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# A PERFORMANCE COMPARISON OF AGGREGATE AND DISAGGREGATE EXPORT MODELS FOR THE SOYBEAN SECTOR

William H. Meyers, Wipada S. Huyser and Michael D. Helmar\*

Simplicity is a virtue in economic modeling in the sense that the cost of model complexity needs to be weighed against the gains in model performance. Zellner has advised that "In connection with realizing the objectives of a model-building project, it is useful to have formulated as simple a model as possible." A common method of simplifying U.S. commodity models while maintaining an open-economy behavior, has been the use of aggregate export demand equations. This approach results in a two-region model of agricultural trade with the second region collapsed into a single net import equation. Thompson has pointed out the limitations of this approach but noted a lack of documented evidence comparing the two-region approach to more complex open-economy models. He specifically noted the failure of two-region models to "reach any consensus on the magnitude of the price elasticity of export demand, the most critical parameter in such models ...".

Our paper will compare the performance of a two-region model of soybean and soybean meal with an eight region model of the same commodities. The two-region model consists of a U.S. model and aggregate export demand equations for soybeans and soymeal. The eight region model is a non-spatial equilibrium supply and demand model including the U.S., Brazil, Argentina, EC9, Spain, Japan, East Europe and the rest of the world. Performance tests will consider both simulation statistics of fit and short and long-run impact multipliers in comparing the two approaches.

The value of this exercise to researchers and practioners is to evaluate the significance of behavioral differences between simple two-

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region models and multi-regional models. Given the heightened interest in whether the magnitude of export demand elasticities are great enough to make total demand elastic, attention is also given to differing elasticities obtained in the two models.

In the first section below a conceptual comparison of the two approaches is discussed. The second section describes the alternative models and parameters used in the comparison. Section three compares the statistics of fit and the impact multipliers generated by the different models. The results are summarized in the last section.

#### Comparison of Conceptual Models

The basic elements of a non-spatial equilibrium supply and demand model are illustrated in Figure 1. The summation of net demands of importers (EDT) less the net supplies of other exporters (ESO) is the net excess demand facing the U.S. market (EDN). The necessary components of this model are detailed in the equations below:

#### General Regional Model

$$\begin{aligned}
 (1) \quad EDT &= \sum DM_i - \sum SM_i = \sum f_i(P_i, X_i) - \sum h_i(P_i, Z_i) & i = 1, \dots, n \\
 (2) \quad ESO &= \sum SX_j - \sum DX_j = \sum f_j(P_j, X_j) - \sum h_j(P_j, Z_j) & j = 1, \dots, m \\
 (3) \quad ESUS &= h_u(P_u, X) - f_u(P_u, Z_u) \\
 (4) \quad ESUS &= EDT - ESO \\
 (5) \quad P_i &= P_u e_i + M_i & i = 1, \dots, n \\
 (6) \quad P_j &= P_u e_j + M_j & j = 1, \dots, m
 \end{aligned}$$

where

$e$  = exchange rate

$M$  = trade margin (cost, tariff, or subsidy)

