Transportation Deregulation and Interregional Competition in the Northeastern Feed Economy

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The effects of rail deregulation on feed transportation in the Northeast are examined through construction of a spatial equilibrium model of the Northeastern feed industry. Short-run and long-run effects of deregulation are analyzed through incorporation of rail rate structures for 1981 and 1984, respectively, into model simulations and comparison with pre-deregulation base year results (1980). The results show that the Northeast feed economy has generally benefited from rail deregulation which has led to lower transportation costs, lower feed costs and an enhanced competitive position relative to the Southeastern U.S.

Introduction

The recent partial deregulation of rail freight transportation in the U.S. has had important effects on the transportation of agricultural commodities nationwide. Legislative enactment of the Railroad Revitalization and Regulatory Reform Act of 1976 and, in particular, the Staggers Rail Act of 1980 was designed to enhance the profitability of the railroads by improving their competitive position vis-a-vis other modes of transportation (Hoffman, Hill, and Leath). The Staggers Act contained many specific provisions, but was basically oriented toward limiting governmental control over rail rates and service and permitting the railroads increased flexibility in responding to competitive conditions as they influence ratemaking and service provisions. While much concern was expressed immediately following the passage of the Staggers Act regarding its potential negative effects—monopolistic pricing, line abandonment, etc.—most of the available evidence to date indicates that, at least in agricultural transportation, rail deregulation has had largely beneficial effects in increasing railroad efficiency and decreasing shipping costs (Casavant).

One of the still unanswered issues regarding rail deregulation concerns its differential regional impacts. Most of the research on the impact of rail deregulation has been conducted with respect to the major Midwestern and Great Plains grain-producing states, often with an emphasis on export market effects. In assessing the effects of rail deregulation on a region such as the Northeast, a very different competitive situation is evident. As in the Midwest, animal production is important in Northeast agriculture, and interregional feed shipments—of corn and soybean meal, especially—represent a significant share of product shipments. However, the Northeast, unlike the Midwestern region, is a deficit producer of feed grains, importing large quantities of feedstuffs primarily from the Midwest. In 1981, for example, net inshipments of feedstuffs to Northeastern destinations totaled over 2.5 million tons. In addition, much of the Northeast is served by a single major rail carrier, Conrail, raising questions as to the degree of competition influencing rail ratemaking in the region. Both of these factors suggest that the changing regulatory environment surrounding rail transportation in the Northeast has had important effects on agricultural transportation and the competitiveness of animal production agriculture in the Northeast.

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The purpose of this analysis is to examine the impacts of changes in rail regulatory policy on Northeastern agriculture through the construction and estimation of an interregional programming model of the Northeastern feed economy.[1] Spatial equilibrium models based on the theoretical results of Enke and Samuel-son have been used frequently in the analysis of agricultural markets. Recent examples of interregional models of particular relevance to Northeastern agriculture include studies of the apple (Dunn and Garafola), broiler (Wu, Jack, and Colyer), and peach (Thatch, Slane, and Edelberg) industries. In this study, changes in both interregional (Midwest to Northeast and Southeast) and intraregional (within the Northeast) transportation costs stemming from rail deregulation are examined. Both their short- and long-run effects on feed transportation are analyzed through simulations based on various rate scenarios and demand and supply conditions which have developed subsequent to rail deregulation. The results yield important insights into the impacts of rail deregulation on the Northeastern feed industry and the resulting competitive position of much of Northeastern agriculture.

Rail Deregulation and Northeast Agriculture

The regulatory environment for rail transportation dates back to the late nineteenth century and the efforts of the federal government, through the creation of the Interstate Commerce Commission and other actions, to curb monopolistic pricing and other abuses by the railroads. Over time, however, continued regulation led to distorted rail rate patterns and significantly hampered the ability of the railroads to compete with increasingly competitive alternative forms of freight transportation, namely waterway and motor carrier transport. In this manner, regulation directly contributed to the low rates of return typically earned by the railroads, which culminated in a series of railroad bankruptcies in the 1960's and 70's, most notably (for the Northeast), the Penn Central bankruptcy. Northeastern and Midwestern rail lines were restructured following passage of the Regional Rail Reorganization Act and establishment of the United States Railway Association (USRA) in 1973, which in turn resulted in the creation of the quasi-public Conrail railroad corporation (Seaver and Hanekamp).

Passage of both the Railroad Revitalization and Regulatory Reform Act and the Staggers Act was designed to improve the financial condition of the railroads. The Staggers Act was especially important and contained a number of provisions relevant to agricultural shippers (Seaver, 1983a). First, the Act allowed railroads greater flexibility in adjusting rates in response to inflationary changes in their variable costs and varying demand conditions. Second, the Act permitted carriers to negotiate rates and conditions and enter into contracts directly with individual shippers. Third, the Staggers Act allowed carriers greater latitude in levying joint rate surcharges, canceling joint rates on through routes, and establishing surcharges on light density lines. Finally, the Act permitted the railroads increased flexibility in dropping unprofitable routes by making rail abandonment procedures easier.

The greater flexibility in ratemaking and service provision permitted by these regulatory changes has been criticized on many grounds. A major concern has been the potential negative effects of increased rate flexibility on smaller shippers who lack the scale economies (and bargaining power) to take advantage of contracted service, rate discounts, and multiple car and unit train rates (Shaffer and Baumel). The greater latitude afforded railroads in abandoning lines raised concerns among rural shippers located on lightly used lines about decreased track maintenance and service levels, and even the availability of rail service. Finally, during the sharp downturn in U.S. economic activity immediately following the passage of the Staggers Act in the early 1980's, some observers .were concerned that the lower rail rates and rail car surpluses would prove temporary, and would be followed by monopolistic rate-setting and rail car shortages as the economy recovered (USDA, 1982).

Most of the available evidence, including research to date in agricultural transportation, suggests that the above concerns have not materialized on a significant scale. In an analysis of changes in rail rates and intermarket price spreads for grain in Kansas, Sorenson concluded that post-Staggers innovations in ratemaking have led to reduced transportation

[1] The Northeast is defined here as the six New England states, plus New York, New Jersey, Pennsylvania. Maryland, Delaware, and West Virginia.

