THE IMPACT OF NATURAL GAS PRICE DEREGULATION ON THE SOUTH CAROLINA FOOD-PROCESSING SECTORS

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The economic distortions that have been caused by federal regulation of natural gas markets have been the subject of many recent studies (Committee for Economic Development [CED]; Brickhill; Hall; MacAvoy and Pindyck; and Means). The most recent policy debate concerns the relative merits of alternatives to the price deregulation schedule of the 1978 Natural Gas Policy Act (NGPA). The range of options runs from freezing natural gas prices at current levels to complete decontrol of natural gas prices by January 1, 1986.[1] Producers of natural gas, pipelines, distribution utilities, and end users all suffer from some sort of economic distortion under the NGPA (CED, pp. 50–60). The CED analysis leads to a national policy recommendation that

> On balance, we believe that the advantage of deregulation in promoting efficient use of natural gas and in encouraging production outweigh the possible drawbacks . . ., we recognize the magnitude of the costs involved in any transition to a deregulated market and the need for consumers to have time to make defensive investments that will cushion them from the shock of significantly higher prices. We also feel that certain reform in the regulation of utilities will add considerable efficiency to the natural gas markets. (CED, p. 61)

The importance of natural gas pricing policy to the farm and food sector is expressed by Gardner. He analyzes how rising natural gas prices affect the price of ammonia-based fertilizers, the use of these fertilizers, and the ultimate effect on farm costs and food prices. He concludes that the aggregate impact of

> deregulation versus current natural gas price regulation on the farm and food sector are significant but far less than those often caused by weather or international events. Consumer and farmer costs together do not exceed more than one percent of the value of farm production. The main burden of adjustment would fall on the ammonia producing industry. (Gardner, p. 5)

In his analysis of the ammonia industry he concludes:

> Under current policy, after 1985, the *interstate* pipelines would have a larger ''cushion'' of previously contracted, relatively low priced gas, and so would be able to compete aggressively for new gas supplies and roll in higher cost new supplies with low priced ''cushion'' gas. Thus, the interstate lines could offer both better terms and better guarantees of supplies than intrastate lines. This would place the ammonia producers on *intrastate* pipelines at a competitive disadvantage. (Gardner, p. 9)

Complete decontrol would eliminate the gas cushion. Assuming that long-term contracts between producers and pipelines would be renegotiated under complete decontrol, these economic distortions could be eliminated.

Gardner's focus on the ammonia industry, however, does not capture natural gas price policy effects on the food-processing industries. Furthermore, Steinhart and Steinhart found that in the farm and food sector, about 40 percent of the total energy used is in the food processing industries (Carter and Youde). Further, within the food-processing sectors, natural gas is often the most widely used fuel (Table 1).

Interstate pipelines (and industries on these pipelines) have a distinct price advantage under the NGPA. The purpose of this paper is to explain and illustrate a method for estimating the economic or location rents that food processors on ''cushioned'' pipelines obtain under the NGPA. There are important efficiency implications from this analysis. Spatial competition between food processors may be distorted by artificial locational rents obtained, and resources may be shifted

Table 1. Natural Gas Use in Selected Food Processing Industries

Sector	SIC	Share of Natural Gas in Total Energy Use (%)
Fluid milk	2026	30-40
Canned Fruit and vegetables	2033	60
Flour	2041	30-40
Bread	2051	50-60
Fats and oils	2071	40-70
Beverages	2086	30-50

Source: Oak Ridge Associated Universities (ORAU), P.10-1 to 10-52, various pages.

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[1] ''For example, the Reagan Administration's bill (H.R. 1760 and S.615, February 28, 1983) would decontrol both new and old natural gas by January 1, 1986. Also, ''old gas,'' which is gas placed under contract before 1978, will not be deregulated under NGPA. Current debate about natural gas pricing policies, therefore, is concerned with whether price regulation should be lifted earlier than planned under NGPA, whether old gas should also be decontrolled, or whether regulation should be extended beyond 1985'' (Schmidt, p. 1). Furthermore, although the Reagan push for complete decontrol is proceeding in the Senate, there are significant problems to decontrol in the House, e.g., ''Rep. Dan Coats of Indiana, 'Reagan robot of the Class of 1980' has abandoned the Reagan administration's drive for gas decontrol. There is one key reason for his apostasy: his home district in Ft. Wayne is dominated by residential and industrial consumers dependent on a cushion of cheap old gas to keep their aging businesses and industries even marginally competitive'' (*The Energy Daily*, p. 4).

toward more inefficient producers that have a fortuitous location on a "deep cushion" pipeline.

