Energy Prices, Factor Reallocation, and Regional Growth

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ENERGY PRICES, FACTOR REALLOCATION, AND REGIONAL GROWTH

by

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EXECUTIVE SUMMARY

There has been recent discussion of the role of energy prices in regional economic growth. In particular, the governors of northeastern states have cited the disparity in energy costs as contributing to the adverse economic condition in the Northeast.

This paper develops an economic methodology to explain how energy prices could affect profits and wages in a state. The changes in profits and wages affect the growth of capital and employment, which in turn affect the growth of output. This model is tested on states of the U.S. over the 1963 to 1972 period. The tests support the hypothesis that energy prices do affect regional growth.

In order to ascertain the importance of energy prices as a determinate of regional growth rates, simulations are run on the model under a hypothetical scenario which assumes that energy price differentials among states are eliminated. This simulation shows that the economic growth of states would be increased substantially where energy prices are high, and _vice versa_. Tables are presented to show for each state the annual growth of capital, labor, and manufacturing output with the energy

prices as actually existed. Changes in these growth rates due to hypothetical changes in energy prices, are also shown.

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The wide diversity in rates of economic growth among the states may have been reinforced by recent events concerning oil supplies and oil prices. In particular, the states in the Northeastern region of the U.S., which exhibit relatively low rates of growth and high unemployment rates, also suffer relatively high prices for energy sources. It has been claimed that high energy prices exacerbate lagging economic growth. For example, in 1976, the Coalition of Northeastern Governors cited the disparity in energy costs as contributing to the adverse economic condition in the Northeast. Among the items mentioned in a regional energy plan is a goal of seeking parity in energy prices across the country.[1]

This paper tests the economic hypotheses implicit in the recommendations of the Northeastern Governors. A general model is developed here to explain how relatively high energy prices may reduce wages and the return on

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[1] This information is contained in "Recommendations of the Energy Policy Panel to the Coalition of Northeastern Governors," Saratoga Conference, New York, November 13-14, 1976. Participating Governors were from N.Y., Conn., N.J., Pa., Vt., RI., and Mass.

capital, which in turn reduce the growth rates of capital stock, employment, and output in the manufacturing sector. This model is tested on the 1963 to 1972 growth experience of states in the U.S.

The importance of energy prices to the growth of manufacturing output is determined by analyzing the impact of a hypothetical energy policy which eliminates energy price differentials among the states. The simulations with the model show that relatively high energy prices are highly correlated with lagging economic growth.

Despite the large and important changes in the world energy markets in recent years, there have been few previous studies that address the issue of the effects of relative energy prices on regional growth. Using an input-output analysis Miernyk (1975, 1976) has discussed the relationship between higher energy prices and the regional growth in income and employment due to the expansion of energy-producing industries. In addition, one study of industrial location has concluded that lower energy prices have contributed to the relatively faster expansion of the manufacturing sector observed in some states.[2] However,

[2] Huntington and Kahn (1976) controlled for several other "sunbelt" attractions (e.g., taxes and land costs) to show that energy prices have been important in the growth of a state's industrial sector.

there have been no attempts to analyze this issue within the context of a growth model. Such an analytical framewo: can reveal the process by which energy prices affect regional growth, i.e., by affecting the growth of either capital or labor, or both.

Recent empirical tests using regional data for the United States have supported the use of the neoclassical growth model.[3] Regional factor price differentials have determined the regional growth rate through their effects on the growth of capital and labor. In this paper, regional energy prices are incorporated into the model as a variable that affects the expected factor returns, and hence, the growth rate of capital and labor as well as regional output. The present model allows both intersectoral (within states) and interstate factor movements.

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[3] Although Borts and Stein (1964, Chapter 3) found little evidence that factor movements were sensitive to factor price differentials, Smith's (1974, 1975) tests of the neoclassical growth model have yielded consistent results. In the first paper, factor reallocation between two sectors within a state was allowed to coexist with interstate movements. The second paper concentrated on regional factor shifts, assuming only one sector in a state. Ghali et.al. (1976) have expanded this basic approach to incorporate the response of factors to expectations as well as to regional differences in factor returns.

1. THEORY

In this section a neoclassifcal growth model is developed to explain the growth of output in one sector of a region as a function of the growth of capital and labor. These inputs grow according to the factor payments in the sector relative to the payments which the respective facto might receive in other sectors and/or in other regions. Payments to labor and capital are made after the regional energy costs are subtracted from the value of manufacturin output. In this manner, regional energy prices affect factor returns and, hence, the interregional flow of capit and labor.

