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Regional Energy Substitution: Results from a Dynamic Input Demand Model*

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I. Introduction

In this note we report results of a study of energy substitution in manufacturing, using two-digit data disaggregated by region in a dynamic, disequilibrium model of firm input demand. The question of regional differences in the impacts of energy price changes is an important one. National energy policy is worked out in a climate of great conflict among regions, based on real or imagined differences in the perceptions of the role of energy in production. For example, it has become commonplace to hear that the older regions, such as the Northeast, will be hurt more by energy price increases than newer regions, such as the Southwest.

In a previous paper we presented results of estimating regional models with a static, full equilibrium manufacturing cost function [6]. We used pre-1974 data, which may have reflected something close to long-run equilibrium positions for firms. It seems valuable, however, to analyze data from a slightly later period with one of the more recently developed models that permit firms to be out of long-run equilibrium. This could yield substantially greater understanding of the direction and speed of induced input adjustments undertaken by firms of the different regions in response to the large price changes of the 1970s.

II. Model and Data

The model and data have been discussed in detail elsewhere; here we will be very brief [1; 2; 7; 11]. A production function is defined at the regional, two-digit manufacturing level as:

$$Y(t) = F[v(t), x(t), \dot{x}(t), t] \tag{1}$$

where $Y(t)$ is output, $v(t)$ and $x(t)$ are, respectively, the vectors of variable and quasi-fixed inputs, $\dot{x}(t)$ is the rate of change of the quasi-fixed inputs and t is an index of technology. Costs of adjustment are represented within this production function as $\partial Y(t)/\partial \dot{x}(t) < 0$,

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i.e., as output foregone due to inputs being devoted to changing the stock of quasi-fixed inputs. In the short-run firms minimize normalized variable costs $C = \Sigma_j^M P_j v_j$ conditional on P_j, Y, x_i and $\dot{x}_i$, where variable input prices have been normalized, i.e., $P_j = P_j / P_1$. The normalized restricted cost function (NRCF)

$$C = C(P, x, \dot{x}, Y, t) \tag{2}$$

under standard regularity conditions on F is increasing and concave in P, increasing and convex in $\dot{x}$, and decreasing and convex in x. Moreover, the partial derivative of the NRCF with respect to the normalized price of any variable input P_j equals the short-run cost-minimizing demand for v_j

$$\partial C / \partial P_j = v_j \qquad \text{for } j = 2, \ldots, M \tag{3}$$

while the partial derivative of C with respect to the quantity of any quasi-fixed input equals the negative of the normalized shadow service price of the quasi-fixed input

$$\partial C / \partial x_i = -u_i \qquad \text{for } i = 1, \ldots, N \tag{4}$$

where $u_i = q_i(r + \mu_i)$ and q_i is the normalized asset purchase price of the ith quasi-fixed factor, r is the rate of return and μ_i is the rate of depreciation.

The firm faces the long-run dynamic optimization problem of minimizing the present value of the stream of future costs, using the control variables $v(t)$ and $\dot{x}(t)$. This problem has been related to the flexible accelerator or partial adjustment models by Treadway [8] to obtain solutions for $\dot{x}$. Our model was specified in terms of labor (L), energy (E), materials (M), and one quasi-fixed input, capital (K). We further assumed that:

(i) prices were given to the firms and that static expectations prevailed about them,
(ii) continuous changes of capital $\dot{K}$ could be represented by discrete changes, $K_t - K_{t-1} = \Delta K$,
(iii) production in t was a function of the capital stock of the previous period, K_{t-1}.

Incorporating these assumptions and normalizing by the price of materials, P_M, we write a normalized restricted cost function in quadratic form:

$$\begin{aligned} C = P_L\, L + P_E\, E + M = {} & D_C + D_{Ct}\, t + D_E\, P_E + D_Y\, Y + D_{\dot{K}}\, \Delta K \\ & + D_K\, K_{t-1} + 1/2(D_{EE}\, P_E^2 + D_{LL}\, P_L^2) + D_{LE}\, P_L\, P_E + D_{LK}\, P_L\, K_{K-1} \\ & + D_{EK}\, P_E\, K_{t-1} + D_{LY}\, P_L\, Y + D_{EY}\, P_E\, Y + D_{L\dot{K}}\, P_L\, \Delta K + D_{E\dot{K}}\, P_E\, \Delta K \\ & + D_{Lt}\, P_L\, t + D_{Et}\, P_E\, t + D_{Kt}\, K_{t-1}\, t + D_{\dot{K}t}\, \Delta K\, t \\ & + D_{K\dot{K}}\, K_{t-1}\, \Delta K + D_{YK}\, Y\, K_{t-1} + D_{Y\dot{K}}\, Y\, \Delta K \\ & + 1/2(D_{YY}\, Y^2 + D_{KK}\, K_{t-1}^2 + D_{\dot{K}\dot{K}}(\Delta K)^2). \end{aligned} \tag{5}$$

The internal costs of adjustment within C are connected with the term ΔK and can be written as a sub-function $G(\Delta K)$. At a stationary point $\Delta K = 0$ implies $G(\Delta K) = 0$. Moreover, we assume that the marginal costs of adjustment are also zero at $\Delta K = 0$, i.e., $\lim_{\Delta K \to 0} G'(\Delta K) = 0$, which implies that:

$$\begin{aligned} \partial G / \partial \Delta K = \partial C / \partial \Delta K = {} & D_{\dot{K}} + D_{L\dot{K}}\, P_L + D_{E\dot{K}}\, P_E + D_{\dot{K}t}\, t + D_{K\dot{K}}\, K_{t-1} \\ & + D_{Y\dot{K}}\, Y + D_{\dot{K}\dot{K}}\, \Delta K = 0. \end{aligned} \tag{6}$$

