Some Implications of Labor Adjustments in a Dual Economy Framework: Wyoming's Energy-Agriculture Interface

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Within Wyoming the significant expansion of the energy[1] sector is forecast to place increasing demands on resources currently utilized in agriculture, particularly water [Dalsted and Leistritz, Leistritz and Hertsgaard]. While the energy-agriculture water issue is a major concern, an additional resource adjustment is occurring within Wyoming's labor market. An accelerated decline in the Wyoming agricultural labor supply, which may result from increased energy development, could have profound effects on the structure of Wyoming's traditional, livestock oriented agricultural sector.[2]

The overall purpose of this paper is to briefly examine some implications of labor adjustments within Wyoming and suggest areas for future research. More specifically, the paper will attempt to 1) explore the magnitude of recent labor adjustments for the energy and agricultural sectors; 2) measure factor price differentials (wage rates) across sectors as a mechanism for such adjustments; and, 3) estimate marginal productivities of labor in each sector via production function estimation procedures. As discussed subsequently, the neoclassical dualistic economy model of Jorgenson, borrowed from the literature of economic development, appears to offer an appropriate framework for analyzing such labor transfers.

Dualistic Theory and the Wyoming Economy

Dualistic development models, such as that by Jorgenson, or the more classical approach of Ranis and Fei, essentially view the development process as a function of labor market interactions between a normally traditional agricultural sector and a dynamic industrial or modern sector. In the Jorgenson model, transfers of labor from the traditional sector into the rapidly expanding modern sector are *not* assumed costless (in terms of agricultural output) given the assumption of a positive marginal product for labor in the traditional sector. While Ranis and Fei initially assume a zero marginal product for labor, both models result in wage rate differentials tending toward equalization through the labor reallocation process.

These theoretical developments are assumed to occur within the context of a closed economy. Obviously, the Wyoming economy can neither be considered closed nor totally dualistic in sectoral composition. However, certain aspects of dual economy theory appear to parrallel current development conditions in rural Wyoming. These similarities may best be presented by examination of specific structural characteristics of each sector, as well as the nature of respective factor-product relationships.

While the services (government and non-government) and trade sectors constitute the two largest employment categories, the energy and agriculture sectors rank third and fourth, respectively, in terms of employment and together constitute approximately 25 percent of the state's labor force (Wyoming DEPAD). Also, the service and trade sectors tend to be located in the Cheyenne, Casper[3] and Laramie urban areas, somewhat in isolation from energy sources within the state. Further, while employment levels within most sectors have been stable

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[1]Energy, as defined in this paper, refers to the aggregate of the mining, petroleum and natural gas industries.

[2]The livestock sub-sector accounts for approximately 80 percent of Wyoming's gross agricultural product (Wyoming Agricultural Statistics).

[3]The relative importance of the Casper area as an energy producing region is being diminished as a result of declining oil production. Currently, most energy development activities are located in Campbell and Sweetwater Counties.

over the last decade, energy employment has expanded by approximately 42 percent, whereas agricultural employment has declined by 25 percent (table 1).

As in dualistic theory, agriculture may be a major supplier of labor for Wyoming's expanding energy sector.[4] Examination of sectoral employment levels for energy and agriculture indicate that the increased employment levels observed for energy (5,000 man-years between 1963 and 1974) correspond approximately to the observed decline for agriculture (4,900 man-years). While no data exist on the magnitude of sectoral transfers within Wyoming, the relative stability of most other sectors and the low net in-migration levels observed for Wyoming (Voelker) suggest that energy may be drafting significantly from within the state.[5]

[4]A basic assumption in dual economy models is relatively homogeneous labor across sectors. Hence, agricultural labor is viewed as possessing sufficient abilities to facilitate transfer to the modern sector. This assumption appears consistent with the present situation in Wyoming, where skills demanded within energy (particularly coal extraction) are of a rather basic nature. This has been confirmed by coal company management, who state that such basic skills can be easily assimilated by most individuals.

[5]A case study by Kiner of the Wyoming Uranium sector indicates that approximately 75 percent of the sectors' labor force was derived from within the state, with over 50 percent of total employment from the immediate area.

In terms of production relationships, the livestock oriented agricultural sector could be classified as traditional, in the sense that technological factor augmentation appears to be very slow, with a relatively low capital-labor ratio (excluding land from the capital measure). Conversely, the energy sector displays a high level of innovation and is relatively capital intensive, as indicated by a correspondingly high capital-labor ratio.