$P$  = domestic price

$X$  = vector of demand shifters

$Z$  = vector of supply shifters

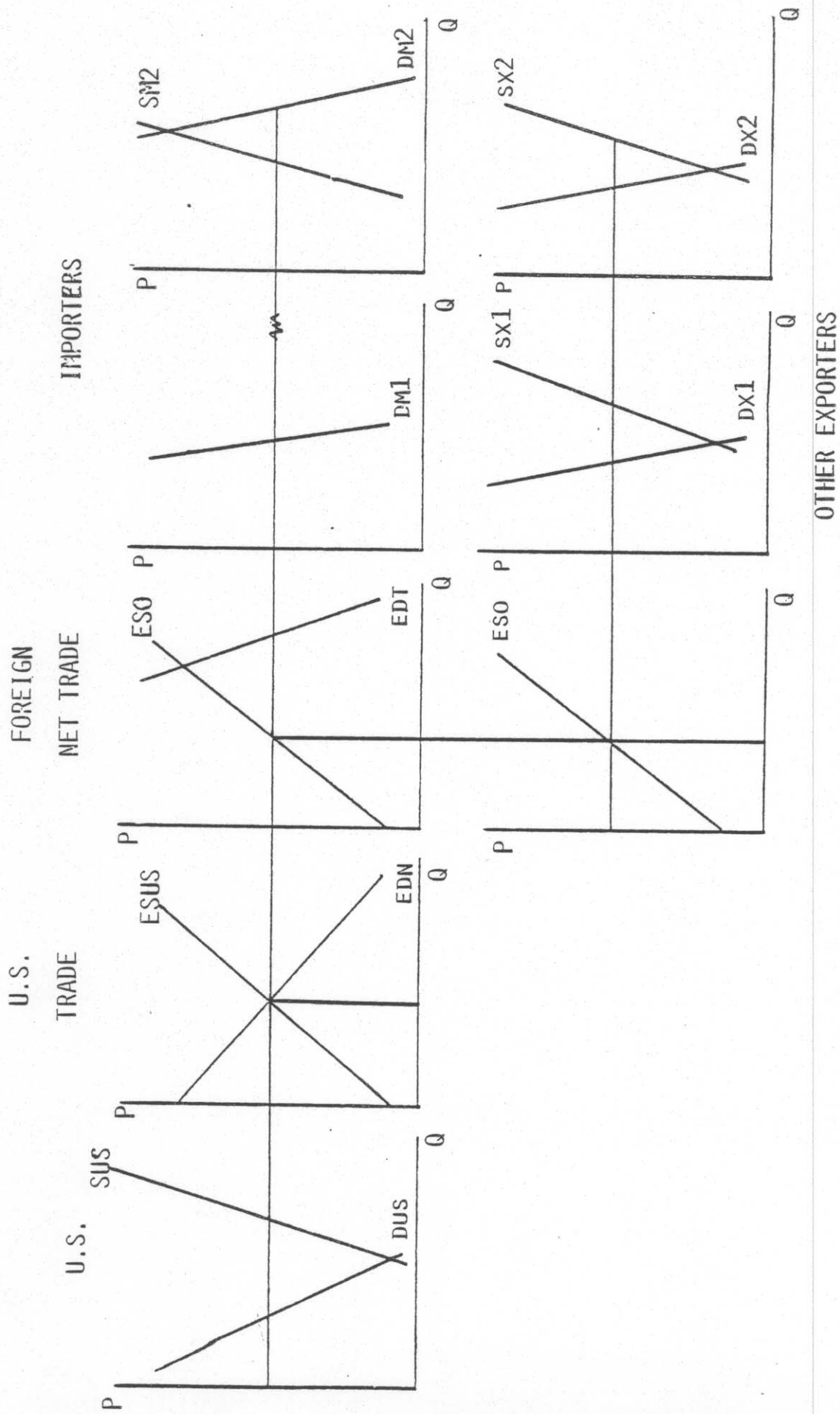


Figure 1. Illustration of Regional Supply and Demand Model

The basic elements of a two-region model are seen in the first two panels of Figure 1. Instead of estimating the numerous supply and demand schedules of the multi-region model, EDN is directly estimated or EDT and ESO are estimated directly. In this study EDT is estimated directly and ESO is taken as exogenous. The corresponding model equations are detailed below:

#### General Two-Region Model

$$(7) \quad ESUS = h_u(P_u, X_u) - f_u(P_u, Z_u)$$

$$(8) \quad EDT = F(P_u e_u, X_F)$$

$$(9) \quad ESUS = EDT - ESO$$

where

$e_u$  = an aggregate US exchange rate measure

$X_F$  = a vector of foreign shift variables

By practical necessity,  $X_F$  is a small subset of all  $X_i, X_j, Z_i$  and  $Z_j$  in equations (1) and (2) above, and the  $M_i$  are implicitly submerged in the constant term. Clearly this is a much simpler model. The question is whether the behavior reflected in equation (8) has any correspondence to that in the combined equations (1), (2), (5) and (6).