Table 1. Northeast Production and Consumption of Major Feed Concentrates: 1977-81

Crop Year	Feed Type	Total Produced	Total Consumed	Deficit	Deficit As % of Consumption
		-(1,000 TONS)-			
1977	Feed Grains	7194	10088	2894	29%
	Soybean Meal	450	1392	942	68%
1978	Feed Grains	7860	10915	3055	28%
	Soybean Meal	450	1506	1056	70%
1979	Feed Grains	8310	12501	4191	34%
	Soybean Meal	450	2213	1763	80%
1980	Feed Grains	7376	11521	4145	36%
	Soybean Meal	450	1847	1397	76%
1981	Feed Grains	9607	12149	2542	21%
	Soybean Meal	450	2109	1659	79%

Source: USDA *Agricultural Statistics;* USDA regional feed consumption data (unpublished).

rates on wheat moved from Kansas origins and have reduced intermarket price spreads, reinforcing previous indications of a "very high level of pricing efficiency in grain markets" (p. 648). Sorenson also noted, however, that "the post-Staggers period has provided very difficult adjustments for some local elevators" as "marketing channels and marketing options have changed drastically," due in part to new "risk and uncertainty for many grain shippers and merchandisers" (p. 648-9). Wilson, Wilson, and Koo confirmed an increased speed of adjustment in rail rates to changes in costs and competitive conditions following Staggers. Casavant, in his review of research on the impact of the Staggers Act, concluded that "real rates and costs to the agricultural shipper have gone down and efficiency of movement for the railroad has increased, but not without additional costs being borne by the shipper" (p. 31); other apparent negative effects of deregulation were also highlighted. In the Northeast, an early evaluation of post-Staggers effects concluded that the restructuring of rail rates "lowered rates on grain and feed ingredients over what rates would have been in the absence of Staggers," but also found only limited contracting among Northeast shippers and other negative effects of rate and route restructuring (Seaver, 1983b, p. 15-16).

While Seaver *s evaluation indicates that the Northeast has shared many post-Staggers effects with other regions, at least two factors suggest that, *a priori,* the impacts of rail deregulation may be somewhat different in the Northeast than elsewhere. To begin, Northeast agriculture is dominated by the production of animal products, particularly dairy products, broilers and eggs. The region's agriculture consequently relies heavily on rail freight transportation to help meet a large and relatively inelastic demand for feedstuffs. The extent to which the Northeast is dependent on other regions to meet regional demand is illustrated in table 1, which gives total estimated feed demand, regional production, and regional deficits for feed grains, mainly corn and soybean meal, from 1977 to 1981. Although individual Northeastern states and subregions are in limited cases self-sufficient in corn and/ or soybean meal production, regional deficits for these feed ingredients are generally large, ranging between 21 percent and 36 percent of consumption for feed grains and between 68 percent and 80 percent for soybean meal over the 1977—81 period. Because virtually all regional inshipments of feed ingredients are by rail, the Northeast feed manufacturing industry and allied animal production sectors are clearly highly dependent on the levels of rail rates and service quality.

Regarding rail service itself, the existence of a single principal rail carrier, Conrail, throughout much of the Northeast, means that the potential for monopolistic behavior in the settings of rates and service levels is present in the Northeast to a greater extent than in many other areas. This is reinforced by the lack of effective intermodal competition in agricultural transportation throughout much of the region (Skinner, Seaver, Lee, and Ecker). Together with the lack of self-sufficiency in feed production, these factors suggest that the competitive position of much of Northeastern agriculture is dependent on developments in feed transportation, especially those developments pertaining to the changing regulatory environment.

Model Specification

A two-period spatial equilibrium model of the Northeast feed industry was constructed to examine the effects of changes in rate structures due to rail deregulation. This model minimizes the transportation costs associated with moving feed concentrates from regions of excess supply to regions of excess demand subject to a number of equilibrium constraints and specified storage costs, transportation rates, etc. Separate models were constructed for the two major high-energy and high-protein feeds—corn and soybean meal, respectively—which together account for roughly three-quarters of all concentrates fed to livestock in the Northeast.

The model includes combined supply-consumption regions within the Northeast, export regions, Midwest supply regions, and a representative Southeast supply-consumption region. Construction of a regional rather than national model sufficed for this study due to the lack of feed grain exports from the Northeast to other regions and the fact that Northeast imports of feed grains from Midwestern sources represent only a small proportion of total (Midwestern) surplus production. The two periods in the model represent a single crop year divided into a harvest (October to December) period, during which the Northeast has surplus grain supplies (e.g., corn), and a post-harvest (January to September) period during which the Northeast is a deficit (net importing) region. Supplies are presumed fixed in the short run, but corn production is allowed to respond to changing prices in the long run. Demand schedules which account for livestock consumption and commercial uses of feed are estimated for each consumption region. Export demands are assumed exogenous and fixed for the purposes of this analysis. Corn stocks carried over from the harvest to post-harvest period are constrained by available storage capacity in the producing regions, and the costs of storage are integrated into the model. Model simulations incorporating three sets of transportation rates based on rail rates in 1980 (pre-Staggers), 1981 (immediately post-Staggers) and 1984 are used to analyze both the short-run and long-run effects of rail deregulation on feed movements, consumption and prices in the Northeast.

Given the above characteristics, the general problem for the corn industry model can be cast mathematically as an optimization problem using programming techniques (Samuel-son), or alternatively, the problem can be formulated as a set of equilibrium conditions subject to a number of constraints. The algorithm used here, based on the Vector Sandwich Method of Kuhn and MacKinnon, searches directly for equilibrium prices and quantities satisfying the equilibrium conditions and constraints. The equilibrium conditions simply require that the supply schedules defining the quantities supplied in each region equal total outshipments from that region. On the demand side, regional consumption is likewise defined by quantity-dependent demand schedules and must equal total inshipments. Total supply must equal total demand for each region in each period. In addition to storage constraints, conditions are included which describe the interspatial and intertemporal price linkages essentially representing the Kuhn-Tucker first-order conditions for the corresponding maximization problem.