This, in turn, implies the following restrictions:

$$D_{\dot{K}} = D_{L\dot{K}} + D_{E\dot{K}} + D_{\dot{K}t} + D_{K\dot{K}} = D_{Y\dot{K}} = 0. \tag{7}$$

Incorporating these restrictions into (5) we derive the short-run demands for variable factors by utilizing the property $\partial C/\partial P_j = v_j$

$$\partial C/\partial P_L = L = D_L + D_{Lt}\, t + D_{LL}\, P_L + D_{LE}\, P_E + D_{LY}\, Y + D_{LK}\, K_{t-1} \tag{8}$$

$$\partial C/\partial P_E = E = D_E + D_{Et}\, t + D_{LE}\, P_L + D_{EE}\, P_E + D_{EY}\, Y + D_{EK}\, K_{t-1} \tag{9}$$

$$\begin{aligned} M = C - P_L\, L - P_E\, E = D_C + D_{Ct}\, t + D_K\, K_{t-1} + D_Y\, Y \\ - 1/2(D_{LL}\, P_L^2 + 2\, D_{LE}\, P_L\, P_E + D_{EE}\, P_E^2) + D_{YK}\, YK_{t-1} + 1/2\, D_{YY}\, Y^2 \\ + 1/2\, D_{KK}\, K_{t-1}^2 + 1/2\, D_{\dot{K}\dot{K}}(\Delta K)^2 + D_{Kt}\, K_{t-1}\, t. \end{aligned} \tag{10}$$

The net capital investment equation becomes:

$$\begin{aligned} \Delta K_t = -1/2\, \{r - [\, r^2 + (4\, D_{KK}/D_{\dot{K}\dot{K}})]^{1/2}\} \\ \cdot [-(1/D_{KK}) \cdot (D_K + D_{LK}\, P_L + D_{EK}\, P_E + D_{YK}\, Y + D_{Kt}\, t + P_K) - K_{t-1}]. \end{aligned} \tag{11}$$

Our model to be estimated comprises four equations: short-run demand equation for L, E and M, and a net capital accumulation equation (11). The system is non-linear and simultaneous since ΔK_t is a right-hand variable in (10) and endogenous in (11). However, as indicated by Morrison and Berndt [7], the system is structurally recursive as ΔK_t in (11) depends only on exogenous variables and also enters only equation (10). The model was estimated as an input-output model (i.e., inputs were measured per unit of output) in order to avoid any distortion coming from different production levels across states which actually have the same production structure.

The dynamic model enables us to derive short- and long-run elasticities which describe the behavior of input demands over time. In our four-input econometric model, short-run elasticities are obtained when capital is fixed while long-run elasticities are derived when capital has adjusted to its long-run equilibrium value K^*.[1] Short-run own and cross-price elasticities for the variable inputs are calculated as:

$$E^{SR}_{v_i P_j} = (P_j/v_i) \cdot (\partial v_i/\partial P_j \,|\, _{K = K_{t-1}}) \qquad i = L,E,M;\; j = L,E,M,K. \tag{12}$$

The corresponding long-run elasticities are:

$$\begin{aligned} E^{LR}_{v_i P_j} = (P_j/v_i) \cdot [\partial v_i/\partial P_j \,|\, _{K = K_{t-1}} + (\partial v_i/\partial K^* \cdot \partial K^*/\partial P_j)] \\ i = L,E,M;\; j = L,E,M,K. \end{aligned} \tag{13}$$

The long-run own and cross price elasticities for capital can be derived as:

$$E^{LR}_{KP_j} = (P_j/K^*) \cdot (\partial K^*/\partial P_j) \qquad j = K,L,E,M. \tag{14}$$

Output elasticities may be calculated both for the short-run (SR) and the long-run (LR) as follows:

$$E^{SR}_{v_i Y} = (Y/v_i)\, (\partial v_i/\partial Y|\, _{K = K_{t-1}}) \qquad i = L,E,M, \tag{15}$$

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[1] The model also permits the estimation of intermediate-run elasticities. In the interests of space we have included only short- and long-run results. The full set of elasticities is available on request.

$$E^{LR}_{v_iY} = (Y/v_i)\,[\partial v_i/\partial Y|_{K=K_{t-1}} + (\partial v_i/\partial K^* \cdot \partial K^*/\partial Y)] \qquad i = L,E,M, \tag{16}$$

$$E^{LR}_{KY} = (Y/K^*)\,(\partial K^*/\partial Y). \tag{17}$$

The primary sources of our cross-sectional (state) time-series data were the Census of Manufacturers and the Annual Survey of Manufacturers. We developed input prices and quantities for each state-level two-digit manufacturing sector for each year 1971 through 1976.[2]

Labor quantity was quality adjusted according to schooling, age and sex. State-level energy prices were constructed using a translog price aggregator applied to the prices of different energy types. Capital service prices were developed with the standard formulas. The service price of capital varies across states due to differences in state property taxes and state corporate profits taxes, and to some extent to regional rates of return as reported by the Federal Reserve. Capital stocks were based on data for "book value of depreciable assets" for state two-digit sectors for 1976,[3] together with annual investment data taken from the Census and Annual Surveys. Gross stocks were converted to net stocks by using BLS data on net stocks for 1976. Output data, at the level of the average firm, were constructed from shipments adjusted for beginning and ending inventories of finished goods.

Identification of regions was the subject of an elaborate pretest, using a static translog cost function model to test for differences in a variety of different regional configurations. Criteria used, in addition to regions as defined by the Census Bureau, were age of capital stock, and relative input prices, with and without contiguity imposed [5]. Based on these criteria, seven regional tests were conducted; the number of regions under each test was four. A static translog cost function was assumed to represent the homothetic production function and sectoral models were estimated with the 1974–76 data first for each of the four regions and second for all observations together. A Chow test was conducted to determine if the regions defined under each one of the seven criteria could be pooled together. The Census designations gave the best results, and were used here. Because of degrees of freedom problems we had to work with only three regions: the Northeast region consists of New England, Middle Atlantic and East North Central census regions; the Southeast contains South Atlantic and East South Central regions; the West includes all other states.