Production is described by (1), where Q is output, K is capital stock, L is employment, E is energy input, M are other material inputs, and ρ is the rate of technical progress,

$$Q = \min\ [K^{\alpha}L^{(1-\alpha)}e^{\rho t};\ \gamma E;\ \gamma_1 M]. \quad (1)$$

This equation combines a Cobb-Douglas production function and fixed proportions inputs.[4] It is assumed that energy

[4] Although restrictive, this production function is theoretically consistent with the practice of using data on value added to estimate production function relationships. As is discussed later, value added excludes payment for energy and materials and, therefore, cannot be substituted for output without assuming that energy and materials are both nonbinding and used in fixed proportion to output.

and other material inputs are required for output in a minimum amount which is a constant proportion (γ) and (γ_1) of output, Furthermore, it is assumed that the regional (state) supply of energy is infinitely elastic at an exogenous price, P_e, which is particular to the region. The supply of other material inputs are available in any quantity at P_m. Hence, the limiting constraints on output are the local endowments of capital and labor. Thus, the growth of output may be described by,

$$Q_i^* = \alpha K_i^* + (1-\alpha)L_i^* + \rho, \qquad (2)$$

where i refers to sector i's production in any state, and an asterisk indicates a percentage rate of growth.

Both capital and labor are fully employed, because the demand for output is infinitely elastic in the neoclassical growth model. Therefore, following Smith (1974), the change in employment equals that in labor force supply, which is the participation rate multiplied by the sum of natural increase and net migration. The proportional growth rate of labor force (or employment) is

$$L_i^* = n + v_1(W_i - W_{ia}) + v_2(W_i - W_j), \qquad (3)$$

where n represents the exogenous rate of natural increase, W_i the regional wage in sector i, W_{ia} the national average wage in sector i for all regions, and W_j the regional wage in sectors other than i. The first migration term represents the net interstate response to the wage differential within sector i across regions, where the costs of greater distances have been ignored. The parameter v_1 is positive, since prospective migrants move in response to relatively higher wages. The second term indicates the intrastate shift of labor between sectors, which is assumed to be responsive to the intersectoral wage differential. The parameter v_2 is also positive.

Investment in each sector will differ from savings by intersectoral capital flows. Transaction costs are ignored and a constant proportion of each sector's output is saved. Under these conditions, investment in one sector of a state is dependent upon the return differential between sectors of a region, and the return differential between states for sector i. The growth of capital stock is,

$$K_i^* = u_1(R_i - R_{ia}) + u_2(R_i - R_j), \qquad (4)$$

$$u_1 > 0 \quad , \quad u_2 > 0.$$

R_j is the payment per unit of capital in sector j, R_i is the payment in sector i, and R_{ia} is the national average payment in sector i.

The assumptions regarding factor payments are presente mathematically in order to show how data on value added is used to test the model. Use of data on value added allows a theoretically consistent approach to the problem of payments for energy inputs, as they affect payments to capital and labor. Output of the homogeneous manufactured good, Q, is normalized so that one unit sells for $1 anywhere in the U.S. However, the value added per unit of output (P_y) is l than the selling price by the amount that must be paid per unit of output for energy and materials. Since the output in one sector of a region may be produced with material inputs which are produced in another sector or region, data on value added is traditionally used to measure the output produced by capital and labor. In this study, value added measures the sum of the payments to capital and labor. Denoting the respective marginal revenue products of labor and capital as W_i and R_i, value added, P_yQ, can be expressed as,

$$P_y Q_i = W_i L_i + R_i K_i,$$
$$= Q_i - P_{ei} E_i - P_m M_i,$$
$$= Q_i (1-(1/\gamma) P_{ei} - (1/\gamma_1) P_m). \qquad (5)$$

With national prices for final output and for materials, P, a higher regional price for energy will leave a smaller amount to pay for capital and labor. Hence, in high energy price states, the wage and the return to capital will be lower, ceteris paribus. From (5), value added per unit of output, P_y, equals $(1-(1/\gamma)P_{ei} - (1/\gamma_1)P_m)$.

For each state the growth rate of value added ,Y*, equals the growth rate of output. Since $Y = Q(P_y)$ and P_y is constant for the period of analysis for each state, $Y^* = Q^*$. Hence, Y* may be substituted for Q* in equation (2).