The input-output (I-O) model used in the analysis does not reveal the individual production function of each firm in a given food processing sector. However, I-O does reflect the aggregate input requirements over similar firms within a given food-processing sector, for example, bakery products. As such, I-O can be used to estimate the effects of higher gas prices relative to output price on the "representative" firm in the sector, that is, on the unit input requirements estimated from data aggregated over all firms in the sector. Comparisons of alternative gas price scenarios on a given food-processing sector are made between such representative firms in that sector.

METHODOLOGY

Food-processing firms on low-cushion pipelines will be faced with the following alternatives: (1) They can pay higher prices than competitors on deep-cushion pipelines. *Ceteris paribus,* this forces these producers either to increase their product price or cut profit margins relative to their competitors on deep-cushion gas. With low price elasticity of demand for the product, higher gas costs will more likely be passed on to final consumers in the form of higher product prices. In this case, firms with low gas costs will obtain higher profits relative to high gas cost producers. With high price elasticity of demand for the final good, higher gas costs are not easily passed on to consumers; therefore, firms will face lower profit margins. Firms that pay low prices for natural gas will again find smaller cuts in profits relative to firms faced with high-priced gas. In either case, the effect of the NGPA price distortions is to create relative profit differentials between firms. In the analysis to follow, we assume high price elasticity of demand for the product. However, we again emphasize the relative profit impacts of the natural gas price scenarios. (2) They can substitute other fuels or inputs for natural gas inputs. This is more difficult for producers that use natural gas as a feedstock or in sophisticated processes. (3) They can shut down the existing plant or relocate on a pipeline with a deeper cushion. With similar input costs, transportation costs, and input availability between plants, this last alternative becomes more probable. This increased likelihood of relocation then depends on the gas price differential, importance of natural gas as an input to the food processor, and the substitution potential of other inputs for natural gas. With estimates of the price and substitution effects of natural gas price deregulation under NGPA, the locational rent of food processors on deep-cushion pipeline may be estimated.

In pursuit of empirical estimates of the natural gas price effects, some strong assumptions are made regarding the production function, for example, a Leontief fixed-proportions production function is assumed initially. Input substitution between natural gas and other inputs is then considered, and the subsequent effects on product price or profit margins in food processing are estimated.

DATA

For three reasons, data used for the analysis are for South Carolina food-processing firms. First, data are available at the establishment level in South Carolina for fuel use by type and total output (see Table 2). Second, an operational nonsurvey regional input-output (I-O) model exists for the state (see Mulkey and Hite for the estimation procedure). Third, fuel prices paid by industrial users in South Carolina have been made available by the South Carolina Petroleum Council, along with their forecasts of fuel prices.

In the following sections, estimates are made of the effect of rising relative natural gas prices on the natural gas input coefficient for various food-processing sectors. Next, estimates are made of locational rents associated with a deep-cushion pipeline location for food processors. Substitution potential is then considered as a moderating force on the generation of location rents.

Table 2. Natural Gas Use by South Carolina Food Processing Firms—Four Digit SIC Level FY1977

SIC NUMBER	SIC GROUP	NUMBER OF FIRMS	EMPLOYMENT	OUTPUT	ALL NATURAL GAS	NATURAL GAS PER OUTPUT	NATURAL GAS PER OUTPUT	SECTOR NUMBER IN I/O MODEL
			NUMBER OF PERSONS	MILLIONS OF $	BILLIONS OF BTU'S	BILLION BTUS PER $1000	DOLLARS PER $1000	
2011	MEAT PACKING PLANTS	32	1273	109.7	141.5	0.00129	1.81343	22
2013	PREPARED MEATS	23	335	23.3	49.6	0.00212	2.98458	22
2015	POULTRY DRESSING PLANTS	17	1561	94.4	341.9	0.00362	5.08675	22
2026	FLUID MILK	15	1070	135.1	112.4	0.00083	1.16868	22
2033	CANNED FRUITS, VEGET	7	343	5.0	2.4	0.00048	0.67147	22
2035	PICKLED FRUITS AND VEG	5	152	22.6	12.5	0.00055	0.77815	22
2036	FROZEN FOOD PROD	11	187	4.1	0.0	0.00000	0.00000	22
2041	FLOUR AND OTH GRAIN PROD	8	152	9.1	0.6	0.00007	0.09525	20
2042	PREPARED FEEDS	30	435	41.8	136.4	0.00327	4.58738	20
2051	BREAD AND RELATED PRODUCTS	43	2181	113.3	415.8	0.00367	5.15803	21
2071	FATS AND OILS	5	861	25.4	18.5	0.00073	1.01956	22
2086	BOTTLED AND CANNED SOFT DRINKS	35	2325	190.6	498.2	0.00261	3.67251	22
2091	CANNED AND CURED FISH AND SEAFO	5	203	16.5	14.7	0.00089	1.25241	23
2097	MANUFACTURED ICE	22	209	8.3	0.0	0.00000	0.00000	23
2099	FOOD PREPARATIONS NEC	12	318	8.2	3.3	0.00040	0.56179	23

Source: Dept. of Labor. These data are aggregations of individual establishments in the state. The 15 four digit SIC groups are aggregated to 4 sectors of the 64 sector S.C. I-O model, sectors 20–23.