As constituted, the Northeast (NE) produced 49 percent of total U.S. value added in manufacturing in 1972, the West (W) produced 35 percent and the Southeast (SE) produced the remaining 17 percent.

Because some state-sectors were not widely represented in certain regions we chose to include only 12 two-digit sectors in our final analysis. These were arrived at by determining the nine largest sectors in each region which, since these were not the same in each region, gave a total of 12 sectors. These twelve sectors accounted for 84 percent of total value added in the NE, 77 percent in the SE, and 65 percent in the West.

III. Results

The results we present here are part of the results of a larger empirical analysis in which we investigate the dynamic behavior of energy demand of each two-digit manufacturing sector

[2] A full discussion of the data is contained in [9, 133–37].

[3] Obtained on a special contract with the Bureau of the Census.

Table I. Number of Significant Estimated Coefficients and Degrees of Freedom, Regional Two-Digit Manufacturing, 1974–76[a]

Sector	Northeast		West		Southeast	
	Number of Significant Coefficients	Degrees of Freedom	Number of Significant Coefficients	Degrees of Freedom	Number of Significant Coefficients	Degrees of Freedom
Food (20)	11	22	6	45	13	19
Textiles (22)	9	16	—	—	15	12
Apparel (23)	8	13	13	15	9	14
Wood and Lumber (29)	9	17	10	16	11	13
Paper (26)	12	12	13	8	9	12
Printing and Publishing (27)	13	21	8	31	10	16
Chemicals (28)	13	16	12	25	13	10
Primary Metals (33)	10	13	12	13	14	13
Fabricated Metals (34)	6	15	12	27	14	16
Non-Electrical Machinery (35)	15	22	11	30	14	14
Electrical Machinery (36)	12	16	10	22	11	10
Transportation Equipment (37)	14	16	10	16	12	7

a. The total number of estimated parameters for each sector is 20.

both at the aggregate (national) and the regional level for the 1971–76 period [9; 10; 11]. In that investigation[4] we concluded that a structural change had occurred after the 1973 embargo so that aggregation of the pre- and post-embargo years together was not permissible. Thus, we estimated two different sets of models; one for the pre-embargo period and another for the post-embargo one.[5] In the rest of this section we present our leading results derived from our post-embargo regional analysis.[6] Our model was fit to data from each of our twelve two-digit sectors in each of the three regions, with no cross-section or cross-region restrictions on parameters. For the sake of space we do not report here parameter estimates but they are available on request. In Table I we present the number of statistically significant parameter estimates at the 95 percent level of significance for each sectoral model in each region.[7] We can conclude from the table that the overall performance of the model is fairly good as a great number of parameter estimates are statistically significant.

We present our leading results in graphic form, since this makes it easier to note

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[4] We conducted an F-test to examine the possibility of a structural change. The null hypothesis was that no structural change had occurred and, thus, aggregation of the pre- and post-embargo data would be appropriate. Our restricted model was the pooled (1971–76) model while our unrestricted ones were two separate models; one for the pre-embargo years and the other for the post-embargo years. All sectoral models were estimated at the aggregate (national) level. Using the non-central F critical values at a 95 percent level of significance we rejected the null hypothesis for fourteen out of the eighteen manufacturing sectors under investigation.

[5] The three-year data combined with cross-sectional observations does capture the dramatic increases in energy prices and also gives enough variability for the variables so that a long-run equilibrium can be described in a dynamic setting. Moreover, long-run elasticities still have a meaning since they are calculated when capital has fully adjusted to its optimal level K^* determined endogenously in our model. This adjustment does not have to happen within the 1974–76 period. Actually, the duration of adjustment depends on the coefficient of adjustment; the lower the coefficient the longer the period of adjustment. However, we should mention that the optimal technology, as captured by K^*, could change as more recent data are added to the 1974–76 period.

[6] For the pre-embargo results see [10].

[7] On average, 55.0 percent of the estimated coefficients (for the twelve sectors together) are significant in the Northeast, 48.8 percent in the West and 60.4 percent in the Southeast.