A discussion of several key assumptions is needed at this point, particularly with respect to prices. Manufacturing output in the U.S. is composed of many products, some of which sell in regional markets due to large transportation costs in relation to their market price. Many other products sell in national markets. By aggregating products sold regionally with products sold nationally the assumption that the price of manufacturing output is exogenous and the same for all regions is approximately correct. The prices of intermediate goods and raw materials will be regionally variable, when transportation costs are significant in relation to price. The assumption of a constant national price for material inputs except energy is a reasonable approximation, since a large proportion of such inputs comes from the output in other states which is sold at a national price.

Energy inputs are products having high transportation costs in relation to their price. Raw material energy products (oil, natural gas, and coal) are available in only several states. The price of energy, therefore, equals a base supply cost (or opportunity cost) at the source plus transportation costs. The regional variation in energy price is due to variable shipping costs which depend on location.

Equation (5) embodies an assumption that labor and/or the owners of capital are unable to increase their factor payments by reducing the payments to energy. Owners of energy would not sell in any state below the mine-mouth or well-head price plus transportation costs. Labor and owner of capital can only increase their returns by migrating to a state with lower energy prices, *ceteris paribus*.

From (1), Q_i in (5) may be expressed as the sum of marginal physical products multiplied by respective quantities of capital and labor,

$$P_yQ_i = Y_i = P_yw_iL_i + P_yr_iK_i, \tag{6}$$

where w is the marginal product of labor and r is the marginal product of capital. The wage, W, is thus wP_y and the return per unit of capital, R_i, is thus rP_y. In effect the marginal physical product of capital and labor is multiplied by the price per unit of value added, P_y, to obtain the marginal revenue product which equals the respective factor payment.

The variable P_{ei} can be separated into two components: the national average energy price level, P_{ea}, and the difference between a region's energy price and the national average, or $\Delta P_{ei} = P_{ei} - P_{ea}$. Thus, the wage and payment per unit of capital can be expressed as,

$$\begin{aligned} W_i &= w_i(\beta-\Delta P_{ei}/\gamma), \\ R_i &= r_i(\beta-\Delta P_{ei}/\gamma), \end{aligned} \tag{7}$$

where $\beta = [1-P_{ea}/\gamma - P_m/\gamma_1]$.

In equation (7) it is seen that the returns to both capital and labor are negatively related to the regional energy price differential. Thus, in this model, high ener prices will tend to discourage the growth of both factor inputs.

It is interesting to note that energy prices promote movements to capital and labor to regions having lower energy prices. Thus capital and labor movements can be in the same direction (i.e., be positive simultaneously in on region). Previous models of regional growth such as Smith (1974) showed that capital and labor would move in opposit directions since high wage levels, which attract labor, implied a low return on capital, which repelled capital. The long run implication of previous work was that low income regions would experience relatively fast rates of growth. Thus regional incomes per worker would tend towar equality.

The present model has different implications for regional growth in the long run. Both capital and labor will be allocated in increasing amounts in those regions having low energy prices. If the origins of energy products were maintained in the same states over the long run, this model would predict that all capital and labor would be reallocated to these states. It is recognized that this assumption is unrealistic over the very long run because the most accessible fuel deposits will be exhausted and new technology will allow energy production in new locations. Over the period of several decades, however, the location of productive fuel deposits is relatively constant Hence, the implications of this model are reasonable.

For testing purposes, the variables W_i and R_i in (7) a changed to functions of value added per worker, y_i. From (6) and (1), $QP_y = Y = K^{\alpha}L^{1-\alpha}e^{\rho t}P_y$. Since Y/P_y equals $K^{\alpha}L^{1-\alpha}e^{\rho t}$, the marginal physical product of labor, w, equals $(1-\alpha)y/P_y$. Hence, with $z = y/P_y$, (7) can be represented as,

$$W_i = \beta(1-\alpha)z_i - ((1-\alpha)/\gamma)\Delta P_{ei}z_i. \tag{8}$$

Similarly, since $r = \alpha e^{(\rho/\alpha)t}(y/P_y)^{-\phi}$ where $\phi = (1-\alpha)/\alpha$,

$$R = \beta\alpha e^{(\rho/\alpha)t} z^{-\phi} - (\alpha e^{(\rho/\alpha)t}/\gamma)\Delta P_{ei}z^{-\phi} \tag{9}$$