Accordingly, the corn industry problem is given as:

Find P_{it}, P_{jt}, Sj, Ki, D_{jt}, and X_{ijt} such that:

subject to:

$$K_i \leq N_i$$

$$P_{jt} = \min_{(I)} [(P_{it} + T_{ijt}) \mid X_{ijt} > 0]$$

$$P_{j2} = (P_{i1} + V_i) \quad K_i > 0$$

where:

t = time period, with 1 = harvest period and 2 = post-harvest period;
i = supply region index (i = 1, . . . , m);
j = consumption region index (j = 1, . . - , n);

P_{it} = price in the 'T'th supply region in the "t"th period;
P_{it} = price in the "j"th consumption region in the "t"th period;
S_i = supply of the 'T'th supply region;
D_{it} = demand of the 'T'th consumption region in the "t"th period;
Ki = stocks carried over between time periods in the 'T'th supply region;
X_{iit} = trade flow from the 'T'th supply region to the "j"th consumption region in the "t" th time period;

and the following are given exogenously:

$S_i(P_{it})$ = supply schedule of the 'T'th supply region during the harvest period;
$D_{it}(P_{it})$ = demand schedule of the "j"th consumption region in the "t"th period;
T_{iit} = per unit rail rates from the 'T'th supply region to the "j"th consumption, region in the "t"th time period;
N_i = available interperiod grain storage in the 'T'th supply region;
Vi = per unit interperiod storage costs.

The formulation for soybean meal is analogous, although no allowance is made for carryover stocks since soybean meal is produced (processed) continuously year round.[2] The two problems are solved independently using Holland's version of Kuhn and MacKinnon's algorithm.[3] The principal advantage of this algorithm is its ability to utilize constant elasticity non-linear supply and demand schedules in the solution procedure. The most important features of the interregional model are described in further detail in the sections below.

Table 2. Definition of Study Regions and Base Points

Region	States in Study Region	Base Point
Northeast:		
1.	Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut	Augusta, ME
2.	New York	Batavia, NY
3.	Pennsylvania and New Jersey	Lancaster, PA
4.	Delaware, Maryland, and West Virginia	Salisbury, MD
Southeast:		
5.	Georgia	Gainesville, GA
Northeast Ports:		
6.	Albany Port	Albany, NY
7.	Philadelphia Port	Philadelphia, PA
8.	Baltimore Port	Baltimore, MD
Midwest:		
9.	Michigan	Saginaw, MI
10.	Ohio and Indiana	Toledo, OH
11.	Illinois	Danville, IL (corn) Decatur, IL (meal)

Spatial Divisions

The Northeast is here divided into four principal supply-consumption regions to approximate the major concentrations of agricultural activity in the region (table 2). Export demand enters the model through three Northeastern ports: Albany, Philadelphia, and Baltimore. A representative Southeastern supply-consumption region, Georgia, is also included in the model in order to analyze the relative impacts of deregulated rail rates on Northeastern versus Southeastern regions.[4] Finally, three major Midwestern sources of Northeast feed imports (Michigan, Ohio and Indiana, and Illinois), are included in the model as excess supply regions. Except for the Northeastern export regions, the study regions follow state borders to facilitate data collection. A city located near the center of major agricultural production activity in each region is designated as that region's base point in the computation of interregional rail rates (table 2).

Regional Demands

For any given time period (t), the total demand (D) for corn and soybean meal in a given consumption region (j) is defined as:

$$(1) \quad D_{jt} = D_{jt}(P_{jt}) - f_{jt}(P_{jt}) + M_{jt} + K_{jt} *$$

[2] A more general formulation of the problem could treat the storage of soybeans endogenously. Since only one of the four Northeastern regions (MD/DEL/WVA) produces significant quantities of soybeans and soybean pricing is largely based on the Midwestern supply-demand situation (see below), the current treatment appears to represent a realistic simplification of the general problem.

[3] For additional details on the Holland algorithm, see Holland (1985).

[4] Previous research has indicated that prior to deregulation, the Northeast's competitive position in grain transportation relative to the Southeast was declining, in pan due to rail rate differentials from Midwestern supply areas (Seaver and Hanekamp).

where ijt(Pjt) is the demand schedule for livestock feeding, M_{Jt} represents exogenously determined commercial requirements, and Kj_t is the stock level carried over between time periods. For the Northeastern export regions, export requirements (Xjt) are also assumed to be exogenously determined and thus demand for these regions is defined simply as:

(2) $$D_{jt} = X_{jt}$$

Of central interest here is livestock feed demand, which accounts for the vast share of corn and soybean meal demand in the Northeast. Demand elasticities for feed are estimated and used to construct constant elasticity demand functions set to 1980 levels. The feed demand schedules are then combined with 1980 crop year requirements for export and commercial demand to obtain the demand schedules used in the spatial equilibrium model.

Feed demand can be specified as a function of prices (own-price; prices of substitute feeds; output price) and aggregate livestock numbers.[5] However, feed demand elasticities estimated from aggregate data suffer an important limitation, namely, then- inability to account for variation in the composition of livestock activities over regions and over time. To circumvent this problem, a procedure adapted from Richardson and Ray is followed in this analysis. This procedure first estimates regional demand elasticities for individual livestock categories and then weights each of these elasticity estimates by each category's respective share of regional concentrate consumption to generate a single composite regional demand elasticity. The procedure is briefly summarized below.[6]

Assume that for a given region, feed demand (Rj_t) for the "i"th livestock category in the "t"th crop year can be expressed as the product of the inventory (or production) of livestock or livestock products (Q_{it}) times the average feed conversion rate (Zj_t) per unit of livestock product or inventory:

(3) $$R_{it} = Q_{it} * Z_{tt}$$

While Q_{it} may be considered exogenous, feeding intensity, as measured by the feed conversion rate for each livestock category, is assumed to vary over time in response to changing prices for corn (PC), soybean meal (PS), the price of the specific livestock product (PL), and trend (T):

(4) $$Z_{it} = g_{it}(PC_t, PS_t, PL_t, T)$$

Estimated as a regression equation, equation (4) would also include a disturbance term (ϵ_t).

A priori, we expect the relationship between the conversion rate and output price to be positive, and that between the conversion rate and corn price to be negative. With regard to the coefficient of soybean meal price, Richardson and Ray postulate a positive sign in keeping with past research which tended to view corn and soybean meal as substitutes in feed use. More recently, however, Hull and Westcott have argued, based on regression results, that feed rations are much more inflexible in the short run (due to nutritional considerations) than previously thought, and that corn and soybean meal should be viewed as complements rather than substitutes. Based on this argument, the expected sign is negative. A time trend is included in equation (4) to serve as a proxy for the technological changes associated with advances in animal breeding and nutrition.