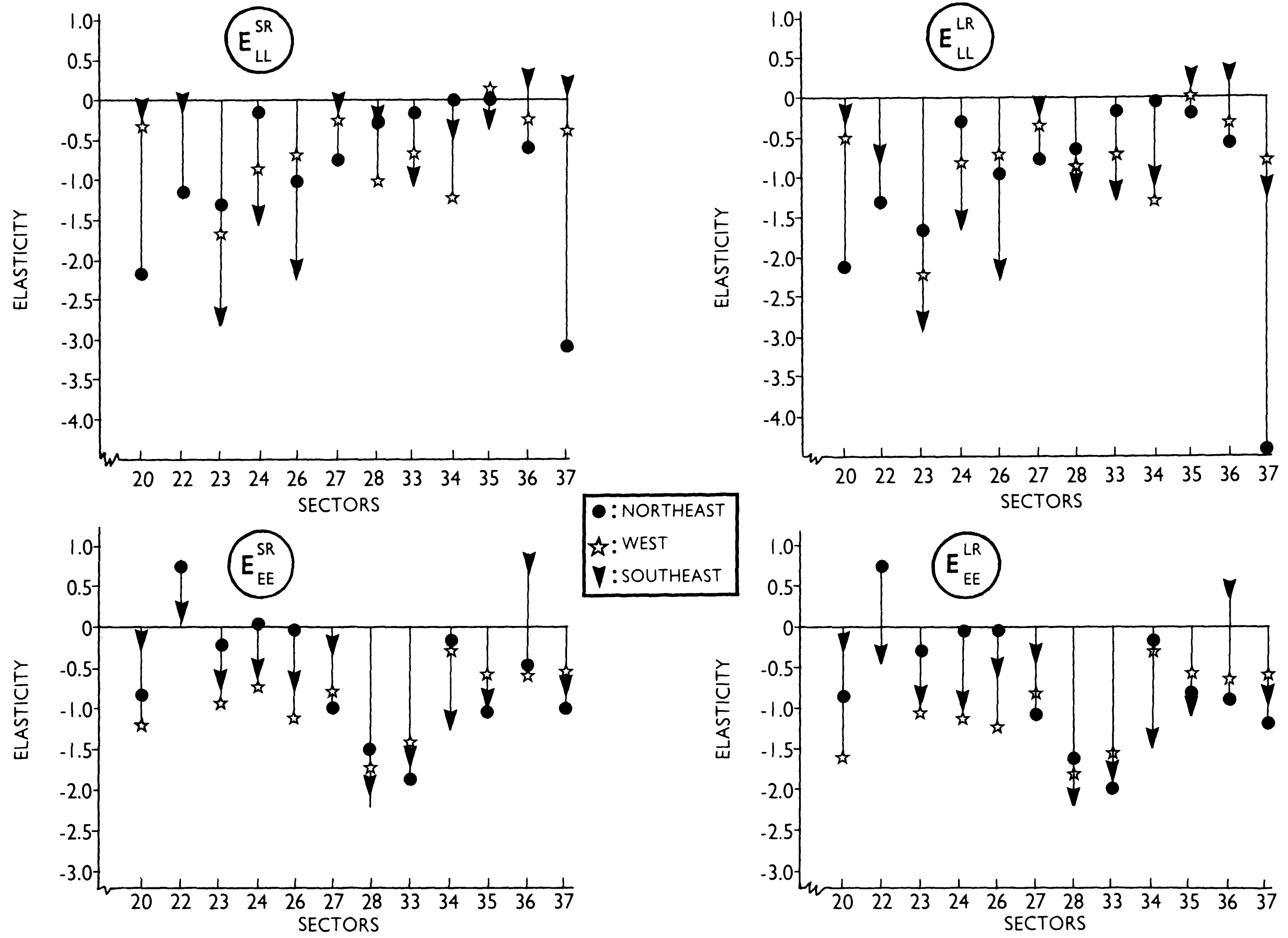

Figure 1. Short-Run (SR) and Long-Run (LR) Own Price Elasticities by Sector.

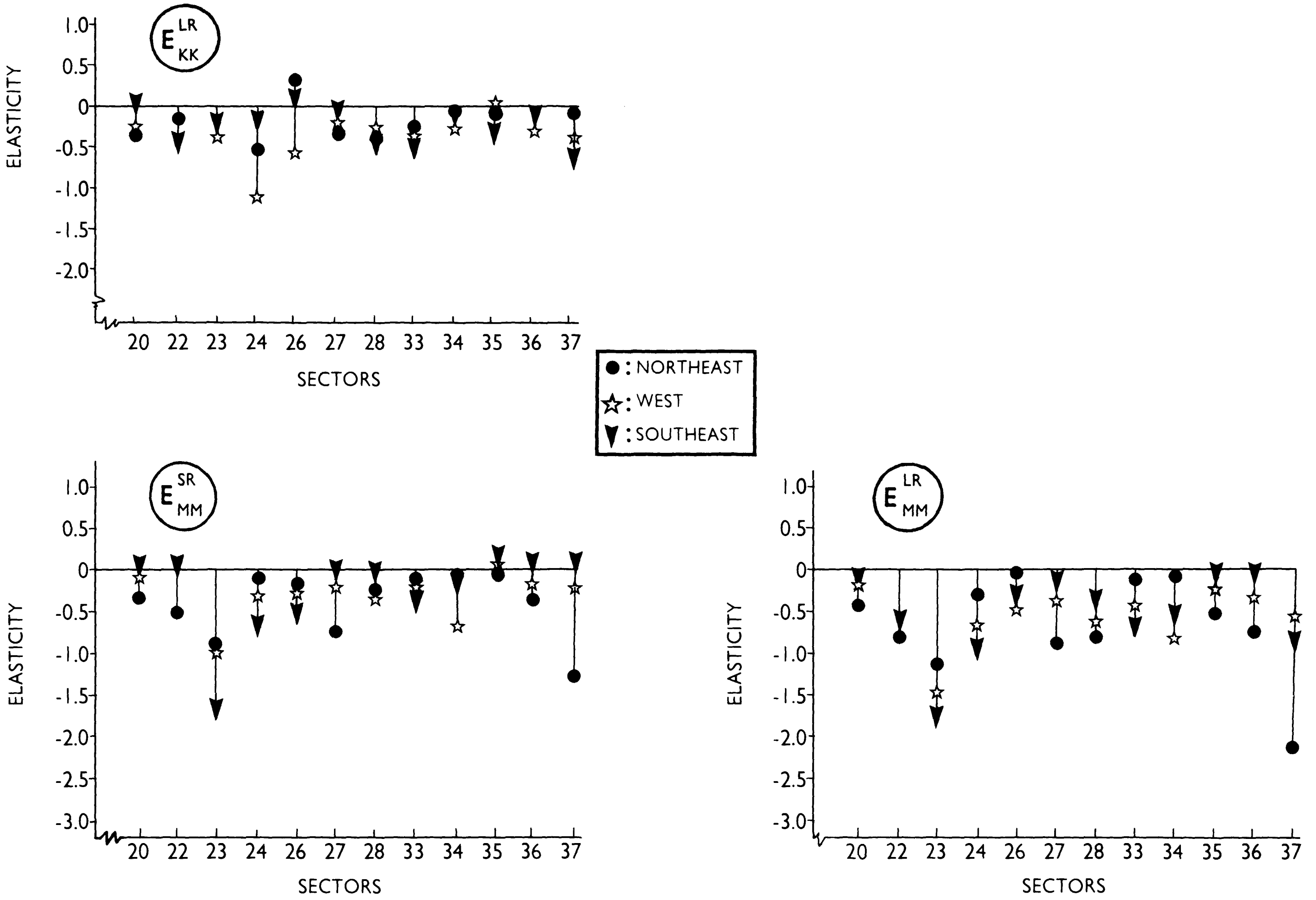

Figure 1. (*Continued*)