When (8) and (9) are substituted into (3) and (4) respectively,

$$L_i^* = [n-v_iw_{ia}] + (v_1+v_2)(1-\alpha)\beta z_i - v_2w_j - (v_1+v_2)(1-\alpha)/\gamma)z_i\Delta P_e, \tag{10}$$

$$K_i^* = -u_1R_{ia} + (u_1+u_2)\beta\alpha e^{(\rho/\alpha)t}z_i^{-\phi} - (u_1+u_2)(\alpha e^{(\rho/\alpha)t}/\gamma)z_i^{-\phi}\Delta P_{ei} - u_2\ (1-\alpha)^{\phi}e^{(\rho/\alpha)t}\alpha W_j^{-\phi} \tag{11}$$

In (11) it is assumed that the factor payments in sector "j" equal their respective marginal products, so that a negative function of the wage may be substituted for the return on capital.

The basic structural model which will be tested is composed of equations (2), (10), and (11). In order to put (11) into linear, testable form, the parameter ϕ is assumed to be 2.03. In order to estimate the growth of capital we must make an a priori estimate of α. Based on previous studies we assume $\alpha = .33$ (See Appendix). With $\alpha = .33$, ϕ equals 2.03.[5] In addition, the estimate of the variable z requires a priori information about both β and $(1/\gamma)$. Based on data from the Census of Manufacturers for 1963, β is set equal to .456 and $(1/\gamma)$ to .00704 (See Appendix). These prior restrictions on the parameters α, ϕ, β, and $(1/\gamma)$ are incorporated into the regression analysis by forming composite variables. The regression equations that are used to test the growth model developed above are:

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5 The results of the model are not sensitive to small changes in α. A linear approximation to (11) also yields similar results.

$$L_i^* = a_1 + a_2X_1 + a_3X_2 + a_4X_3 + \mu_1$$

$$K_i^* = a_5 + a_6X_4 + a_7X_5 + a_8X_6 + \mu_2$$

$$Y_i^* = a_9 + a_{10}L_i^* + a_{11}K_i^* + \mu_3 \qquad (12)$$

where $X_1 = (1-\alpha)\beta z_i$

$X_2 = (1-\alpha) z_i \Delta P_{ei}$

$X_3 = W_j$

$X_4 = \alpha\beta z_i^{-\phi}$

$X_5 = (\alpha/\gamma) z_i^{-\phi} \Delta P_{ei}$

$X_6 = (1-\alpha)^{\phi}\alpha W_j^{-\phi}$

$a_1 = n - v_1 W_{ie} \lesseqgtr 0$

$a_2 = v_1 + v_2 > 0$

$a_3 = -(v_1 + v_2) < 0$

$a_4 = -v_2 < 0$

$a_5 = -\mu_1 R_{ia} < 0$

$a_6 = (\mu_1 + \mu_2) e^{(\rho/\alpha)t} > 0$

$a_7 = -(\mu_1 + \mu_2) e^{(\rho/\alpha)t} < 0$

$a_8 = -\mu_2 e^{(\rho/\alpha)t} < 0$

$a_9 = \rho > 0$

$a_{10} = (1-\alpha) > 0$

$a_{11} = \alpha > 0$

and μ_1, μ_2, and μ_3 are normally and independently distributed error terms within each equation. However, the disturbance term of the capital equation could be related to that of the labor equation, because exogenous and unexplained influences on the movement of one factor to a state could affect the movement of the other factor to a state.

2. EMPIRICAL RESULTS

The model is tested on data from the 1963-72 period for the 48 contiguous states of the United States. Sources and manipulation of data may be found in the Appendix. Each state is divided into a manufacturing sector, i, and a combined agricultural and services sector, j. Energy prices are expressed as dollars per thousand kilowatt-hour equivalents for all electricity and fuels purchased. This information on energy costs is not available by state prior to 1971 and excludes energy consumption that is not purchased, e.g., fuels that are supplied internally by the consuming firm itself. The use of relative state energy prices based on the differences prevailing in 1971 rather than 1963 appears to be an acceptable specification because relative state energy prices changed little during the 1963-71 period.

Differences in factor returns affect the growth of capital and labor, which jointly determine the growth of value added in manufacturing. The model is recursive rather than simultaneous because the influence of the growth rates of capital and labor on output is one way. However, the error terms of the capital and labor equations are not assumed to be independent of each other. Use of three-stage estimation allows correlation among residuals across equations to be taken into account.[6]

In the first two rows of Table 1, the coefficients of the capital and labor equations are presented. The coefficients of energy terms (X_2 and X_5) are each significantly different from zero and negative as hypothesized. This implies that high energy prices deter the growth of capital and labor by reducing the wage and return to capital as indicated by equation (7).