#### Comparison of Empirical Models

The models used in this study are more complex than the simplified versions used in the previous section. First, the soybean sector includes three distinct but closely related markets for soybeans and its two products, soymeal and soyoil. Second, the domestic demand in the U.S. is disaggregated into crush and inventory demand for soybeans, and consumption and inventory demand for soyoil.

The regional trade model was developed by Huyser (1983) to evaluate trade policies in soybean and soymeal markets. The supply and demand model for U.S. soybeans and soymeal is linked to supply and demand models for Argentina and Brazil and demand models for the EC 9, Spain, Japan, and Eastern Europe -- regions where soybean production is insignificant. The net imports of the USSR and the PRC are exogenous. The rest of the world total meal demand adjusts to changes in the U.S. export price with an elasticity of  $-0.3$  and the allocation of this demand between meal and bean imports is based on historical proportions. Price transmission linkages like equations 5 and 6 are included for all regions except for the soymeal price in Brazil, which was found to be independent of U.S. prices.

The aggregate trade model was constructed by replacing all the regional equations and linkages with an aggregate export equation for soybeans and one for soymeal. The aggregate export models are based on Bredahl, Gallagher and Matthews, and Bredahl, et al. and have previously been used in the soybean model reported by Baumes and Meyers. Soybean exports remain aggregated in both models, since this is a minor component of the total sector.

In both models there is a high degree of simultaneity among explanatory and dependent variables, and the number of exogenous variables exceeds the number of observations in the estimation period. For these reasons 2SLS estimation is used and the first 10 principal components from the exogenous data are used as instruments. Thus there are two potential sources of difference between the aggregate and the regional models:

1. The behavioral difference between the aggregate export equations and the corresponding excess demand derived from the regional supply and demand models.

2. The differences in the estimated parameters in the U.S. domestic equations, due to the different set of exogenous variables used in generating the principal components.

Both sources of difference are explored in this study.

The estimated coefficients and t-statistics are compared in Table 1. There are no changes in sign that occur and most of the corresponding behavioral coefficients are of similar magnitude. In general, the standard errors of the aggregate model coefficients are larger. The implications of the differences in magnitude of coefficients will be seen in the impact analysis of the next section.

The aggregate export equations are presented in Table 2. These are specified as total net import demands of countries other than the USSR and the three major exporters. The USSR imports are assumed to be policy determined and not responsive to market prices. The export demand facing the U.S. for soybeans (SOYMX) and soymeal (SOMMX) are derived by subtracting the net exports of Brazil and Argentina and adding the net imports of the USSR. This method implies another assumption -- that the net exports of Brazil and Argentina are independent of market prices. This is not the case in the regional model, but it is an assumption frequently employed in aggregate export models for the U.S.

Another concessions necessary in an aggregate model are the omission of some  $X_i$  variables and the use of aggregate measures. The aggregate exchange rate measure used here is the SDR rate. Since most trade in these commodities is with developed countries, this measure does not differ substantially from a trade-weighted exchange rate. Another aggregation is

Table 1. Comparison of 2SLS Estimates of Common Coefficients in the Regional and Aggregate Models.<sup>a/</sup>