Table II. Own Elasticities for Energy by Sector and Region, Static and Dynamic Models

	Northeast			West			Southeast		
Sector	Static Pre-Embargo	Dynamic Pre-Embargo	Dynamic Post-Embargo	Static Pre-Embargo	Dynamic Pre-Embargo	Dynamic Post-Embargo	Static Pre-Embargo	Dynamic Pre-Embargo	Dynamic Post-Embargo
20	−0.82	−0.84	−0.95	−0.94	−1.21	−1.66	−0.27	−0.60	−0.19
22	—	0.14	0.79	—	—	—	—	0.24	−0.42
23	−0.47	—	−0.41	−0.30	—	−0.98	−0.92	−1.45	−0.62
24	−0.89	−0.17	−0.11	−1.01	−0.95	−0.92	−0.77	−0.72	−0.81
26	0.13	0.28	−0.09	−1.49	−2.11	−1.34	−0.36	−0.59	−0.48
27	−1.09	−1.04	−1.17	−0.35	−0.39	−0.88	−0.13	−0.19	−0.37
28	−2.29	−2.35	−1.63	−1.64	−1.91	−1.81	−2.78	−3.03	−2.10
33	−2.78	−2.49	−1.83	−2.39	−2.85	−1.63	−2.62	−2.18	−1.73
34	0.05	0.10	−0.24	−0.54	−0.86	−0.35	−0.61	−0.85	−1.17
35	−1.14	−1.32	−0.92	−0.83	−1.08	−0.60	−1.07	−0.83	−0.94
36	−0.68	1.15	−0.95	−0.76	−0.76	−0.70	1.13	1.15	0.64
37	−1.75	−1.38	−1.08	−0.55	−0.07	−0.67	−0.49	−0.96	−0.69

patterns than with tables of elasticities. Figure 1 shows the short- and long-run own price elasticities for the three variable inputs and the long-run elasticity for capital. As with most previous cross-section studies at the two-digit level [3; 4] we have a certain amount of noise in our estimates. For example, there are a small number of positive own elasticities. For the most part, however, these are close to zero, probably implying that the elasticities are essentially nil. The LeChatelier principle, that the long-run price elasticities are greater in absolute value than the corresponding short-run elasticities, holds for all inputs across regions with the exception of sector 20 in the Southeast and sector 6 in the Northeast and Southeast. These violations are connected with those cases for which a positive own elasticity for capital is indicated.

Own price elasticities for labor, both short- and long-run, are relatively inelastic, although sectors in the 20s (i.e., 20, 22, 23, etc.) show greater elasticity. This may indicate a difference between heavy and light manufacturing. There do not appear to be any regional patterns in these estimates; for six sectors (20, 22, 27, 35, 36, 37) demand is more elastic in the NE, while for five (23, 24, 26, 28, 33) it is most elastic in the SE. These regional rankings are the same in both short- and long-runs. We note also the relatively small difference in many cases between short-run and long-run elasticity estimates.

The demand for energy is also relatively inelastic for the most part. There are two sectoral outliers in this regard; in sectors 28 and 33 the elasticities are relatively elastic consistently across all three regions. Again, there seems to be little difference between short- and long-run estimates, and little change in regional patterns as between short- and long-run.

In Table II we provide a comparison of own price elasticities for energy estimated by a static model with pre-embargo (1971–73) data and reported in an earlier paper [6] and long-run own energy elasticities estimated by the dynamic model of this study with pre-embargo (1971–73) and post-embargo (1974–76) data. We can observe similarities between the static and dynamic pre-embargo elasticities. They are quite close in magnitude although in three sectors in the NE and seven sectors in the SE and West the dynamic elasticities are greater than the static ones. Comparing pre- and post-embargo elasticities we note that in a