In the growth of capital equation the coefficient of X_4, the value-added-per-worker term, is positive as expectec and indicates that capital is moved between states toward a higher return. The nonsignificant coefficient of X_6 may indicate that intrastate capital movements are not responsive to return differentials.

In the growth of labor equation, the coefficient of X_3 is significantly negative. This indicates that labor moves within a state between manufacturing and nonmanufacturing

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[6] See Johnston (1972) pp. 238-241; 395-400. The correlation coefficient between the residuals of the capita: and labor equations is .49. That between the capital and the output equation is -.13; and between the labor and output equation is -.11. Based on a t test there is a statist cally significant relation between the residuals of the capital and labor equations.

Table 1: Structural Coefficient Estimates[a/]

Endogenous Variables			Exogenous Variables							
Y_i*	L_i*	K_i*	X_1	X_2	X_3	X_4	X_5	X_6	1	R^2
--	--	-1				418.5	-8051	2.06	.080	.367
						(3.88)	(-2.44)	(.385)	2.29	
--	-1	--	.00082	-.00081	-.0168	--	--	--	.092	.217
			(.307)	(-2.86)	(-2.64)				(3.80)	
-1	1.22	.296	--	--	--	--	--	--	-.001	.984
	(18.6)	(14.97)							(-.38)	

a/ t - statistics in parentheses.

in response to the relative wages in the two sectors. The nonsignificant coefficient of X_1 may imply that the relati wages themselves are not an important factor in inter-regional migration. This tends to support an alternative hypothesis, that labor moves between regions both in searc of higher wages and of expanding employment opportunities. Expanding employment opportunities will result from new investment, which is in low wage areas. Thus, labor may move to high wage states in search of higher income, and t low wage states, where the probability of finding employme is higher.

For each of the factor growth equations in (12), the terms associated with z and $z(\Delta P_e)$ are expected to have equivalent coefficients. An F-test is used to compare the sum of the squared residuals for the estimated equation with that for an equation where the coefficients of z and $z(\Delta P_e)$ are restricted to equivalency. The coefficients a_2 and a_3 in the labor equation are not significantly differe from each other at the 95 percent level; while a_6 and a_7 i the capital equation are. These tests are not central to explaining the relationship between energy prices and regional growth. Hence, they are not found serious enough to reject the basic structural model.

In the growth of value added equation, the coefficients of both labor and capital are significantly positive as expected. Thus, the hypothesis that higher energy prices reduce the growth of value added in a state's manufacturing sector by deterring capital and labor is found to be consistent with the system of equations estimated here.

The coefficient of L* in the Y* equation is larger than is expected but is not surprising in light of the measurement problems for capital and labor. Due to data problems the measurement of capital growth is indirect (using data on the value of output, wage payments, and productivity of labor). Unknown errors in the measurement of capital may also introduce biases in the estimate of the coefficient of L*. Other problems could exist with the data on the growth of employment, especially due to possible variations in the quality of the labor force, or the intensity of its use.

3. SIMULATIONS

This section presents a simulation of the impact of reducing state energy price differentials. Each state's energy price is set equal to the average of state prices for the period.

Using the coefficient estimates presented in Table 1, the actual value of the exogenous variables are used to form fitted values of the growth of capital, FK*, and of labor FL*. Using the estimated coefficients for the growth of value-added equation (row 3 of Table 1) and FK* and FL*, the fitted values for the growth of value-added, FY*, are calculated.

The above procedure is repeated as a simulation with an assumption that the price of energy is $2.15 per thousand kilowatt-hour equivalents in every state. SK* and SL* are calculated using the same parameters and exogenous variables used above, except that the ΔP_e equals zero in the factor growth equations. The simulated variables SK* and SL* are then used with the relevant parameters of Table 1 to calculate SY*.

To obtain the impact on growth of the change in energy prices, the difference in the growth rate of capital, labor, and value added is obtained: DK* = SK* - FK*; DL* = SL* - FL*; DY* = SY* - FY*. Table 2 presents the state energy price in 1971, the actual annual growth rates of capital and labor, and the change in growth rates resulting from the simulation.