The second part of the feed demand estimation procedure recognizes that total feed demand has two primary components, high-energy feed grains (chiefly corn) and high-protein feeds (mainly soybean meal). Further, the relative demand for both feed grains and high-protein feeds has varied over time. In the case of feed grains, this variation can be captured as follows:

(5) $$FG_{it} = R_{it} * (FG_{it}/R_{it})$$

(6) $$FG_{it}/R_{it} = h(PC_t, PS_t, PL_{it}, T)$$

(7) $$C_{it} - FG_{it} * (C_{it}/FG_{it})$$

(8) $$C_{it}/FG_{it} = k(T)$$

where FG_{it} represents total feed grain consumption for the "i"th livestock category in year "t", and all other variables are as previously defined. Equations (5) and (7) are simple equalities which express, respectively, feed grain consumption as a percentage of total concentrate consumption (equation (5)) and corn consumption as a percentage of total feed grain consumption (equation (7)). Equation (6) is a behavioral equation which allows feed grain consumption as a proportion of total concentrate consumption to vary in response

[5] See, for example, Fox and Taeuber, Ahalt and Egbert, and King.

[6] For a detailed explanation of the procedure outlined here, see Richardson and Ray or Randolph.

to changes in corn prices (expected negative sign), soybean meal prices (expected positive sign), and output prices (indeterminate expected sign).[7] Equation (8) allows corn consumption as a proportion of total feed grain consumption to vary solely in response to time and not as a function of relative prices. This is done to avoid confusing the demand for corn as the principal feed grain and demand for corn as a substitute for other high-energy feeds.[8] A set of equations exactly analogous to equations (5)-(8) can be constructed to represent the demand for high-protein feeds as a proportion of total concentrate demand and the demand for soybean meal as a proportion of total high-protein feed demand.

Equations (3)-(8) and an analogous set of equations for soybean meal demand provide the information necessary to calculate own-price elasticities of demand for corn and soybean meal for each major livestock category. The demand elasticity for corn $(r\backslash_c)$ can be shown to be the sum of the elasticity of the feed conversion rate (Z) with respect to corn price and the elasticity of the proportion of feed grains in the ration (FG/R) with respect to corn price[9]:

$$(9)\quad \eta_c = \frac{d[Q * Z * (FG/R) * (C/FG)]}{d[PC]} * \frac{PC}{C} = \frac{dZ}{dPC} * \frac{PC}{Z} + \frac{d(FG/R)}{dPC} * \frac{PC}{FG/R}$$

The price elasticity of demand for soybean meal can be calculated in a similar manner. The elasticity estimates derived for each major livestock category (dairy, broilers, eggs, and "other") are then weighted by their respective shares of regional concentrate consumption in deriving aggregate feed demand elasticities for each region within the Northeast.

In estimating feed demand elasticities, crop year price and consumption data for the period 1960-1981 were used. These data were obtained primarily from the following USDA publications: *Agricultural Prices: Annual Summary; Agricultural Statistics;* and *Feed Outlook and Situation Report.* Additional feed consumption data based on grain-consuming animal units (GCAU's) at the state level were furnished by USDA.

Demand elasticities estimated for each major livestock activity, their respective consumption shares, and aggregate elasticity estimates derived for each Northeastern sub-region are reported in table 3. The final estimates indicate a high overall inelasticity of corn and soybean meal demand to changes in own prices for most livestock categories and for all subregions. The aggregate own-price elasticity for corn ranges between —. 19 and —.26 and for soybean meal between —. 17 and — .22. These estimates are generally in line with those estimated in previous research, and confirm a somewhat greater inelasticity of feed demand in the Northeast compared to the U.S. as a whole. This finding is no doubt due to the limited production alternatives of many Northeastern livestock producers and their resulting heavy dependence on imported feedstuffs.

Also reported in table 3 are feed demand elasticity estimates for the representative Southeastern region. The aggregate elasticity for this region was based on demand elasticities for individual livestock categories estimated in Richardson and Ray, weighted (as above) by the relevant consumption shares of each of these livestock categories.

In addition to animal feed, other sources of corn and soybean meal demand in the Northeast include commercial demand (for corn only), export demand (corn and soybean meal), and the demand for carryover stocks (for corn). As noted previously, for the purposes of this study, commercial and export demand are assumed to be exogenous. Regional commercial demand—principally in wet-milling but also in dry-milling and fermentation—amounted to an estimated 432,000 tons in 1981 of a nearly 780,000 ton capacity (Randolph). In the spatial equilibrium model development here, it is assumed that Northeast wet-milling facilities operate at full capacity and that commercial demand is allocated evenly over the crop year (i.e., 25 percent of demand during the harvest period and 75 percent of demand during the post-harvest period).

Export demand for corn and soybean meal

[7] The expected sign for the coefficient on output price is indeterminant. Richardson and Ray postulate, without explanation, a negative expected sign on the output price coefficient. However, other empirical evidence (Heady, Guinan, and Balloun; Heady, Bal!oun, and Me Alexander) suggests that adjustments in rations to changes in output prices may be toward either higher energy or higher protein content and may depend on initial output prices and/or the shape of the expansion path.

[8] This analysis focuses on the use of corn as the major feed grain and thus abstracts away from the issues involved in the modeling of corn as a substitute for other high-energy feedstuffs.

[9] For a derivation, see Randolph.

Table 3. Feed Demand Elasticity Estimates for Major Livestock Categories

					Broilers		Other[a]		Weighted Aggregate
Region	Elast.	Share[b]	Elast.	Share[b]	Elast.	Share[b]	Elast.	Share[b]	Elast.
					Corn				
One	-.39	.414	-.13	.444	-.24	0	-.32	.142	-.26
Two	-.17	.700	-.09	.172	-.40	.001	-.50	.127	-.20
Three	-.18	.399	-.09	.237	-.15	.109	-.41	.254	-.21
Four	-.14	.125	-.09	.073	-.15	.607	-.38	,195	-.19
Five[a]	-.16	.055	-.23	.251	-.18	.379	.30	,315	-.23
					Soybeain Meal				
One	-.15	.414	-.19	.414	-.09	0	-.05	.142	-.21
Two	-.16	.700	-.19	.172	-.09	.001	-.07	,127	-.22
Three	-.15	.399	-.18	.237	-.09	.109	-.08	.254	-.22
Four	-.15	.125	-.14	.073	-.09	.607	-.08	,195	-.17
Five*	-.28	.055	-.06	.251	-.06	.379	-.36	,315	-.15

[a] Elasticity estimates for "other" livestock activities and for the representative Southeastern region (Region 5) are derived from estimates reported in Richardson and Ray.
[b] Shares based on 1980 feed concentrate consumption levels. Estimated shares may not sum to 1.000 due to rounding.
Note: Regional definitions as follows: (1) New England; (2) NY; (3) PA/NJ; (4) MD/DEL/WV; (5) GA.

at three major Northeastern port facilities (Albany, Baltimore, and Philadelphia) is assumed constant at 1980-82 average levels. Annual regional export levels for this period averaged 6.6 million tons for corn and 272,000 tons for soybean meal. Of the three ports, Baltimore handled the greatest quantities, exporting an average of 67 percent of regional corn exports and 45 percent of Northeastern soybean meal exports. The demand for carryover stocks of corn between the harvest and post-harvest periods is determined endogenously within the model.