	REG. MDL.		AGG. MDL 2	
	Coef.	t	Coef.	t
SOYSAE				
SOYPF/CORPF	9.61	8.61	9.12	9.06
SOYPF/COOPF	59.66	2.70	72.17	2.99
CORPE/SOYPE	- 7.38	- 1.26	- 7.04	- 1.12
CORPD/CORPF	-12.83	- 1.23	- 8.84	- 0.70
SOYSAE <sub>-1</sub>	.845	13.32	.885	11.24
D73	- 3.74	- 2.54	- 4.22	- 2.85
SOYSC				
SOYPM	-330.3	- 4.65	-328.9	- 4.86
VALOM	276.9	4.09	274.0	4.26
CVSOY <sup>b/</sup>	1.0	--	1.0	--
SOYHC				
SOYPM	-49.5	- 2.09	-54.7	- 1.40
SOYSC+SOYMX	.132	2.33	.160	2.47
SOYSPE	-.027	- 0.49	-.037	- 0.50
SOYHG	-1.93	- 1.74	-.212	- 1.63
SOYHC <sub>-1</sub>	.172	1.00	.133	0.69
SHIFT72	-203.3	- 3.02	-214.9	- 2.04
D7274	-64.2	- 3.36	-68.9	- 3.22
D80	146.0	3.49	140.2	2.98
SOYPF				
SOYPM	.929	114.65	.930	112.73
D72	- 1.45	-25.43	- 1.46	-25.58
D74	.717	12.56	.712	12.49
SOMDD				
SOMPM	-25.69	-13.07	-23.82	- 4.54
CORPF	1532.	6.96	1873.	2.14
LIVIF	3654.	8.95	3363.	3.14
HPAU	25080.	10.86	25755	5.45
FEEDHP	- 1.17	- 5.83	- 0.647	- 0.63
D73	-958.5	- 4.19	-1141.	- 1.87
D74	-3089.	- 9.49	-3157.	- 4.74
D80	3072.	6.94	2015.	0.92

<sup>a/</sup>The regional model has 13 additional behavioral equations for other countries or regions. Variable definitions are in the Appendix.

<sup>b/</sup>Restricted to 1.0.

Table 1. (continued)

	REG. MDL.		AGG. MDL 2	
	Coef.	t	Coef.	t
SOODD				
SOOPM/GNPD	-215.4	- 0.72	-363.9	- 0.19
LN(CEN/GNPD)	4428	0.81	5754	0.35
OTHFO	- 1.42	- 0.91	-0.981	- 0.19
BUTTLD	- 2.82	- 1.22	- 3.23	- 0.45
SOOHC				
SOOPM/GNPD	-20.71	- 2.41	-12.5	- 1.28
SOOSP	.162	6.15	.185	6.18
SOOHGPL	- 5.84	- 2.84	-.354	- 1.50
SOYSPE	-.647	- 3.99	-.801	- 4.48
SOOHC-1	.270	1.32	.563	2.38

Table 2. Aggregate Export Equation for Soybeans and Soymeal Estimated for Aggregate Model. (t-statistic in parenthesis)

$$\text{TSOYMX} = -653.2 - 187.5 \text{ SOYPM/SDR} + 141.6 \text{ VALOM/SDR}$$

(-7.51)      (-2.46)                      (2.15)

$$+ 3.676 \text{ CORPXB} + 745.6 \text{ LIVPEJ1}$$

(2.10)                      (5.43)

$$R^2 = .955$$

$$\text{D.W.} = 2.25$$

$$\text{SOYMX} = \text{TSOYMX} - \text{BXBZAR} + \text{BMUSSR}$$

$$\text{TSOMMX} = -5625.6 - 4588.7 (\text{SOMPM/SDR})/\text{CORPXM}$$

(-1.63)      (-2.69)

$$10163. \text{ LIVPEJ1} + 18.38 \text{ FIMPW} + 1474.6 \text{ SHIFT77}$$

(3.66)                      (2.21)                      (1.79)

$$R^2 = .799$$

$$\text{D.W.} = 2.33$$

$$\text{SOMMX} = \text{TSOMMX} - \text{MXBZAR}$$

where

- BMUSSR = Soybean net imports of USSR
- BXBZAR = Soybean net exports of Brazil and Argentina
- MXBZAR = Soymeal net exports of Brazil and Argentina
- CORPXB =  $(.53 \times \text{CORPF} \times 39.368/\text{SDR}) + .47 \times \text{CORPA}$
- CORPXM =  $(1 - \text{SOME C}) \times (\text{CORPF} \times 39.368/\text{SDR}) + \text{SOME C} \times \text{CORPA}$
- SOME C = Proportion of soymeal exports going to EC9
- TSOYMX = Total soybean net exports of the US, Brazil and Argentina less USSR net imports
- TSOMMX = Total soymeal net exports of the US, Brazil and Argentina

the weighted average corn price. The weighted average of U.S. export price and EC threshold price reflects the proportion of soybeans or soymeal trade that goes to the EC 9. The livestock production index is for the EC 9 and Japan, reflecting their predominance in these markets.