Rhode Island, a state with a relatively high energy price, demonstrates a 20.8 percent growth rate of capital. When the energy price is reduced from $3.12 to the average price of $2.15, the growth of capital would be increased by 4.6 percentage points to 25.4 percent. The growth of labor would be increased 1.0 percentage points from a base growth rate of 0.5 percent. Texas, a state with a relatively low energy price ($1.02) would experience a 2.2 point decline in the growth of capital on a base rate of 15.2, when the energy price is raised to the national average. Based on the same policy, the growth of employment would be reduced 1.9 points from a base rate of 4.8 percent.

Table 3 presents the actual growth rates of output, and the predicted change in the growth of output resulting from changes in the growth of capital and labor as presented in Table 2. As a result of the reduction of

Changes in Annual Growth Due to Energy Price Equalization [From 12/15/76]

	P_e	K*	DK*	L*	DL*
Maine	$2.16	19.3	0.	0.1	0.
New Hampshire	2.93	27.3	4.6	0.6	0.7
Vermont	3.52	17.4	5.2	1.0	1.5
Massachusetts	3.43	20.5	4.7	-0.9	1.4
Rhode Island	3.12	20.8	4.6	0.5	1.0
Connecticut	3.38	11.3	3.6	-0.5	1.6
New York	3.17	15.9	3.1	-1.0	1.3
New Jersey	2.98	14.0	1.9	0.1	1.2
Pennsylvania	2.43	14.9	0.9	0.2	0.3
Ohio	2.40	14.6	0.5	1.0	0.3
Indiana	2.31	14.2	0.3	1.7	0.2
Illinois	2.58	15.5	1.0	0.9	0.6
Michigan	2.77	13.3	1.1	1.3	1.0
Wisconsin	2.60	16.9	1.1	0.9	0.6
Minnesota	2.52	11.7	0.9	2.6	0.5
Iowa	1.96	21.3	-0.5	2.3	-0.3
Missouri	2.42	19.7	0.7	1.2	0.3
North Dakota	2.13	31.9	-0.1	6.1	-0.1
South Dakota	2.64	16.9	1.4	3.4	0.6
Nebraska	1.97	26.3	-0.5	3.6	-0.3
Kansas	1.62	20.3	-1.2	2.2	-0.8
Delaware	3.00	21.3	2.2	2.1	1.1
Maryland	2.74	12.1	1.5	-0.4	0.8
Virginia	2.31	18.0	0.5	2.6	0.2
West Virginia	1.81	3.4	-0.5	0.3	-0.7
North Carolina	2.68	24.2	2.4	4.4	0.5
South Carolina	2.51	25.6	1.8	3.6	0.3
Georgia	2.44	22.5	1.1	3.5	0.3
Florida	2.33	19.9	0.5	6.6	0.2
Kentucky	2.90	17.8	1.2	4.8	1.2
Tennessee	2.39	22.2	0.8	4.4	0.2
Alabama	2.09	20.6	-0.3	3.6	-0.1
Mississippi	1.68	30.0	-2.8	6.2	-0.5
Arkansas	1.71	34.5	-2.3	6.5	-0.5
Louisiana	0.97	23.1	-2.3	3.2	-1.9
Oklahoma	1.32	22.4	-3.1	4.9	-1.0
Texas	1.02	15.2	-2.2	4.8	-1.9
Montana	1.75	24.4	-1.1	0.5	-0.6
Idaho	2.37	19.5	0.4	4.8	0.3
Wyoming	1.32	19.7	-2.2	0.3	-1.2
Colorado	1.69	13.9	-1.0	4.6	-0.7
New Mexico	1.82	26.8	-1.3	5.9	-0.4
Arizona	2.24	39.4	0.2	7.3	0.1
Utah	1.64	7.1	-1.5	0.6	-0.8
Nevada	1.94	8.2	-0.3	5.2	-0.4
Washington	2.07	13.8	-0.2	0.1	-0.2
Oregon	2.34	26.2	0.5	2.5	0.2
California	2.36	18.2	0.4	1.2	0.3

Table 3: Energy Prices; Annual Growth of Value Added; Changes in Growth of Value Added if All States Have National Average Energy Price