THE LEONTIEF PRICE MODEL

The modeling procedure used to assess the direct impact on each food-processing sector of the natural gas price scenarios is a version of the Leontief I-O model. Simply put, a fixed-proportions production function is assumed for each sector in physical terms.[2] Specifically for South Carolina, a 64-sector model was estimated where up to 64 different categories of inputs are purchased by a given sector with a series of a_{ij} coefficients for each sector where:

$a_{ij} = q_{ij} \frac{P_i}{P_j}$ = dollar cost of input i ($i = 1, \ldots, 64$) per dollar output of sector j

q_{ij} = physical inputs of type i required to produce a physical unit of good j (e.g., BTU's of gas needed per ton of bricks)

P_i = price of the input i (e.g., price of natural gas per BTU)

P_j = price of output j (e.g., price of brick per ton)

If a fixed q_{ij} coefficient is assumed, then an increase in the price of input i relative to output price j will mean that the a_{ij} coefficient will increase. This means, for example, if the price of natural gas inputs rises, relative to the product price, then the producer of the product is faced with rising natural gas costs per dollar of product sold. This, in turn, may result in (1) a further rise in the product price, (2) a fall in profits per dollar of sale, or (3) substitution for natural gas. If we do not allow substitution and assume competitive product and factor markets (the producer is a market price taker), then profit margins per dollar of sales will fall.

Consider a single price equation for good 1 in a simple 3-sector model with wage and profit payments to primary resources:[3]

$$P_1 = q_{11} P_1 + q_{21} P_2 + q_{31} P_3 + q_{01,1} W_1 + q_{02,1} \pi_1$$

$q_{01,1}$ = labor hours per unit of output 1

$q_{02,1}$ = proprietor input per unit of output 1

W_1 = hourly wage rate

π_1 = profit per unit of proprietor input

P_1 = average input cost and profit markup as shown in the P_1 equation. Let input 3 be natural gas. If P_3 increases, then P_1 will increase by (q_{31} * increase in P_3) *ceteris paribus*. However, if P_1 can not increase in the short run because of competitive conditions, then $q_{02,1}\,\pi_1$ may fall as P_3 increases by (q_{31} * increase in P_3). Generalizing,

$$(1) \qquad P_j = \sum_{i=1}^{n} q_{ij} P_i + q_{01,j} W_j + q_{02,j} \pi_j$$

or

$$(2) \qquad P = Q' P + Q_1 W + Q_2 \pi$$

with $i,j = 1, \ldots, n$ and n = number of sectors in the I-O model.

where

P = output price vector nx1

Q' = transpose of the matrix of real direct input coefficients, q_{ij}, nxn

Q_1 = diagonal matrix with $q_{01,j}$ along the diagonal, nxn

W = vector of sector wage rates, nx1

Q_2 = diagonal matrix with $q_{02,j}$ along the diagonal, nxn

π = vector of sector profit rates, nx1

There are several ways to approach the problem of how rising relative natural gas prices will affect food processors within the I-O framework. If the physical input coefficients q_{ij} were known, then prices could be calculated from the general price equation. Unfortunately, these are not generally known. A second tact is to assume that q_{ij}'s are constant (no physical substitution) so that the known or forecast changes in a_{ij}'s (value coefficients) are attributable solely to relative price changes between input i and output j.[4] Rising a_{ij} coefficients for natural gas then imply a smaller residual (profit-type) income per dollar of sales.[5,6] Simply, if a fluid-milk processor purchases \$5 of natural gas per \$1000 of sales before gas prices rise relative to milk prices and \$10 of natural gas prices after a relative price

[2] The Leontief fixed-porportion production function exhibits characteristics similar to those of a linear homogenous Cobb-Douglas production function. Both exhibit constant returns to scale and fixed proportions of factor inputs, given factor prices. Thus, the Leontief production function can be thought of as the "optimal" production process at a given point in time, and it is used to produce all levels of output (see Yan p. 28–30 for elaboration).