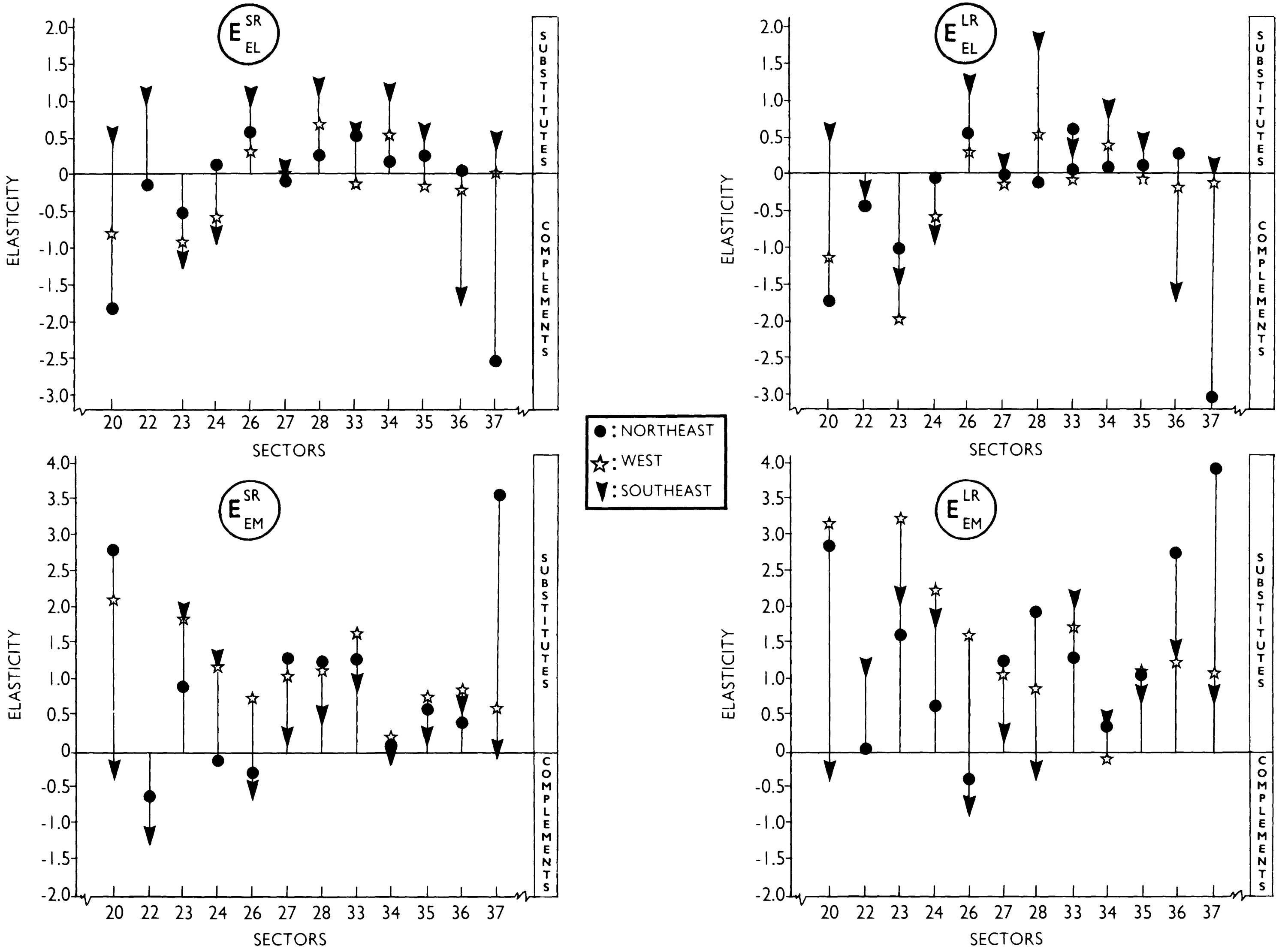

Figure 2. Short-Run (SR) and Long-Run (LR) Cross-Price Elasticities by Sector.

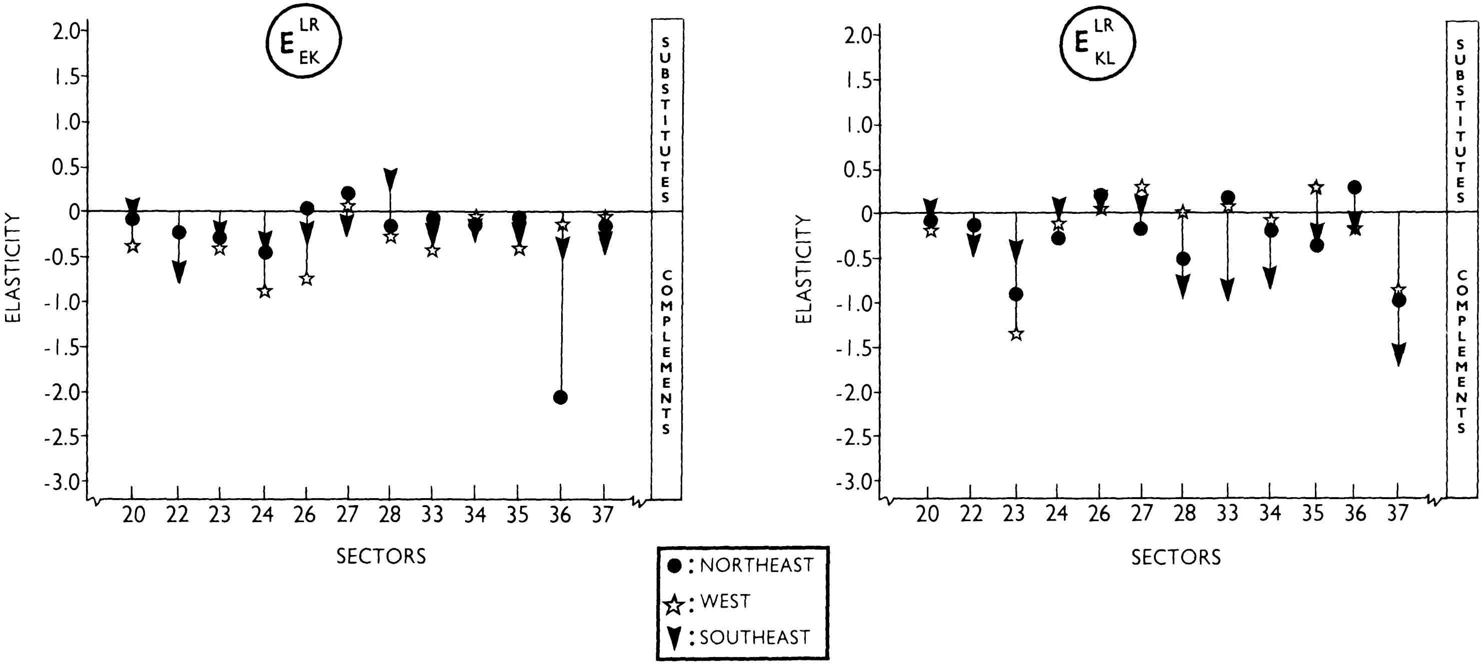

Figure 2. (*Continued*)

considerable number of sectors the post-embargo elasticities are smaller in absolute value than the pre-embargo ones.