Finally, the prevailing wage rate differential between the sectors appears to be exerting two influences on the lower wage sector, agriculture, as posited in dualistic theory. First, the differential provides an obvious transfer incentive, at least with respect to hired labor. Second, the differential will tend to exert upward pressure on the agricultural wage.[6] Theory indicates an ultimate equilibrium condition, where the MVP of labor across sectors is equalized. An examination of wage differentials between agriculture and energy for 1963 and 1974, while not sufficient to constitute an empirical verification of dualistic theories, does indicate that the relative differential has been reduced slightly (table 1).

[6]A rising wage rate may also be expected to stimulate factor augmentation of the relatively more expensive input; i.e. labor.

Table 1. Employment, wage rates and gross revenue, energy and agriculture, 1963 and 1974

Sector and Year	Employment[a]	Gross Revenue[b]	Wage Rage[c]	Agricultural Wage as Percent of Energy Wage
	man-years	*$ millions*	*$ per annum*	*percent*
1963				
Agriculture	19,800	183.00	2,760.00	
Energy	11,900	361.00	7,824.00	35
Total	31,700	544.00		
1974				
Agriculture	14,900	410.00[d]	5,750.00[d]	
Energy	16,900	1,045.00[d]	13,460.00[d]	43
Total	31,800	1,455.00		

[a]Employment sources for agriculture — *Wyoming Agricultural Statistics, Wyoming Data Handbook.* For energy—Employment Security Commission of Wyoming.

[b]Gross Revenues from *Wyoming Agricultural Statistics,* and Wyoming State Board of Equalization.

[c]Wage rates obtained from Employment Security Commission. The agricultural wage does not include nonmonetary compensation such as housing, food, or utilities that may accompany such employment. Hence, it tends to understate the real wage. Also, the agricultural wage excludes returns to "management" for owner-operators. The energy wage refers to nonmanagement personnel covered by the Unemployment Insurance Law.

[d]Estimated wages and revenues are in actual dollars.

Estimated Labor Marginal Productivities

To examine impacts associated with actual or potential transfers of labor from agriculture to energy, some measure of resource productivity within sectors is needed. The most feasible approach, and that suggested by Jorgenson, is the estimation of sectoral production functions. The hypothesized functional relationship between factors and output for both sectors is as follows:

$$Y = f(L, K)^{7} \quad (1)$$

Where: Y = total sectoral output, in dollars;
L = labor usage, in man-years;
K = capital expenditures,[8] in dollars; and
f is of the Cobb-Douglas or power function type.

The use of a Cobb-Douglas type production function ($Y = AL^{\alpha} K^{\beta}$) was deemed consistent with previous research [Jorgenson, Nerlove, Zarembka]. More specifically, the function to be estimated, in log-log form, is as follows:

$$\text{Log } Y_i = \log A + \alpha \log L_i + \beta \log K_i + e_i \quad (2)$$

where the usual conditions concerning the error term are assumed.[9] Given the log-log form of the function, α and β may be interpreted as elasticities of production for L and K, respectively.

The results of the ordinary least squares estimation procedure are presented in table 2, with the resulting marginal value products for labor and capital contained in table 3. Observations gleaned from table 2 indicate that while all estimated equations proved significant at the 5 percent level, as measured by the F statistic, insignificant (5 percent) estimates for capital in agriculture in both years, as well as labor in energy for 1963, were obtained. While the estimated MVP of each input is presented in table 3, caution should be exercised in drawing inferences from those inputs with insignificant coefficient estimates.

The primary purpose of production function estimation was to achieve some measure of labor marginal productivity in each industry. As evidenced by table 3, the 1963 MVP of agriculture was considerably lower than that observed for energy. However, 1974 estimates indicate that this differential has been sharply reduced. It should be noted that the rather high values for labor in agriculture relative to wage rates is due in part to inclusion of family labor in the labor estimate for agriculture. Therefore, some of labor's MVP may be attributed to "management," and thus may overstate the "transfer incentive" of the wage rate differentials.

The MVP's associated with capital usage in energy appear quite high, indicating that each dollar of capital expenditure will yield more than two dollars of output. Such a high MVP may be a reflection of the high level of risk inherent in energy exploration and development, as well as the high level of technology embodied in the capital inputs used in that sector.