[3] Note that P_1 is both an input and output price if there are nonzero intraindustry purchases. This is only one question out of the system.

$$\begin{bmatrix} P_1 \\ P_2 \\ P_3 \end{bmatrix} = \begin{bmatrix} q_{11} & q_{21} & q_{31} \\ q_{12} & q_{11} & q_{32} \\ q_{13} & q_{23} & q_{33} \end{bmatrix} \begin{bmatrix} P_1 \\ P_2 \\ P_3 \end{bmatrix} + W_1 \begin{bmatrix} q_{01,1} \\ q_{01,2} \\ q_{01,3} \end{bmatrix} + \pi_1 \begin{bmatrix} q_{02,1} \\ q_{02,2} \\ q_{02,3} \end{bmatrix}$$

or

$$P = Q' P + W_1 Q_{01} + \pi_1 Q_{02}$$

then

$$P = (I - Q')^{-1} (W_1 Q_{01} + \pi_1 Q_{02})$$

if we assume that W_1 and π_1 are scalars.

[4] See Lee et al., p. 17, for an example of this type of I-O analysis. Of course, lower wages might also result, other inputs might be substituted, or gas might be used more efficiently (through new capital purchase of machinery that uses less gas per unit of output), etc.

[5] A third tact is the Griffin and Gregory translog model. Lack of detailed four-digit SIC level data precluded this approach. However, it is instructive to note their expectations regarding short run and long run elasticities of substitution between energy inputs and other inputs. "It would not be surprising if higher energy prices were to induce increases in labor and material inputs and a corresponding reduction in capital in the short run . . . on the other hand, in the long run one might expect capital and energy to be substitutes since new equipment could be designed to achieve higher thermal efficiencies, but at greater capital costs" (p. 846).

[6] Profit-type income in the I-O accounts includes proprietors income, rental income of persons, corporate profits, and business transfer payments, less subsidies.

increase, then without input substitution profits will suffer by $5 per $1000 of sales in a competitive market. Price projections are listed in Tables 3 and 4; note that these projections are not forecasts of what gas prices will be. Gas prices in 1985 are assumed to range from $4/MCF to $9/MCF; then, they are projected into the future so that the implications of alternative natural gas prices relative to other fuel prices can be made. Other fuel prices represent projections made by industry analysts. We accept these as representative of current thinking but do not defend their methodology or the accuracy of the results. Our emphasis is to gauge the potential impacts over these price ranges. The methodology developed can be used for alternative forecasts of future prices (see Ott and Tatom for an interesting analysis of the interdependency of oil and gas prices).

Following Lee et al., we replace the P vector with price indices wherever P appears in equation 2. P, the base-year index of price, is the unit vector (1980 is the base year for the model considered here). Also the q_{ij} coefficients are in real dollar terms where the base-year coefficients are equal to that year's a_{ij} coefficient. Thus, the Q′ matrix (equation 2) is found from our 1980 base-year I-O model. The Q_1W and $Q_2\pi$ products need not be estimated for the purpose of estimating direct natural gas price effects. This holds if Q_1W share is held constant, and $Q_2\pi$ is a residual that falls if the column sum of intermediate purchases, iQ′P, increases and vice versa (i is the unit summation vector [ixn]). If we assume that wage rates are determined independently of natural gas prices, then labor's share would decrease if Q_1 decreases. Q_1 (labor hours/unit of output) will fall as gas prices rise relative to wage rates if labor and natural gas are substitutes. For sectors that use natural gas in food processing, for example, bakery products, with given technologies, labor is not likely to substitute as an alternative source of heat in the manufacturing process.

By using the price projections in Table 3, future relative price change scenarios are constructed for 1980–85, 1980–90, and 1980–95. Direct natural gas use coefficients, a_{ij}, are projected to 1985, 1990, and 1995 for each natural gas price scenario.

Table 3. Approximate S.C. Energy Prices for Industrial Users

Year	Coal per 10^6 BTU	Crude Oil per Bbl.	Electricity per 10^6 BTU	Natural Gas per 10^6 BTU	GNP Price Deflator 1972=100
		"Constant (1982) Dollars"			
1973	.946		3.66	1.233	105.70
1976	1.517	3.106	6.47	1.958	132.34
1977	1.685	-	7.32	2.295	140.05
1980	1.732	24.77	10.81	3.051	176.52
1985	2.73	38.93	14.70	varied	206.35
1990	3.10	56.86	14.89	as model	
1995	3.21	77.67	14.94	parameter	
		"Current Dollars"			
1973	.485		1.874	.6318	
1976	.972	8.38	4.147	1.255	
1977	1.146		4.962	1.556	
1980	1.479	21.19	9.238	2.605	
1982	1.914	-	13.18	3.873	
1985	3.25	49.00	17.508	varied	
1990	4.94	100.00	23.73	as model	
1995	6.85	177.00	31.87	parameter	

Source: Calculated from S.C. Petroleum Council Data and Projections, Energy Information Administration, U.S. Dept. of Energy, p. xii.