Short-run demand for materials input is very inelastic; materials is more elastic in the long-run, but in only two sectors (23 and 37) are the coefficients greater than unity in absolute terms.

With respect to capital, own price elasticities across regions cluster together in the range between zero and -0.5, indicating a very inelastic demand for capital. Although there are no consistent regional patterns across all sectors for any of the inputs, it does seem to be generally true that the regional rankings of elasticities in each sector are similar across inputs. That is, in a given sector, if the NE has the most elastic demand for labor compared to the other regions, this pattern also tends to hold for the energy and materials inputs.

Some of the important cross-price elasticities are presented in Figure 2. Primary concern centers on the cross elasticities of energy with the other inputs. With respect to the relationship of energy and labor the overall picture is that they are substitutes for the most part. The main exceptions are sectors 23 and 24. Looking at sectors across regions, we find that for nine sectors in the short-run the SE experiences the greater *E-L* substitutability, in the sense of higher positive elasticities or lower—in absolute value—negative elasticities, than the other regions. This holds true for eight of the twelve sectors in the long-run. Thus, we may discern a regional pattern of higher *E-L* substitutability in the SE.

Regarding the energy-materials relationship we note that energy and materials are predominantly substitutes across regions. There is, moreover, a greater spreading out of elasticities at the sectoral level across regions as we move from the short-run to long-run and a few switches from complementarity to substitutability or vice versa. Energy and materials are less substitutable in the SE than elsewhere.

Our energy-capital elasticities in the different regions show a complementary relationship. However, many sectoral *E- K* elasticities are very close to zero, indicating a weak complementarity pattern.

Finally, with respect to regional capital-labor elasticities we notice that *K* and *L* are in most sectors complements; however, a great number of these elasticities are close to zero. The NE shows nine sectors, the SE eight, and the West six, in which *K-L* complementarity occurs.

In order to provide an approximation of the energy substitutability patterns in regional manufacturing we constructed aggregate regional elasticities for energy as weighted averages of the separate sector elasticities where the weights are the proportions of the energy demanded by that sector in the total twelve sectors' energy consumption in each region. Since these twelve sectors account for a high share of the total energy consumed by manufacturing in each region, they are reasonable approximations to the regional elasticities for total manufacturing. In Table III we present both post- and pre-embargo aggregate regional elasticities for energy for comparison.

We note from the table that post-embargo own price elasticities for energy are quite close in size for all the three regions although the demand for energy in the SE is less elastic. The same pattern is observed for the pre-embargo years, as well. Comparing pre- and post-embargo elasticities for each region we find that the demand for energy has become more inelastic post-embargo.

With respect to energy-labor elasticities, we find that energy and labor are substitutes in the SE and complements in the NE both for the post- and pre-embargo periods. In the

Table III. Pre- and Post-Embargo Long-Run Energy Elasticities for Regional Manufacturing

	E_{EE}		E_{EL}		E_{EK}		E_{EM}	
Region	Pre-Embargo	Post-Embargo	Pre-Embargo	Post-Embargo	Pre-Embargo	Post-Embargo	Pre-Embargo	Post-Embargo
Northeast	−1.47	−1.34	−0.54	−0.18	−0.28	−0.22	2.32	1.66
West	−1.51	−1.36	−0.37	0.07	0.01	−0.34	2.13	1.62
Southeast	−1.35	−1.20	1.62	0.78	0.06	−0.01	−0.66	0.10

West the energy-labor elasticity post-embargo is positive but close to zero indicating a very weak pattern of substitutability while pre-embargo is negative but still small in magnitude showing a weak pattern of complementarity. We also note that the differences in the energy-labor substitutability patterns between regions have become smaller post-embargo than pre-embargo.

Regarding the energy-capital elasticities we note that energy and capital are complements in all three regions post-embargo but this pattern is weak as the elasticities are small in absolute value. Pre-embargo energy and capital are weak complements only in the NE while in the other two regions the elasticities are positive but quite close to zero. Comparing pre- and post-embargo elasticities we note that only the West shows a clear change into E-K complementarity.

With respect to the energy-materials relationship we find that energy and materials are substitutes in all regions but less substitutable in the SE. This pattern holds true both for the post- and pre-embargo periods. While substitutability has decreased in the NE and West, in the SE a shift occurred from complementarity to substitutability.

Figure 3 shows the long-run output elasticities for the four inputs, by sector and region. Unitary output elasticities signify constant returns to a particular factor, while elasticities greater (less) than one indicate decreasing (increasing) returns.

Output elasticities for labor cluster together for a great number of sectors and show generally constant or increasing returns to this input. In the Northeast we find a significant number of sectors with essentially constant returns to labor.

Energy-output elasticities are quite spread out across regions and sectors. The Northeast experiences decreasing returns to energy clearly in four sectors, constant returns in another four, while in the remaining sectors experience decreasing returns to energy. In the West seven sectors show clearly decreasing returns to energy while in the Southeast only three sectors show decreasing returns to energy and another four constant returns.

Capital-output elasticities show clearly decreasing returns in five sectors in the Northeast and in three sectors in the West and Southeast. The majority of sectors in each region seem to experience weak increasing returns to capital. We cannot discern any clear interregional pattern. For materials decreasing returns seem to predominate, with no regional patterns.