#### Comparison of Performance

The performance comparison included statistics of fit generated by the SAS-ETS simulation program, dynamic impact multipliers over 5-years for a yield shock and first-year impacts of key exogenous variables in domestic and export equations. The regional model is compared with aggregate model 1 which shares the same domestic parameters, and aggregate model 2, for which all parameters are re-estimated.

#### Statistics of Fit

The root mean square percent error and the random component of the error decomposition are compared in Table 3. The overall performance of any one model does not appear to be superior to all others. The two aggregate models tend to perform better for domestic demands (SOYSC, SOMDD, SOODD) and meal prices (SOMPM), about equally well for bean prices (SOYPM) meal exports (SOMMX) and production (SOYSP), and somewhat worse for oil prices (SOOPM) and bean exports (SOYMX).

In the error decomposition, the figures reflect the proportion of the (endogenous variable) prediction error which is random. These are mostly of the same magnitude. The regional model has a greater proportion of random error for exports and a lower proportion for oil demand. Again, the differences are not very substantial overall.

#### Dynamic Properties

The dynamic properties are compared in Table 4 by imposing a one time yield shock on each model and observing the impacts over 5 years. All

Table 3. Root Mean Percent Square Error and Proportion of Error which is Random for Historical Dynamic Simulation

	RMS % Error			Error Decomposition % Random		
	Reg.Mdl.	Agg.Mdl 1	Agg.Mdl 2	Reg.Mdl.	Agg.Mdl. 1	Agg.Mdl. 2
SOYPM	.12	.12	.12	1.00	1.00	1.00
SOMPM	.16	.11	.10	.99	.95	.94
SOOPM	.16	.21	.20	.99	.97	.96
SOYMX	.06	.08	.08	.99	.63	.66
SOMMX	.18	.18	.19	.37	.26	.26
SOYSC	.07	.05	.05	.65	.63	.69
SOMDD	.04	.02	.02	.90	.98	.94
SOODD	.05	.03	.04	.56	.81	.73
SOYSP	.06	.07	.07	.85	.79	.83

Table 4. Dynamic Impacts of a one period change of 10% in U.S. Yield per Acre

	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5
SOYPM (\$/bu)					
Reg. Mdl	-1.00	.53	.40	-.07	-.14
Agg. Mdl 1	-0.79	.27	.34	.07	-.07
Agg. Mdl 2	-0.72	.20	.33	.11	-.04
SOMPM (\$/s.t.)					
Reg. Mdl	-34.8	16.1	13.3	-1.8	-4.3
Agg Mdl. 1	-20.9	7.7	8.4	1.2	-2.1
Agg Mdl. 2	-21.4	5.8	9.4	3.2	-1.3
SOYSP (mil.bu.)					
Reg. Mdl	151.	-119.	-38.	33.	19.
Agg Mdl 1	147.	-96.	-55.	10.	19.
Agg Mdl 2	148.	-88.	-61.	1.	18.
SUPPLY (mil.bu.)					
Reg. Mdl.	151.	-55.	-57.	5.	18.
Agg Mdl 1	148.	-4.	-62.	-13.	10.
Agg Mdl 2	149.	-31.	-66.	-26.	6.

SOYPM = soybean price

SOMPM = soybean price

SOYSP = soybean production

SUPPLY = production plus beginning stocks

versions of the model are stable and converge in approximately the same pattern and at approximately the same rate. The first year impact on soybean and soymeal prices is larger in the regional model, indicating a more inelastic export demand. These differences are explored further in the next section. It can be noted here and in the next section that the major differences observed are due to the change in the export sector not to the differences in domestic parameters.