Table 4. Natural Gas Price Projections, 1985–1995[a]

Year	Case I	Case II	Case III	Other Price Index Projections[b] (1980=100)
1985	4.00	6.00	8.00	1.3382
1990	5.877	8.82	11.754	1.7908
1995	8.635	12.953	17.271	2.3966

[a] Natural gas prices are assumed to increase at an 8% annual nominal rate after 1985. These estimates are in current dollars.
[b] All non-fuel prices increase at a 6% annual nominal rate from 1980.

Since the South Carolina I-O model was based on the 1972 U.S. I-O model, several updating adjustments were required to reflect price and substitution effects from 1972–80. First, because of the large changes in fuel prices since 1972, these direct-use coefficients (a_{ij}) were not taken from national tables, but were constructed from FY 1977 data for South Carolina manufacturing firms. The data source was the Annual Wage and Salary Survey of all manufacturing firms by the South Carolina Department of Labor. These coefficients reflect both the physical substitution potential and relative price effects on the decision by South Carolina manufacturing to use each type of fuel. These a_{ij} coefficients were updated to 1980 prices using the price data series provided by the South Carolina Petroleum Council. Equation 3 describes the updating procedure.

$$(3) \qquad A^* = \hat{P} A \hat{P}^{-1}$$

where

A^* = matrix of price updated a_{ij} coefficients, nxn
$\hat{P}$ = diagonal matrix with price indices for each sector along the diagonal, nxn[7]
A = matrix of base year a_{ij} coefficients, nxn

To update the 1977 fuel-use coefficients the operation in equation (3) is carried out only for the 4 fuel-use rows and 26 manufacturing sectors.

Updating of all other sectors was carried out by deriving price indices for the 1973–80 period and then using the procedures in equation (3). This allowed for relative price effects without any physical substitution between inputs. The 1985, 1990, and 1995 a_{ij} coefficients were computed using equation (3), substituting the respective price indices into the $\hat{P}$ matrix for each year.

Table 5 lists the results of these computations. Direct gas use coefficients in 1980, 1985, 1990, and 1995 are shown. Also listed are the change in these a_{ij} coefficients for 1980–85, 1980–90, and 1980–95 for each of the South Carolina food-processing sectors and three natural gas price scenarios. Under the assumptions of

[7] The nonfuel price indices used are producer price indices, 1973–80, from the Bureau of Labor Statistics, U.S. Department of Labor. See E. Bowen for a complete description. The four fuel sectors were updated from the price series in Table 3 after conversion to an index with 1977 as the base year.

evant elasticities of substitution do not exist. Second, forecasts of relative fuel prices over the 15-year period are tenuous at best.

Gardner (p. 16) demonstrates that the elasticity of demand for an input x given the prices of other inputs is:

$$E = S_x n - (1 - S_x)\sigma \tag{4}$$

where

S_x = share of input x in cost
n = elasticity of demand for output
σ = elasticity of substitution between input x and all other inputs as an aggregate

From the discussion on the a_{ij} coefficients for natural gas in food processing, S_x is equivalent to the relevant input-output direct use coefficient of natural gas in each food-processing sector. These are listed in Table 5.

To obtain an idea of the potential substitution of other inputs for natural gas, E can be simulated over reasonable parameter values. For the food-processing sectors, S_x varies from 0.00870 to 0.02098 (See Table 5). Now, if n is -0.50, -1.0, or -1.50, and σ varies from 0 (the Leontief case) to 1.0 (the Cobb-Douglas case), the absolute value of E will be very close to the σ assumed. For $\sigma = 0$, the E range is -0.004 to -0.013; for $\sigma = 1.0$, the E range is -0.995 to -1.013.

The natural gas input price elasticity depends critically on the elasticity of substitution between natural gas and other inputs in the production of food products. Since no substantial econometric evidence exists on the σ value in this case, σ can be approximated roughly from the percentage change in natural gas use relative to other energy inputs divided by the percentage change in natural gas prices relative to other energy prices over some sample period. Consider Table 7 where direct cross-price elasticities for fuels by industrial users (less feedstock use) are listed.

Looking at the gas row in Table 7, a 10 percent increase in the price of natural gas use results in a 8.1 percent decrease in gas use, a 1.4 percent increase in the use of oil, a 1.5 percent increase in coal use, or a 3.4 percent increase in electricity use. Thus, in the long-run ample substitutes for natural gas are available.