In Table IV we present the regional adjustment coefficients. These coefficients indicate the percentage of adjustment to long-run equilibrium that takes place within the first year. The first thing to note is that these adjustment coefficients are very small (with the exception of sector 27—Northeast). In a number of sectors, 24 and 34 in the Northeast, sectors 24, 28 and 34 in the West, and sector 23 in the Southeast, the coefficients indicate unstable adjust-

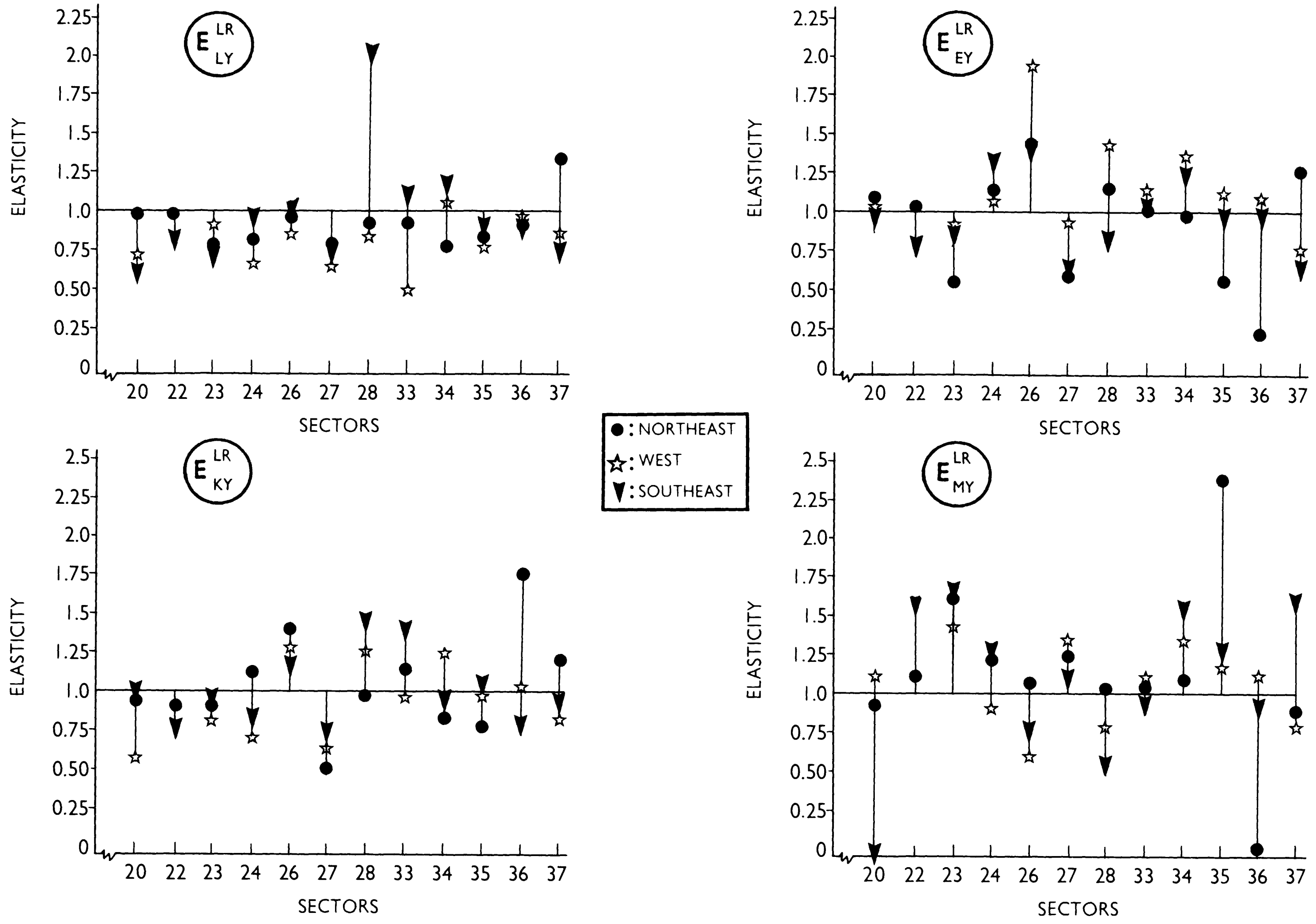

Figure 3. Short-Run (SR) and Long-Run (LR) Output Elasticities by Sector.

Table IV. Regional Adjustment Coefficients[a]

Region	20	22	23	24	26	27	28	33	34	35	36	37
Northeast	.092	.098	.122		(.380)	.602	.114	.098		.082	.067	.109
West	.147		.115		.161	.159				.171	.089	.111
Southeast	(.152)	.363		.1386	(.127)	.184	.152	.111	.153	.126	.114	.293

a. Blanks signify negative adjustment coefficients, parentheses signify positive adjustment coefficients due both to a positively sloped demand for capital and decreasing marginal cost of adjustment.

ment process, due to decreasing marginal costs of adjustment. Moreover, sector 20 in the Northeast and sector 26 in the Northeast and Southeast become unstable in their adjustment due to a positively sloped demand for capital and to decreasing marginal costs of adjustment. These unstable adjustment coefficients make it difficult to compare regions. In seven sectors we can compare NE and SE, and in all but one of these the adjustment coefficient is smaller in the former. This would support a conclusion that firms adjust faster in the SE than in the NE. Other regional comparisons do not lead to definite conclusions one way or the other.

IV. Conclusions

Our results do not indicate strong differences among regions in terms of input demand elasticities and output elasticities. The demand for energy for whole regions is relatively elastic although for each regional sector it is mostly inelastic. For energy and labor we have identified a substitutability pattern in the Southeast different from that of the other two regions. We have weak evidence that input adjustment speeds are slower in the Northeast than in the Southeast. However, there do seem to be some clear sectoral differences; more elastic demand for labor in sectors 23 and 26; more elastic demand for energy in sectors 28 and 33; and so on. But these sectoral differences persist across regions for the most part.

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