Regional Supplies

In the short run, given the lags involved in supply response at the farm level and the fixity of soybean processing capacity, regional supplies of corn and soybean meal are assumed to be fixed at their 1980 levels (see table 1). In the longer run, grain producers can respond to changing prices by adjusting their crop acreages. This is reflected by allowing for positively sloped supply curves for corn in the long-run simulation of changes resulting from rail rate adjustments induced by deregulation. Constant elasticity functional forms are specified for the supply schedules. The regional supply elasticities used are based on the work of Langley, who estimated own-price elasticities of supply for corn of + .04 for the Northeast (Regions 1-4), and +.48 for the Southeast (Region 5). Using these elasticities, supply schedules are set to their appropriate 1980 levels. Regional soybean meal production is assumed to remain fixed over both the short and long run, given the fixity of soybean processing capacity and the assumption here of processing plant operation at full capacity.

The Northeastern demands for corn and soybean meal not met by regional production are assumed to be satisfied by inshipments from three Midwestern excess supply regions: Michigan, Ohio and Indiana, and Illinois (Regions 9-11, respectively). Estimates of 1980 corn surpluses for these three regions are as follows (Randolph): Michigan, 4.58 million tons; Ohio and Indiana, 17.12 million tons; Illinois, 20.30 million tons. Since deficits in Northeastern markets are small in relation to the surpluses, changes in Northeastern demand are unlikely to significantly influence prices for corn (and soybean meal) in Midwestern markets. For this reason, the assumptions of fixed surplus supplies in Midwestern regions (at 1980 levels) and price-taking behavior in consumption and export Regions 1-8 appear reasonable.

For soybean meal, a single Midwestern supply region (centered in Decatur, Illinois) is included in the model. This reflects the unique pricing system under which the soybean meal industry operates. Before rail deregulation, a Decatur equivalent quoting system was used in pricing soybean meal, in which a buyer had only to add the rail rate from Decatur to a meal processor's Decatur equivalent price. This system effectively equalized prices over a gen-

Table 4. Selected Corn and Soybean Meal Rail Rates to Northeastern Destinations: 1980, 1981, and 1984

	Destination											
	Augusta, ME[a]			Batavia, NY			Lancaster, PA			Salisbury, MD		
Origin	1980[b]	1981	1984	1980[b]	1981	1984	1980	1981	1984	1980	1981	1984
	-dollars per ton-											
	Corn (Single car, 95 ton minimum)											
Batavia, NY	25.70	29.00	20.01	xxx	xxx	xxx	. . .[c]					
Lancaster, PA	24.80	29.00	21.80	18.60	12.60	13.06	xxx	xxx	xxx			
Salisbury, MD	26.80	31.20	23.41	22.00	16.80	17.27	11.60	9.00	6.13	xxx	xxx	xxx
Saginaw, MI[a]	31.60	26.33	24.88	17.80	25.20	14.66	28.40	30.40	21.68	31.30	34.80	26.54
Toledo, OH	31.60	33.20	24.88	17.80	13.00	11.34	23.50	20.20	17.27	28.60	26.40	22.12
Danville, IL	39.20	41.20	33.78	24.40	22.60	20.51	31.30	28.20	24.55	34.40	32.40	28.05
	Soybean Meal (Single car, 5 ton minimum)											
Bellevue, OH[a]	31.90	34.20	35.60	17.20	18.40	20.80	23.70	23.20	29.20	28.60	26.60	33.40
Decatur, IL[a]	42.10	45.00	36.65	28.80	26.00	27.80	33.30	36.40	31.60	37.50	31.20	37.00

[8] Not directly serviced by Conrail.
[b] Rates as of October 1.
[c] Rate is same as rate for return route shown elsewhere in the table.
Source: Agway, Inc. Michigan-origin rates only: Chessie System, Inc.

eral supply region serving a specific consumption area. After an initial period of confusion in the soybean meal pricing system following deregulation, the industry has returned to a system resembling the original one, in which buyers are generally quoted a delivered price which includes the Decatur price plus a (Decatur to processing plant location) basis plus freight. Despite the added competitive factor provided by the variation in rail rates due to contract arrangements and rate discounts, the net result has been the same type of equalization of soybean meal prices as existed prior to deregulation. This provides the justification for including only a single supply region in the spatial equilibrium model.

Storage and Transportation

Corn stocks carried over into the post-harvest period are stored in the interim and cannot exceed available storage space in the individual production regions. Storage constraints for regions 1—5 were estimated by subtracting regional grain inventories (excluding corn) as of January 1, 1981 from total 1980 storage capacity. The resulting storage capacity estimates are as follows: Region 2: 2,04 to 2.33 million tons; Region 3: 4.30 to 4.94 million tons; Region 4: 2.27 million tons; Region 5: 4.03 to 4.15 million tons. Based on earlier cost estimates (Casler; Leath, Meyer, and Hill), storage costs were updated and estimated at 2.5 cents per bushel per month, or $5.36 per ton for interperiod storage, computed for an average duration of six months.

Rail rates for the model are based on published tariffs and represent the least-cost rate between each pair of study region base points.[10] Three sets of rates were obtained, those in effect in: October 1980, just prior to passage of the Staggers Act; October 1981, to examine the short-run effects of deregulation; and those in effect in October 1984, to estimate the long-term effects of deregulation.[11] For all non-export destinations in the Northeast (Regions 1-4), single car rates for corn were used. This was based on Anderson's findings that 88 percent of all 1979 rail receipts by New York feed manufacturers were shipped using single car rates. For Region 5, three-car rates for corn were used in view of the highly concentrated nature of poultry production in that region. For all export destinations (Regions 6-8) the cheapest multiple car or unit train rate for corn was used under the assumption that shipments to export terminals are normally high volume.