However, if the price of the substitutes increases at the same or at a faster rate than natural gas, there is little incentive to make this substitution. Table 8 lists the projected percentage price increases (in current dollars) for each fuel. From Table 7, gas is shown to be a good substitute for oil, coal, or electricity (that is, a 10 percent rise in these fuel prices would result in about a 7.5 percent increase in gas use).

These coefficients of elasticity can be used to obtain some idea of what happens to the underlying physical-use coefficient for natural gas as fuel prices vary over time. However, this must be done with some caution since these elasticities are computed at the mean values of the price and fuel use by type. Accordingly, large price changes imply large movements away from the mean price and thus changes in the price elasticity coefficient, *ceteris paribus*.

Nevertheless, we can say that small price increases of similar magnitude in both electricity and gas prices will result in little change in the physical use of gas relative to electricity. However, if gas prices increase twice as fast as electricity, then substantial substitution is likely. There is some evidence from Table 8 that substantial physical substitution for gas is unlikely in case 1, but the likelihood of substituting electricity for gas becomes more likely for cases 2 and 3, and of coal for gas in case 3.

Several bounds on σ can be placed, given the estimates of Tables 7 and 8. Consider electricity as the most likely substitute for natural gas in the food-processing sector. Since electricity is expected to increase in price throughout the 1985–95 period at a faster rate than gas with a 1985 price of $4/MCF, little or no substitution is likely. Considering $6/MCF or $8/MCF gas, the relative percent changes in price between electricity and gas are given in Table 9.

The own- and cross-price elasticities of demand for

Table 7. Long-Run Elasticity/Cross-Elasticity Matrix for the Industrial Sector (Less Feedstocks)

Elasticity of Consumption	In response to a price change at the point of consumption			
	Gas	Oil	Coal	Electricity
Gas	-0.81	0.14	0.15	0.34
Oil	0.75	-1.32	0.14	0.33
Coal	0.75	0.14	-1.14	0.33
Electricity	0.73	0.13	0.14	-1.29

Note: Mean values calculated for the following fuel consumption configuration: 52% natural gas; 19.5% oil; 7.4% coal; 21.1% electricity.
Source: Oak Ridge Associated Universities. P. 3-11.

Table 8. Projected Nominal Fuel Price Increases for S. C. Industry

Item	1980-85 %Δ	1980-90 %Δ	1980-95 %Δ
Gas			
$4/MCG	54	126	231
$6/MCF	130	239	397
$8/MCF	207	351	563
Oil	131	372	735
Coal	119	234	463
Electricity	157	257	345

Calculated from S. C. Petroleum Council Data and Projections.

Table 9. Relative Price Forecasts for Natural Gas and Electricity

Item	1980-85	1980-90	1980-95
%ΔP Gas/%ΔP Elec. $6/MCF Gas	130/157=0.828	239/257=0.929	397/345=1.15
%ΔP Gas/%ΔP Elec. $8/MCF Gas	207/157=1.32	351/257=1.37	563/345=1.63

(Computed from estimates in Table 8).

Table 5. Direct Use of Natural Gas by South Carolina Food Processors, 1980–1995

South Carolina Input-Output Sector	SIC	Natural Gas Expenditures/ $100,000 of Output[a] NG80	NG85	NG90	NG95	Change 1980-85	1980-90	1980-1995
		Dollars						
Natural Gas Price = $4/MCF								
20. Grain Mill	204	556	638	701	769	82	144	213
21. Bakery	205	758	870	955	1049	112	197	290
22. Meats,etc.	206-208	378	433	476	522	56	98	145
23. Other food	209	387	443	487	535	57	100	148
Natural Gas Price = $6/MCF								
20. Grain Mill	204	556	957	1051	1154	401	495	598
21. Bakery	205	758	1305	1433	1573	547	675	815
22. Meats,etc.	206-208	378	650	714	783	272	336	406
23. Other Food	209	387	665	731	802	279	344	415
Natural Gas Price = $8/MCF								
20. Grain Mill	204	556	1276	1401	1538	720	845	982
21. Bakery	205	758	1740	1911	2098	982	1152	1339
22. Meats,etc.	206-208	378	867	951	1044	489	574	667
23. Other Food	209	387	887	974	1069	501	587	683

[a] NG80 = Natural Gas Expenditures in 1980/$100,000 of output.
NG85 = " " " " 1985/ " " "
NG90 = " " " " 1990/ " " "
NG95 = " " " " 1995/ " " "
Source: Calculated from I-O model; see equation 3 in the text.

no substitution and competitive markets, a reduction in profit per dollar of output can be inferred as the impact of rising natural gas prices for each food-processing sector. Furthermore, this assumption of profit reductions implies that indirect price effects in the I-O system are negligible as each sector absorbs the higher relative price of natural gas.