#### Impact Multipliers

The first period impacts of changes in several exogenous are compared in Table 5. The first two are purely domestic variables and the last two are purely export variables.

The yield impact has already been previewed in Table 4. Here the impacts on other variables are shown. In the regional model the increase in exports quantities is slightly larger than for the aggregate models, but the total value of exports (VALX) still declined. In fact the magnitude of decline in export value was greater for the regional model, again indicating a more inelastic export response.

The increase in HPAU shifts the U.S. meal demand to the right. The resulting increase in meal demand and meal price is very similar across all models. In the regional model most of the meal use increase comes from a decline in meal exports, so soybean exports increase to partially offset this. In the aggregate models about 2/3 of the needed meal comes from exports and the rest from increased crush, while soybean exports hardly change. The soybean price impact is slightly larger in the regional model. In all cases, however, total meal-equivalent exports decline and the value of exports increases. Again the more inelastic export behavior in the regional model results in a larger value increase.

Table 5. First period impacts of changes in selected exogenous variables.

	SOYPM	SOMPM	SOOPM	SOYMX	SOYSC	SOYHC	SOMMX	SOMDD	SOODD	SOOHC	VALX
Base	\$6.32	\$139.	30.7¢	421	701.	188.	4299	12552	6580	561	3222
Domestic											
YIELD (+10%)											
Reg.Mdl.	-1.00	-35.	-1.7	39.	48.	64.	893.	264.	274	163	
Agg.Mdl 1	-0.79	-21.	-2.2	37.	56.	55.	805.	537.	359	173	-536
Agg.Mdl 2	-0.72	-21.	-1.3	36.	56.	57.	824.	509.	369	132	-271
HPAU (+10%)											
Reg.Mdl.	0.54	31.	-0.5	19.	6.	-25.	-1318	1473	91	-23	253
Agg.Mdl 1	0.43	29.	-1.1	1.	19.	-20.	-1054	1504	183	16	130
Agg.Mdl 2	0.47	30.	-0.8	2.	22.	-24.	-1086	1598	223	3	146
Export											
CORPA (+10%)											
Reg.Mdl.	0.10	5.	-0.09	3	1	-4	167	-139	16	-4	106
Agg.Mdl 1	0.17	6.	0.25	15	-7	-8	-2	-160	-43	7	185
Agg.Mdl 2	0.16	6.	0.14	15.	-7	-8	-7	-152	-40	-30	182
EXCH (+10% revalue)											
Reg.Mdl.	-0.18	-4.	-0.66	-24	16	8	285	91	114	52	-201
Agg.Mdl 1	-0.07	-3.	0.03	-3	0	3	-92	90	-5	5	-74
Agg.Mdl 2	-0.07	-4.	0.03	-3	0	3	-92	84	-9	6	-74

VALX = combined value of soybean and soy meal exports.

An increase in the EC threshold price of corn (CORPA) makes soymeal a relatively less expensive feed ingredient in the EC. The impact on soymeal prices is slightly lower with the regional model and the impact on soybean prices is more than 1/3 lower. In the regional model both soybean and soymeal exports increase, which is reasonable. In the aggregate model CORPA has a positive initial effect in both export equations, but the shift soybean exports is so large that crush (and hence meal production in the U.S.) must be reduced. The net effect on meal exports is a slight decline. The increase in meal-equivalent exports is smaller in the regional model, which explains the smaller impacts on prices and export value.

A revaluation of the U.S. dollar makes U.S. commodities more costly and should reduce exports and U.S. prices. The decline in meal-equivalent exports is about 70% greater in the regional model than in the aggregate models. Consequently, the impact on soybean prices and the value of exports is more than twice as large in the regional model.

#### Summary and Implications

It would be hazardous to generalize too much from this limited experiment. The comparison was between a particular regional model and a particular specification of aggregate models, all estimated over a particular data period. Given this caveat several observations emerge from the comparisons made in this study.