Table 4 reports rail rates between selected

[10] Much of the feed transported *within* the Northeast is done so by truck. A comparison of truck versus rail rates for the routes in the model, however, uniformly showed that rail was the least-cost mode of transport both for corn and soybean meal. Thus rail rates were used for these routes as well.

[11] While rail deregulation was the major force behind decreased rail freight rates in the early 1980's, it is important to note that other forces influencing rate levels, such as an economic recession, a depressed agricultural economy and rail car surpluses, were also present, and that it would be erroneous to attribute all rail rate changes simply to deregulation.

Table 5. Corn Model: Base Year Solution and Validation

			Deviation	Model	Actual	Deviation
	($/ton)		(%)		(1,000 tons)	(%)
One	143.82	136.79	5.1	1,386	1,414	2.0
Two	130.02	125.00	4.0	2,1H	2,140	1.4
Three	135.90	136.79	0.7	3,414	3,430	0.5
Four	141.00	129.64	8.8	2,255	2,303	2.1
Northeast	136.78	132.27	3.4	9.165	9,287	1.3
Five	123.00	123.21	0.2	4,052	4,080	0.7

[a] Simulated and actual prices are for the harvest period, as actual post-harvest prices in 1980 were depressed due to expectations of an unusnally large corn crop in 1981; this counteracted the expected rise in prices in the post-harvest period.
Note: Regional definitions as follows: (1) New England; (2) NY; (3) PA/NJ; (4)MD/DEL/W/V; (5) GA. Consumption solution values are for crop year.

origins and destinations for corn and soybean meal for each of the years 1980, 1981, and 1984. For corn, of the 18 routes shown, 10 rates had declined between October 1980 and October 1981. All those that rose over this period either originated or terminated at points directly served by Conrail. By Fall 1984, all 18 rates were lower than their 1980 levels. Rate reductions ranged from 14 to 47 percent and averaged 22 percent over the whole sample. Soybean meal transportation rate changes were more mixed. Initially, four rates rose and four declined in magnitude. By 1984, all Ohio-origin rates were higher and all Illinois-origin rates were lower than pre-deregulation levels.

It is important to note that these figures likely *underestimate* the actual rate savings realized by Northeast feed receivers. While only single car rates are reported here, larger volume shippers are often able to take advantage of cheaper multiple car rates. Deregulation has alos allowed confidential contracting between railroads and individual shippers, leading to rate discounts for large volume shipers.[12]

Simulation Results

The general spatial equilibrium model was estimated under the three transportation rate scenarios noted previously. Solution of the model using the Holland algorithm required that the transshipment problem outlined above first be transformed into an equivalent transportation problem; this was accomplished using procedures described by Cheong. Although models were estimated for both corn and soybean meal, the relative simplicity of the latter model (single excess supply region; no storage) made solving this model much more straightforward than the corn model.

Base Year Solution and Validation

The model was first solved for base year equilibrium prices, consumption, and trade flows assuming transportation costs at 1980 levels and perfectly inelastic supply functions for corn. As seen in table 5, equilibrium prices and consumption levels for Regions 1-5 and the Northeast as a whole are close to their actual 1980 harvest period levels. Percentage deviations in simulated prices ranged from 0.2 percent in Region 5 (GA) to 8.8 percent in Region 4 (MD/DEL/WV), but averaged only 3.4 percent for the Northeast as a region. Both actual and simulated prices for the Northeast were highest in Region One (New England) and lowest in Region Two (NY).

Simulated consumption levels were generally ever closer to their actual 1980 crop year values. Percentage deviations from actual values. Percentage deviations from atual levels ranged from 0.5 percent for Region Three (PA/NJ) to 2.1 percent for Region Four (MD/DEL/WV), averaging only 1.3 percent for the Northeast overall. For the Northeast as a whole,total deamand amounted to roughly 9.94 million tons of corn (excluding exports), of which an estimated 9.17 million tons were consumed by livestock, with 3.32 million tons being imported from Midwestern sources. These results are for the total crop year, abstracting from harvest and post-harvest period variations.

[12] Despite the increasing use of contract rates, the confidentiality of these date prohibits their consistent use in the inter-regional model estimated here.

The model performed reasonably well in estimating equilibrium trade flows from Midwestern sources to Northeastern and Southeastern destinations. The model was unable, however, to generate shipments to specific destinations from secondary suppliers; each importing region was restricted to a single source for all corn inputs. This is a common problem encountered by spatial equilibrium models where the general imposition of supply constraints is not called for.

Sensitivity analysis demonstrated that equilibrium Midwest to Northeast trade flows were relatively sensitive to changes in rail rates. At the extreme, relative rate changes of only about one percent from Michigan and Ohio/Indiana sources to New England and New York destinations were sufficient to cause shifts in sources between the two supply regions. Export route shipments were also found to be highly competitive. On the other hand, supplies originating from Northeastern supply regions were found to be generally cost inefficient and highly insensitive to rail rate variations in the base model. For the soybean meal model, the simplicity of the assumptions and parameters of the base year simulation led to results which exactly replicate the data on which the model is based. Thus, these results are not reported here.

Simulation of Short-run Effects

In simulating the short-run effects of post-Staggers rail rate changes, the 1981 rate structure was introduced into the model while holding regional supplies fixed. As mentioned previously, in comparison with rates existing in 1980, 1981 rates to Northeastern destinations were mixed, some lower (generally those served solely by Conrail) and some higher. Corn prices in this simulation model were broadly lower than in the base model, ranging from $ 142.81 per ton in Region Four to $129.11 per ton in Region Two, and declining an average $3.48 per ton over the entire Northeast, about 2.5 percent lower than 1980 prices (table 6). Prices for the export markets were mixed. For the Southeastern region, prices rose slightly (1.2 percent) in response to a higher rail rate on the single rail route serving Region Five in the model. The overall price differential for delivered corn between the Northeastern and Southeastern regions decreased sharply from $13.78 per ton in the