For each of the natural gas scenarios (1985 price of $4, $6, or $8 per MCF),[8] the bakery products sector is most sensitive to natural gas price change. The short-term (1980–85) increase in natural gas costs for bakery products ranges from $112/$100,000 of output (1985 price = $4/MCF) to $982/$100,000 of output (1985 price = $8/MCF). To put these numbers in perspective, consider the "profit-type" income earned per dollar of sales for food and kindred products (SIC 20). The Bureau of Economic Analysis (p. 62) estimates that profit-type income earned is $8,204/$100,000 of output in this sector. This profit is found by subtracting employee compensation and indirect business taxes from value added in the sector.[9] Assuming that the $8,204 is representative of bakery products profits margins in 1980, Table 6 lists the new profit margin, given our calculated increases in natural gas prices relative to product price. These estimates are representative of potential profit margin reductions, given our assumptions.

Table 6. Profit Margins for Bakery Products with Alternative Natural Gas Prices per $100,000 of Bakery Products

1985 Price of Natural Gas	Increase in Direct Natural Gas Price 1980 to: 1985	1990	1995	Profit per $100,000 of Output 1985	1990	1995
	Dollars					
$4/MCF (Firm A)	112	197	290	8092	8007	7914
$6/MCF (Firm B)	547	675	815	7657	7529	7389
$8/MCF (Firm C)	982	1152	1339	7222	7052	6865

Source: See Table 5

The results in Table 6 are instructive. Four dollar natural gas will have very little impact on profit margins in the bakery products sector, even through 1995 when the no substitution is assumed. However, $6 natural gas prices in 1985 result in a 10 percent reduction of profit margin by 1995. Finally, a 1985 natural gas price of $8/MCF results in about a 16 percent reduction in profit margin.

Clearly, firms on noncushioned pipelines are faced with profit reductions caused by "heavy cushioned" competitors. Consider three firms, each with $100 million of annual sales, each expected to make about $8.2 million dollars in profit-type income. In 1985, Firm A with $4 gas will lose about $112,000 in profits relative to 1980 profits, while Firm B with $6 gas faces about $547,000 in relative profit loss, and with $8 gas Firm C will suffer about $982,000 in profit loss annually. Thus, Firm A reaps a location rent of about $870,000, while Firm B reaps about $335,000 in location rent.[10]

Thus, the annual difference in 1985 of the profitability of Firms A and B relative to C can be inferred from Table 5 by substracting Firm C profits from those earned by A and B. Similar operations are carried out for the years 1990 and 1995 to find the locational rents in these years. Now, assume that the 1985 locational rents persist from 1985–89; the 1990 rents accrue from 1990 to 1994; finally, the 1995 rents persist from 1995–2000. This 15-year rent series can be evaluated in present-value form with a discount rate of 8 percent. Results of these calculations for firms with $100 million in annual sales yield a present-value of about $8 million for Firm A and $3.8 million for Firm B in locational rent attributable to their ability to purchase less expensive natural gas. The expected profits will be 11.4 percent higher for Firm A and 5.5 percent higher for Firm B, relative to Firm C.

SUBSTITUTION POTENTIAL

These locational rent estimates are on the high side of the range possible since no substitution was allowed over this time period. Reasonable estimates of the degree of substitution of fuel oil, electricity, and/or coal for natural gas are very difficult to obtain for two reasons.[11] First, reliable industry level estimates of the rel-

[8] $4/MCF seems a likely 1985 price under the NGPA (Schmidt). Also, the deep gas price currently deregulated has been as high as $10/MCF. Thus, the $6 and $8 scenarios may be representative of a complete decontrol scenario where "old gas," now as low as $.30/MCF, is also deregulated (Schmidt). Of course, under these conditions, long-term contracts would have to be renegotiated between producers and pipelines. Prices to end users by pipeline will still vary by the rate at which renegotiated contracts phase in new prices, the proportion of "deep well" gas available to pipelines in certain locations, the relative bargaining strength of producers and users, and for other reasons. See Schmidt for a recent summary of deregulation scenario effects on gas prices.

[9] More detailed (4-digit SIC) data on profit-type income are not available from BEA for the 1972 I-O model.

[10] Location rent refers in this case to the profit-type income earned by Firm A and B relative to Firm C. Since these "excess" profits are generated by fortuitous locational advantages of A and B relative to C, they may be thought of as locational rents.