Substitution of aggregate export models for the more detailed regional models did not alter the fundamental behavior of the U.S. component. In both cases total demand was inelastic, but it was somewhat less inelastic with the aggregate export equations. Previous speculation had been that, on the contrary, directly estimated export equations might be more inelastic.

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## APPENDIX

## Variable Definitions and Sources

Endogenous Variables

SOMDD	Soybean meal, U.S. domestic disappearance, October-September, (1,000 S. ton)
SOMMX	Soybean meal, U.S. exports plus shipments to U.S. territories, October-September, (1,000 S. ton)
SOMPM	Soybean meal price, 44 percent protein, Decatur, October-September, (\$/S. ton)
SOMSP	Soybean meal, U.S. quantity produced, October-September, (1,000 S. ton)
SOODD	Soybean oil, U.S. domestic disappearance, October-September, (mil. lb.)
SOOHC	Soybean oil, U.S. ending private stocks, October-September, (mil. lb.)
SOOPM	Soybean oil, U.S. price, crude, Decatur, October-September, (Cents/lb.)
SOOSP	Soybean oil, U.S. quantity produced, October-September, (Mil. lb.)
VALOM	Value of oil and meal, wholesale (September year price beans, October year price oil and meal), (\$/bu.) Computed $VALOM = (SOMSC * SOMPM/20) + (SOOSC * SOOPM)$
SOYHC	Soybeans, U.S. total ending private stocks, August 31, (mil. bu.)
SOYMX	Soybeans, U.S. total exports, September-August, (mil. bu.)
SOYPF	Soybeans, U.S. average price received by farmers, September-August, (\$/bu.)
SOYPM	Soybeans, U.S. average price, #1 yellow, Decatur, September-August, (\$/bu.)
SOYSAE	Soybeans, U.S. acreage planted for next crop year, (mil. ac.)
SOYSC	Soybeans, U.S. quantity crushed, September-August, (mil. bu.)
SOYSPE	Soybeans, U.S. total production for next crop year, September-August, (mil. bu.)

Predetermined Variables

BUTDDL	Butter and lard, U.S. domestic disappearance, October-September, (mil. lb.)
CEN	Personal consumption expenditure on nondurable goods and services, calendar year (Bil. \$)
COOPF	Cotton, U.S. American upland, average price received by farmers, August-July, (Cent/lb.)
COPRA	Corn, EC threshold price, Jan. 1, (UOA/m.t.)
CORPD	Corn, effective diversion rate (support payment included in diversion payment), (\$/bu.)
CORPE	Corn, effective price support, (\$/bu.)
CORPF	Corn, U.S. average price received by farmers, October-September, (\$/bu.)
CVSOY	Soybean crushing capacity, (Mil. bu.)
FEEDHP	U.S. feed, high protein consumption less fish meal and soymeal, October-September, (1,000 S. ton)
FIMPW	Fishmeal price, CIF European ports, Peruvian and/or any origin, 65 percent, calendar year 1961 with crop year 1960, (\$/S.ton)
GNPD	GNP deflator for the U.S.
HPAU1	High protein animal unit, calendar year (1971=1.0)
LIVIF1	Livestock price index, calendar year (1967=1.0)
LIVPEJ1	Index of livestock production in EC6, U.K. and Japan, calendar year
SDR	U.S. dollars per SDR, average of quarterly means, October basis, (\$/SDR)
SOMSC	Soybean meal, computed crushing yield, (Cwt.bu.)
SOOHH	Soybean oil, ending stocks, CCC owned, September 30, (Mil.lb.)
SOOSC	Soybean oil, computed crushing yield, (Cwt.bu.)
SOYHG	Soybeans, ending stocks, CCC owned and reseal, August 31, (mil.bu.)
SOYPE	Soybeans, U.S. loan rate, September-August, (\$/bu.)
SHIFT72	1 for years prior to 1972, 0 elsewhere
D7274	1 for 1972, -1 for 1974, 0 elsewhere
D(t)	1 for t, 0 elsewhere