Table 6. Simulation Results for Short-Run Effects

	Price		Feed Consumption	
Region	Model Solution	Deviation from Base Solution[a]	Model Solution	Deviation from Base Solution
	($/ton)	(%)	(1,000 tons)	(%)
		Corn		
One	142.56	-3.6	1,399	+ 0.9
Two	129.11	-3.7	2,126	+ 0.9
Three	136.61	-2.4	3,431	+ 0.5
Four	142.81	-1.5	2,261	+ 0.3
Northeast	137.31	-2.5	9,217	+ 0.6
Five	128.51	+ 1.2	4,040	-0.3
Six	129.72	+ 1.6	43	—
Seven	129.89	+ 1.6	2,019	—
Eight	129.55	-0.1	4,494	—
		Soybean Meal		
One	350.10	+ 0.8	246	-0.1
Two	323.00	-0.9	280	+ 0.4
Three	315.10	+ 1.0	605	-0.2
Four	330.10	-1.9	601	+ 0.2
Northeast	326.55	-0.3	1,732	+ 0.1
Five	310.60	+ 1.0	1,060	0.0
Six	252.58	-1.1	91	—
Seven	252.38	-0.4	61	—
Eight	249.98	-1.0	221	—

[a] Deviation measured with respect to crop year equilibrium prices in base model.
Note: Regional definitions as follows: (1) New England; (2) NY; (3) PA/NJ; <4)MD/DEL/WV; (5) GA; (6) Albany; (7) Philadelphia; (8) Baltimore. Solution values are for crop year.

base model to $8.80 per ton, a decline of 36 percent.

With regard to changes in feed consumption, feed demands increased slightly in all Northeastern regions and decreased slightly in the Southeastern region. The only substantial change in interregional trade patterns from the base model was a switch from Region Nine (MI) to Region Ten (OH/IN) as the supplier of Region Two's (NY) excess demand. Region Nine continues to exhaust its available supplies. Again, sensitivity analysis showed routes within the Northeast to be relatively insensitive to rate reductions. In addition, Regions Nine and Ten appear to have effectively captured the trade to specific subregions within the Northeast; the competitiveness between rates from these two regions apparent in the base model is no longer evident.

For soybean meal, both price and consumption level changes are generally more modest than for corn. Prices for the Northeast region as a whole decrease by 0.3 percent, while meal consumption is nearly stable, increasing only 1,000 tons or about 0.1 percent. Little geographic pattern is evident with respect to price or consumption changes. Soybean meal prices in the Southeast region rise by 1.0 percent or $3.00 a ton to $310.60, with little perceivable change in consumption. As with corn, the price differential between the Northeast and Southeast narrows significantly, from $20.08 to $15.95 a ton, a 21 percent reduction.

Simulation of Longer-run Effects

The second simulation examines the longer-run effects of deregulation-induced rail rate changes through use of the 1984 rail rate structure and positively sloped regional supply functions. In general, Midwest to Northeast corn and soybean meal rail rates decreased significantly over the 1980-1984 period, while rates from the Midwest to the Southeastern location increased. Overall, the longer-run solution (table 7) accentuates the trends identified in the short-run simulation. Northeastern corn and meal prices are driven still lower, especially for the more northern regions. The average Northeastern price for corn drops 4.8 percent from 1980 levels to $134.29 per ton, while that for soybean meal drops 0.7 percent to $325.50 per ton. Accompanying these price reductions, the consumption of both corn and soybean meal rises slightly. The Southeastern region again exhibits trends opposite those in the Northeast as corn prices rise 2.9 percent

Table 7. Simulation Results for Long-Run Effects

	Price		Feed Consumption	
Region	Model Solution	Deviation from Base Solution	Model Solution	Deviation from Base Solution
	($/ton)	(%)	(1,000 tons)	(%)
		Corn		
One	140.14	-5.5	1,405	+ 1.4
Two	127.75	-4.9	2,130	+ 0.9
Three	133.68	-4.7	3,447	+ 1.0
Four	138.53	-4.7	2.274	+ 0.8
Northeast	134.29	-4.8	9,256	+ 1.0
Five	130.79	+ 2.9	4,024	-0.7
Six	129.53	+ 1.4	43	—
Seven	129.53	+ 1.3	2,019	—
Eight	129.53	-0.1	4,494	—
		Soybean Meal		
One	341.75	-1.6	247	+ 0.3
Two	321.80	-1.2	280	+ 0.2
Three	310.30	-0.5	607	+ 0.1
Four	335.90	-0.1	600	0.0
Northeast	325.50	-0.7	1,733	+ 0.1
Five	317.20	+ 3.1	1,058	-0.2
Six	250.38	-1.9	91	—
Seven	252.78	-0.3	61	—
Eight	250.58	-0.7	221	—

Note: Regional definitions as follows: (1) New England; (2) NY; (3) PA/NJ; (4) MD/DEL/WV; (5) **GA;** (6) Albany; (7) Philadelphia; (8) Baltimore. Solution values are for crop year.

over 1980 levels, while feed consumption decreases slightly, 0.7 percent. Price differentials between the Northeast and the Southeast drop sharply, decreasing to $3.50 per ton for corn, 75 percent less than the 1980 base solution, and $8.30 per ton for soybean meal, 59 percent less than 1980 levels.

No significant changes from the short-run simulation occur in interregional trade patterns for corn or soybean meal. There are slight adjustments in shipment volumes to account for changing levels of production and consumption, but no routes are introduced or leave the solution. Sensitivity analysis reveals that a higher degree of competition exists between Regions Nine (MI) and Ten (OH/IN) than is evident in the short-run solution. However, most routes originating in the Northeast remain uneconomic. On the production side, regional supply changes are very modest, dropping by about 0.1 percent overall for the Northeast, due to the highly inelastic nature of regional supply functions for corn. Corn production in the Southeast is more favorably affected, rising 1.6 percent above 1980 levels.

Conclusions and Implications

The overall results from the two scenarios pertaining to total transportation and feed costs, producer revenues and regional cost differentials are summarized in table 8. It is evident that although different groups have been affected differently, Northeast agriculture has clearly benefited as a whole from the lower rail rates that have followed rail deregulation. As indicated in table 8, transportation rates especially for corn but also for soybean meal have decreased significantly since the passage of the Staggers Act. Aggregate transportation costs for the two feeds decreased nearly 10 percent from $133.3 million in 1980 to $120.5 million in 1981, and decreased further to an estimated $108.3 million in 1984, nearly 19 percent lower than 1980 levels. The New England and New York regions benefited particularly from reduced transportation rates, with estimated feed transportation costs falling nearly 20 percent in New England and nearly 26 percent in New York between 1980 and 1984.