	P_e	Y*	DY*
Maine	2.16	5.7	-0.2
New Hampshire	2.93	8.5	2.2
Vermont	3.52	6.9	3.4
Massachusetts	3.43	4.7	3.2
Rhode Island	3.12	6.6	2.5
Connecticut	3.38	3.0	3.0
New York	3.17	3.5	2.5
New Jersey	2.98	4.5	2.0
Pennsylvania	2.43	4.8	0.6
Ohio	2.40	5.6	0.6
Indiana	2.31	6.5	0.3
Illinois	2.58	5.8	1.0
Michigan	2.77	6.0	1.5
Wisconsin	2.60	5.7	1.0
Minnesota	2.52	6.8	0.8
Iowa	1.96	9.3	-0.5
Missouri	2.42	7.3	0.6
North Dakota	2.13	17.0	-0.1
South Dakota	2.64	8.7	1.1
Nebraska	1.97	11.9	-0.5
Kansas	1.62	8.3	-1.4
Delaware	3.00	8.0	2.0
Maryland	2.74	3.5	1.4
Virginia	2.31	8.3	0.3
West Virginia	1.81	1.8	-1.0
North Carolina	2.68	13.0	1.3
South Carolina	2.51	12.3	0.9
Georgia	2.44	11.3	0.7
Florida	2.33	13.5	0.4
Kentucky	2.90	10.9	1.9
Tennessee	2.39	11.9	0.5
Alabama	2.09	10.4	-0.2
Mississippi	1.68	17.0	-1.4
Arkansas	1.71	18.6	-1.2
Louisiana	0.97	10.9	-3.0
Oklahoma	1.32	11.9	-2.1
Texas	1.02	10.0	-2.9
Montana	1.75	7.9	-1.0
Idaho	2.37	11.1	0.5
Wyoming	1.32	5.9	-2.1
Colorado	1.69	9.5	-1.2
New Mexico	1.82	12.8	-0.9
Arizona	2.24	19.5	0.2
Utah	1.64	2.9	-1.3
Nevada	1.94	7.9	-0.6
Washington	2.07	4.4	-0.3
Oregon	2.34	10.8	0.4
California	2.36	6.3	0.4

regional energy price differentials, the states which exhibit high energy prices would experience a stimulus to growth. Rhode Island, for example, would experience a 2.5 point increment to a base growth rate of 6.6 percent. The growth rate of output (or value added) in Texas would decline by 2.9 points from a base rate of 10.0 percent.

The impact of reducing regional energy price differentials is easily identified by large geographical regions. The New England and Middle Atlantic regions exhibit a large stimulus to the growth of output. The West South Central and most of the East South Central region would receive a relatively large negative impact. The East North Central and South Atlantic regions are giver a mostly positive stimulus. The impact on the West North Central and Mountain regions is mostly negative. Of the Pacific states, Oregon receives a major, and positive, impact.

In relative terms, the impact of the energy price change is significant. Many states would receive a change in growth rate of two to three percentage points when the existing growth rate is 3 percent to 10 percent. According to the results shown in Table 3, reducing energy price differentials would increase or decrease the growth rates of some states by 60 to 90 percent.

The states which experienced relatively low growth rates of output from 1963 to 1972 are states which had relatively high energy prices. Table 4 shows that the coefficient of ΔP_e is negative and significantly different from zero when regressed on Y*. States which have relatively high energy prices are also those which are shown to have positive and large increments to the growth of output in the simulation. Hence, states which are growing more slowly (and have high energy prices) would receive a positive stimulus to growth brought about by more equal energy prices. This is exhibited in Table 4, where the DY* is negatively related to Y*.

Table 4: Regression with Changes in Growth of Output, the Growth of Output, and Energy Price Differentials. [12/27/76].

DY*	Y*	ΔPe	Const.	R^2
-1		.025 (165.4)	-.00002 (-.21)	.998
	-1	-.022 (-2.3)	.09 (15.4)	.103
-1	-.12 (-2.3)		.013 (2.73)	.102

4. CONCLUSIONS

This paper develops a neoclassical model to explain how high (or low) energy prices may cause slow (or fast) rates of economic growth. The data are consistent with the hypothesis that higher payments for energy result in lower returns to capital and lower payments to labor. The lower payments to capital and labor in turn lower the rate of investment and rates of increase of labor supply in the respective high energy price states. As a result of the lower growth of capital and labor, the growth of output (o value added) is lower in states exhibiting high energy pri

In order to determine the sensitivity of growth rates to the magnitude of existing energy price differentials, a hypothetical change in energy prices is introduced. Each state's energy price is changed to the national average price. These energy prices are simulated on the model with parameters estimated from the 1963 to 1972 growth experience of states. These simulations show that the growth rates of the relatively slow growing states would be stimulated; those of some rapidly growing states would be retarded.

