equipment has to be replaced as maintenance costs rise with age and gradually become larger than the costs of replacement.

The dynamic multipliers for a 1% increase in assessed taxes per acre *(TX)* on selected endogenous variables over a ten-year period are reported in Table 6. A 1% increase in *TX* is associated with an increase in acreage planted of wheat *(ACW)* amounting to 1.3% in the short run and 2.38% in the long run, an increase in acreage planted of corn (ACC) by 0.65% in the short run and 2.54% in the long run, and increased quantities supplied of wheat, corn, apples, and peaches in the short and long run. Although barley yields increase, the decrease in acreage results in a reduction in total quantity supplied. The positive relationship between crop supplies and land taxes paid for all fruit and field crops (except barley) is one of the more unique aspects of the results for WV, and suggests that increased production arises from the need to offset increased fixed production costs resulting from higher land tax payments. In the long run, unless product prices simultaneously increase, such production responses will have undesirable financial consequences for producers and lead to suboptimal resource use. From a policy standpoint, such production responses suggest that lowering farmland assessed values or tax rates would be unlikely to stimulate increases in state agricultural production, although it could increase profitability or reduce losses.

The third simulation illustrates the impacts of a 1% change in the feed-con version ratio, labor productivity, and the own-price feed-cost ratio on the poultry subsector. Poultry was selected since it has been, and is likely to continue to be, a high-growth industry in WV. An examination of the dynamic

Table 5. Dynamic Multipliers for a 1% Increase in Interest Rates on Selected Endogenous Variables

Endogenous	Lag in Years						Total
Variable	0	2	4	6	8	10	Multiplier
CCS[a]	-0.310	-0.039	-0.003	-0.002	-0.00002	-1.709E-06	-0.682
WCS	-0.231	-0.073	-0.016	-0.003	-0.0007	-0.0001	-0.632
HGIN	-0.139	-0.091	-0.063	-0.043	-0.029	-0.020	-0.775
QPK	-0.073	-0.107	-0.092	-0.069	-0.049	-0.035	-0.980
BFIN	-0.034	-0.023	-0.018	-0.014	-0.010	-0.008	-0.241
QBF	-0.014	-0.012	-0.009	-0.007	-0.005	-0.004	-0.121
DMH	-0.063	-0.006	-0.0006	-0.00007	-7.09IE-05	-7.317E-07	-0.0474

[a] See Table 1 for a description of the variables.

multipliers (Table 7) shows large increases in long-run (total-multiplier) chicken, turkey, and egg supply levels *(QCK, QTK,* and *QEG,* respectively) and associated cash receipts *(CRCK, CRTK,* and *CREG)* from a 1% increase in the feed-conversion ratio. The short-run impacts, captured by the coefficients of the structural equations (impact multipliers), on the other hand, are much smaller. Thus, a sustained 1 % increase in the feed-conversion ratio will cause chicken or broiler supply to increase by 1.21% in the long run, compared to an increase of only 0.35% in the current period. The increase in chicken supply *(QCK)* induces a 1.4% long-run increase and a 0.4% short-run increase in cash receipts from chickens *(CRCK).*

The multipliers in Table 7 also show that the increases in chicken and turkey supplies and receipts associated with a sustained long-run increase in labor productivity are generally much less than those resulting from a comparable increase in either the feed-conversion ratio or the own-price feed-cost ratio. Further, turkey supply and cash receipts are much more sensitive to a change in the own-price feed-cost ratio than either chicken or egg supplies and cash receipts. These findings suggest that technology (as embodied in the feed-conversion ratio) and prices are likely to play an important role in the future of the poultry industry in WV, which is consistent with the structural-equation results in Table 2. The implications of the dynamic-multiplier results for potential competition for available resources between broiler and turkey production are not clear and could need further study. However, given that cash receipts from broiler production are relatively more sensitive to technological change (namely feed conversion) and cash receipts from turkey production are relatively more sensitive to changing prices, a diversification strategy might provide some "feed" for thought.

Concluding Comments

The picture of WV agriculture that emerges portrays a situation in which its major component, beef cattle production, does not conform to normative

Table 6. Dynamic Multipliers for a 1% Increase in Tax Rates per Acre on Selected Endogenous Variables

Endogenous	Lag in Years						Total
Variable	0	2	4	6	8	10	Multiplier
*ACW**	1.301	0.219	0.033	0.005	0.001	0.0001	2.378
YDW	-0.135	-0.021	-0.003	-0.00!	-0.0001	-0.00001	-0.222
ACBY	-0.356	-0.175	-0.087	-0.043	-0.022	-0.011	-1.193
YDBY	0.026	0.013	0.006	0.003	0.002	0.001	0.087
ACC	0.653	0.330	0.208	0.131	0.082	0.052	2.539
YDC	0.043	0.027	0.017	0.0li	0.007	0.004	0.209
QAP	0.0013	0.000i	0.0000	0.0000	0.0000	0.0000	0.0010
CRAP	0.0011	0.0001	0.0000	0.0000	0.0000	0.0000	0.0009
OPH	0.0025	0.0008	0.0002	0.0001	0.0000	0.0000	0.0057
CRPH	0.0022	0.0007	0.0002	0.0001	0.0000	0.0000	0.005 1

[a] **See Table 1 for a description of** the variables.

Table 7. Dynamic Multipliers for a 1% Change in Selected Exogenous Variables

							Own-Price Feed-Cost		
			Total	Impact	Interim	Total	Impact	Interim	Total
QCK	0.346	0.244	1.207	0.217	0.154	0.762	0.279	0.200	0.986
CRCK	0.396	0.284	1.404	0.250	0.179	0.886	0.323	0.232	1.146
QTK	0.396	0.222	0.942	0.153	0.087	0.369	0.832	0.459	1.950
CRTK	0.205	0.113	0.455	0.212	0.116	0.469	1.098	0.602	2.432
OEG	0.243	0.238	2.197	—	—	—	-0.101	-0.011	-0.113
CREG	-0.032	-0.029	-0.272	—	—	—	0.019	0.018	0.164

[a] See Table 1 for a description of the variables.
[b] The impact multipliers refer to the current-period effect of a change in the exogenous variable on the endogenous variable. [c] The interim multipliers measure the effects of changes in the exogenous variables after one year. The total multipliers refer to the situation where the increase is sustained for an infinite period.

expectations in terms of adjustments to price and nonprice changes. Other groups of producers, such as fruit and poultry producers, however, do exhibit behavior that is consistent with normative expectations. Expanding the production of these commodities would ensure that producers' responses are more consistent with consumer demand, while simultaneously leading to a healthier state farm economy. By virtue of the farm sector's linkages with the nonfarm economy, this could also contribute to strengthening the currently weak state economy. In certain other cases, the potential for modification of producer behavior through policy or other types of intervention is evident—a modification that should result in producers altering their input-output mix in response to changes in price variables and "desirable" nonprice variables such as technology and changing market conditions.

The potential for refinements in the model exists even though it is generally recognized that the ability of a given model to accurately capture all essential elements of producer behavior is limited. Further, the availability of more state-level data could improve the analysis. Model and data limitations notwithstanding, the findings from this study do reveal some unique characteristics of the individual components of WV agriculture, characteristics that were masked up until now. By conducting similar analyses and enabling comparisons to be made with the agricultural sectors of other states, important implications could be forthcoming for decision and policy making, and eventually for the competitive position of the agricultural sector in individual states and for the nation as a whole. This is especially important at a time when this position is eroding.

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