Since shipping costs represent only a small component of feed prices, the percentage changes in total feed costs were much smaller than for transportation costs, yet these costs declined as well. Estimated feed costs for corn and soybean meal for the entire Northeast fell nearly 2.0 percent from $1,858 million in 1980 to $1,824 million in 1981, and subsequently fell to $1,794 million in 1984, roughly 3.4 percent below 1980 levels. Again, New England and

Table 8. Summary of Deregulation Effects in Northeast

	1980	1981		1984	
Item	Value	Value	Change from 1980	Value	Change from 1980
Transportation Costs:					
Corn ($/ton)	26.87	22.67	- 15.6%	20.31	-24.4%
Soybean meal ($/ton)	34.50	35.17	+ 1.9%	32.37	-6.2%
Total Costs (mill. $)	133.3	120.5	-9.6%	108.3	-18.8%
Feed Costs:					
Corn ($/ton)	140.79	137.31	-2.5%	134.29	-4.8%
Soybean mean ($/ton)	327.68	326.55	-0.3%	325.50	-0.7%
Total Costs (mill. $)	1,857.6	1,823.7	-1.9%	1,794.2	-3.4%
Feed Consumption:					
Corn (1,000 tons)	9,165	9,217	+0.6%	9,256	+ 1.0%
Soybean meal (1,000 tons)	1,731	1,732	+0.1%	1,733	+0.1%
Total (1,000 tons)	10,896	10,949	+0.5%	10,989	+0.9%
Revenues of Northeast					
Corn Producers (mill. $)	933.3	910.2	-2.5%	890.2	-4.6%
Northeast-Southeast					
Cost Differentials:					
Transportation Costs:					
Corn (S/ton)	16.01	10.30	-35.7%	5.66	-64.6%
Soybean meal ($/ton)	13.50	11.17	-17.3%	1.77	-86.9%
Feed Costs:					
Corn ($/ton)	13.78	8.80	-36.1%	3.50	-74.6%
Soybean meal ($/ton)	20.08	15.95	-20.6%	8.30	-58.7%

New York experienced the largest proportionate declines in estimated feed costs, 4.1 percent and 3,8 percent, respectively. However, due to the higher feed consumption levels in Pennsylvania/New Jersey and Maryland/Delaware/West Virginia, the total estimated cost savings resulting from reduced rail rates were highest in these areas, $12.9 million and $6.2 million, respectively.

The downward pressure on feed prices also has been apparently accompanied by a modest expansion in the consumption of corn and soybean meal in the Northeast. Estimated consumption levels of the two feeds together increased 0.5 percent from 10.90 million tons in 1980 to 10.95 million tons in 1981, and 0.9 percent to 10.99 million tons in 1984. At the same time, however, lower feed prices have also had a negative effect in reducing production levels and the revenues earned by regional feed grain producers below what they otherwise would have been (table 8). Northeastern corn producers experienced losses totaling nearly $23.0 million in 1981 and $43 million by 1984, due to lower corn prices induced by lower rail rates. Within the region, the estimated revenue loss ranged from zero in New England (due to the assumption of no corn production in Region One) to 4.7 percent in New York, with revenues in the other two subregions both declining an estimated 4.5 percent. Importantly, however, the magnitudes of these losses were smaller than the corresponding savings accruing to Northeastern feed buyers, implying a net gain to the region's agricultural sector.

The preceding discussion also highlighted some changes in interregional flows of feed grains following deregulation. While the ability of a spatial equilibrium model to precisely represent complex interregional trade flows is limited, the simulations demonstrated, immediately following deregulation, a relative insensitivity of equilibrium quantity solutions to *small* changes in rail rates and supply region prices. Specifically, Michigan appeared as the feasible supply region for New England while Ohio/Indiana served as the supply region for the rest of the Northeast. This result is consistent with Seaver's early assessment of deregulation in which he noted that deregulation appeared to be redefining supply markets available to Northeast feed manufacturers, and, in particular, had made single-line movements more attractive than under the regulated rate structure (I983b, pp. 7-8). Results from the long-run simulation, however, suggest that supplying Northeastern grain requirements has since become somewhat more competitive, so that regional supply origins are likely no longer as limited to those located in single rail line territories as initially was the case.

Finally, the simulation results permit some insight into the changing competitive position of the Northeast compared to the Southeast. The results indicate that since deregulation, the competitive position of the Northeastern feed grain industry has improved relative to that of the Southeastern industry. For example, the Northeast-Southeast transportation cost differential for corn decreased nearly 36 percent from an estimated $16.01 per ton in 1980 to $10.30 per ton in 1981, and by 1984 had fallen further to $5.66 per ton, a nearly 65 percent decline from 1980 levels. Analogous trends are also shown in table 8, applying to soybean transportation cost differentials and to the overall feed cost differentials for corn and soybean meal. The results must be interpreted with some caution, however, since only one Southeastern supply area has been integrated into an essentially Northeastern model, and only one supply route in the model connects the Southeast region to Midwest supply markets. Nevertheless, the nature of the trend is clear and indicates that the earlier picture of declining Northeastern competitiveness relative to the Southeast, argued by Seaver and Hanekamp, for example, may have changed significantly with rail deregulation.

In sum, according to the results presented, rail deregulation has had a generally beneficial effect on Northeastern agriculture, in reducing the transportation costs of imported feed, in reducing feed costs overall, and in enhancing the competitive position of the Northeast with respect to the Southeast. Issues outside the limited scope of this analysis may alter this picture somewhat. As mentioned previously, other economic factors aside from deregulation were at work in the early 1980's influencing rail rate changes and it is difficult to identify those changes specifically attributable to deregulation. In addition, there continues to exist significant concern throughout much of the Northeast with issues such as branchline abandonment, the potential for monopolistic pricing of rail services in areas served by single rail lines, and the future of the Conrail system. Indeed, this analysis has raised an additional concern, namely, the tradeoff between feed cost savings to Northeastern producers versus the loss of potential crop revenues. Yet, overall, the results largely support the evidence cited in Casavant's recent review; as in other regions, the effects of rail deregulation have been largely positive with respect to the Northeast feed economy.

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