From this very simple model we tentatively conclude that energy price differentials exert an important influence on regional growth. However, the model needs further work to test whether the correlations so far established are not spurious correlations with other variables which influence regional growth. For example, the influence of regional tax rates, quality of labor force, and labor force unionization could be correlated with high energy prices, and also be important influences on regional growth prices.

If, after further refinement of the model, the correlation between energy prices and growth rates is maintained, analyses of regional energy prices in relation to costs is necessary. Market imperfections, subsidies, or other controls on energy sources may result in energy prices different from their marginal costs. In these cases, for efficiency reasons, the government may pursue programs to modify energy prices. Such programs, e.g., natural gas deregulation or reduction of Federal subsidy of federally owned power installations, may reduce regional price differentials and, hence, mitigate adverse economic conditions in areas such as the Northeast.

DATA APPENDIX

Data is generated from the Census of Manufactures, 1963, 1972, Vol. 1, Table 7, and County Business Patterns, 1962, 1964, 1972, Table I-H. Data on value added, payments to labor, and employment are available directly.

The growth rate of capital stock is calculated indirectly because data on the actual capital stock by state is not available. Payments to owners of capital, R_T, equal the marginal return to capital, R_i, multiplied by the capital stock, K. Therefore, capital stock grows at a rate,

$$K_i^* = R_T^* - R_i^*. \qquad (12)$$

The derivative of log of (9) produces the proportional rate of growth of the return to capital, which is substituted for R_i^*. The capital growth equation (12a) becomes,

$$K^* = R_T^* + [(1-\alpha)/\alpha]y^* - \rho/\alpha \qquad (13)$$

where R and y (but not ΔP_e) for each state are allowed to change over time. Data for R_T is calculated by subtracting wage payments from value added. The computation y*'s contribution to K* requires an a priori assumption about α. Based on many studies of capital's share, we assume α=.33. This procedure is preferable to ignoring a variable compone of K*, since the computation of a region's growth in capital stock will be sensitive to its growth in output per worker. The third term in (13) is a constant for which we have no a priori estimate. Since this latter term is a constant, its omission will affect the magnitude of the constant term in the output growth equation (2) but will not affect the coefficient of capital stock. This can be shown by writing the estimating equation for Y* as,

$$Y_i^* = \alpha_8 + \alpha_9(\bar{K}_i^* + X) + \alpha_{10}L_i^*$$

where X = the constant error in calculating K* and K = the real capital stock. Thus,

$$Y_i^* = (\alpha_8 + \alpha_9 X) + \alpha_9 \bar{K}_i^* + \alpha_{10}L_i^*,$$

where α_9 remains the coefficient of capital stock.

The error in K* will also affect the magnitude of the constant term in estimating equation (12). Because the specific magnitudes of the constant terms in equations (2) and (12) are not the object of an important hypothesis in this model, the errors will not affect the tests of the model.

An estimate of physical output per worker, z, is also required for the manufacturing sector of each state. This is calculated as value added per worker (y) divided by the price per unit of value added (P_y). According to (5), the latter can be represented as

$$P_y = 1 - (1/\gamma)P_e - (1/\gamma_1)P_m$$
$$= 1 - (1/\gamma)P_{ea} - (1/\gamma_1)P_m - (1/\gamma)\Delta P_{ei}$$
$$= \beta - (1/\gamma)\Delta P_{ei}.$$

The national component of P_y (i.e., β) is calculated as the ratio of value added to value of shipments for the nation in 1963, or .456. The second term that represents the regional component of P_y is calculated by: (1) setting $(1/\gamma)$ equal to the physical energy consumption per unit of output in 1963; and (2) multiplying $(1/\gamma)$ by the difference between the region's and the nation's energy prices (ΔP_{ei}). Since only 1971 data is available for ΔP_{ei}, the energy price differentials are converted to 1963 differentials through multiplication by the ratio of the average national energy price for 1963 and that for 1971. This assumes that the state energy prices have not changed relative to the national average during the 1963-71 period.

The wage in nonmanufacturing is calculated from the residual of state personal income payments and employment after manufacturing payrolls and employment are subtracted. Industrial energy prices are from a special report of the

U.S. Census of Manufactures [10]. In Tables 2 and 3 these prices are presented in units of one thousand kilowatt-hour equivalents.

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