[11] While coal presents some technical substitution problems, oil could be readily substituted for gas. However, the South Carolina Petroleum Council price projections indicated expected oil price increases in excess of natural gas price increases. Although recent oil price trends may make these forecasts somewhat precarious, we make no attempt to forecast fuel prices. See Ott and Tatom for an analysis of the interdependencies between oil and gas prices.

natural gas and electricity in Table 7 allow some crude estimates of quantity changes, given these relative price changes. Recall that a 10 percent increase in the price of gas will result, *ceteris paribus,* in a 8.1 percent decrease in gas use and a 3.4 percent increase in electricity use; a 10 percent increase in electricity price will result, *ceteris paribus,* in a 12.9 percent decrease in electricity use and a 7.3 percent increase in gas use. Under the assumption that these elasticities hold over the relative price changes in our example, the percentage changes in quantity of natural gas and electricity resulting from each scenario are given in Table 10.

The price elasticity of demand for natural gas, given the price of all other inputs, was shown to approximate σ. Thus, for $4/MCF gas and our expected changes in electricity prices, very little physical substitution is likely. Similarly, for $6/MCF gas the E coefficient is very small until the 1980–95 period, when it becomes approximately 0.20. This is a small elasticity measure; thus, it implies little physical substitution between energy sources. Only with $8/MCF gas does the elasticity measure approach 0.50 by 1995.

Given these estimates, firms with $8/MCF gas will continue to use significant amounts of natural gas over the relative price ranges considered. Accordingly, the economic rents accruing to deep-cushion firms will exist throughout this period, although they may be only about 50 percent of the rents estimated when no substitution is allowed.

Table 10. Crude Estimates of Substitution Elasticity Between Natural Gas and Electricity

Item	1980-85	1980-90	1980-95
% Δ Quantity of Gas/ - % Δ Quantity of Electricity			
For $6/MCF gas	-0.059	0.024	0.225
For $8/MCF gas	0.401	0.457	0.807
Implied σ are:			
For $6/MCF gas		0.026	0.196
For $8/MCF gas	0.290	0.33	0.495

Source: See text for calculation procedures.

SUMMARY AND CONCLUSIONS

Using a nonsurvey regional I-O model of South Carolina, estimates are made of the impact of natural gas price increases on the direct-requirements coefficient for several food-processing sectors. Operating under the assumption of profit-margin reductions in response to an increase in the price of natural gas relative to food products, direct gas-use coefficients are estimated for 1985, 1990, and 1995 under alternative price scenarios for natural gas.

The impact of natural gas price deregulation differs according to the cushion position of the natural gas pipeline serving the food processor. Pipelines that will be able to roll in cheaper regulated gas even beyond 1985 clearly have price and market advantages over pipelines purchasing deregulated gas only (low- or no-cushion pipeline). Using $4/MCF natural gas in 1985 as the price for deep-cushion pipeline gas and $6 and $8/MCF gas for low-cushion pipelines, locational rents are estimated for those firms located on the deep-cushion pipeline. Under the assumption of profit reductions in response to higher natural gas prices, these rents are estimated to result in a 11.4 percent reduction in profits for firms with $8/MCF gas relative to $4/MCF, and a 5.5 percent reduction for firms with $6/MCF gas relative to $4/MCF firms.

Finally, the sensitivity of the results to possible physical substitution for gas with other energy sources is considered. Estimates show that very little substitution is likely for firms in the short run, but by 1995 the reduction in natural gas use likely for the $6/MCF firms is 20 percent and 50 percent for the $8/MCF firms.

In sum, the impact of natural gas price deregulation under NGPA over the range of prices assumed in this study is likely to result in small, but not insignificant, reductions in profit margins for low-cushion food processors relative to deep-cushion food processors. For bakery products firms with $100 million of annual sales over the 1985–2000 period, $4/MCF firms will receive a location rent stream through the year 2000 that has an $8 million present value over $8/MCF firms and a $3.8 million present value over $6/MCF firms without substitution. Substitution for natural gas may reduce these estimates of location rent by about 50 percent. Since annual sales for the South Carolina bakery product sector were about $117 million in 1977, these estimates are illustrative of the potential impact in South Carolina for bakery products. There are too many assumptions (for example, profit margin of bakery products equal to that of SIC 20 group-food products) to make specific predictions of deregulated natural gas price effects on the South Carolina bakery products sector. However, the analysis is illustrative, given the data used, of how representative firms within the food-processing sector are and may be affected by the natural gas price scenarios considered.

Emphasis should be placed on the illustrative nature of these results. Anticipation of such relative profit margin distortions by producers, pipelines, utilities, and end users will likely bring market and political pressure to eliminate some of the distortions of the NGPA illustrated in this analysis.

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