Implications

The primary purpose of the production function estimation was to provide some measure of the economic efficiency of labor allocation. Such estimates may serve as reasonable guides to resource allocation, within limits defined by data and specification considerations.

As is evident from table 3, the MVP of labor in agriculture has increased dramatically between 1963 and 1974. In fact, the 1974 estimated MVP of labor across sectors indicates near equality. From an efficiency standpoint (in a purely static sense, assuming homogeneous labor and zero transfer costs) the 1974 MVP estimates suggest that in terms of dollar value of output, gains from labor transfers across sectors may be minimal, given the approximate equality of labor MVP in both lines of production. However, the difference in prevailing nominal wage rates across sectors indicates that a labor transfer incentive still persists, i.e., the agricultural wage rate is less than half that of energy.

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[7] Land was excluded from the agriculture production function. Also, Jorgenson's production function assumes no capital in agriculture.

[8] The measure for capital expenditures in agriculture was obtained from the Wyoming State Board of Equalization and included such items as machinery, livestock, and structures, but excluded land. For energy, capital expenditures were derived from Census of Mineral Industries, 1967 and 1972.

[9] The cross-sectional data used in the estimation procedure consisted of county estimates for each sector, for the years 1963 and 1974. Agricultural sector data, for each of Wyoming's 23 counties were obtained primarily from Wyoming Agricultural Statistics and the Farm Income Situation series. Energy sector data for those counties with energy development (17 in 1974), were derived from the Census of Mineral Industries as well as the Wyoming Employment Security Commission. The usual caveats and limitations associated with the aggregative nature of the data and the function estimation procedure, as discussed elsewhere [Nerlove, Heady and Dillon], must be recognized.

Table 2. Estimated production functions for Wyoming agricultural and energy sectors, 1963 and 1974.

Sector and Year	Regression Coefficients and t Statistics[a] A	Log L[b]	Log K[c]	Summary Statistics R^2	F	Number of Observations[d]
Agriculture						
1963	1.362	.961 (8.01)	.092 (.82)	0.919	113.97	23
1974	1.594	.706 (4.61)	.160 (.99)	0.767	32.96	23
Energy						
1963	1.264	.317 (1.05)	.621 (2.04)	0.601	9.69	16
1974	1.278	.418 (2.90)	.532 (3.55)	0.761	22.32	17

[a]Values in parentheses are t statistics.
[b]L is in man-years of labor, including both family and hired for agriculture.
[c]K is in thousands of dollars of capital.
[d]Variation in number of observations due to absence of energy development in some counties.

Table 3. Marginal value products of labor and capital, by year and sector[a]

Sector and Year	MVP of Labor	MVP of Capital	Capital-Labor Ratio	Annual Wages as Percent of MVP
	per man-year	*per $ of capital*		
Agriculture				
1963	$ 8,965	$ .553[c]	1.554	.308
1974[b]	18,777	1.439[c]	2.976	.306
Energy				
1963	$17,301[c]	$3.245	10.51	.452
1974	19,765	2.559	9.83	.681

[a]Derivation of the marginal products follows the procedure set forth in Heady and Dillon, page 231.
[b]The overall level of agricultural commodity prices for 1974 were substantially higher in 1974 than 1963. For Wyoming, depressed livestock prices were partially offset by continued high price levels for crop commodities.
[c]MVP computed from statistically insignificant (5% level) regression coefficient, as presented in table 2.

The traditional nature of Wyoming agriculture coupled with pervasive wage pressures from energy implies that livestock operations may be placed at a comparative disadvantage in the labor market. The decline in Wyoming's sheep industry, while a casualty of several factors, has been attributed in part to a failure to obtain sufficient labor. The beef industry also appears to be plagued with relatively low rates of return on owned assets. Given the relatively limited potential for factor-augmenting technical change in livestock operations vis-a-vis crop production, a continued decline in labor supplies, and/or rising wage rates, may further increase pressure to shift more mobile assets, given high opportunity costs.

Finally, it should be noted that the conclusion of the Jorgenson model reveals a modernization of the traditional sector (agriculture) through the labor market and other linkages. While energy development may provide an impetus for modernization of agriculture, the present situation reveals conflicts for those resources with relatively inelastic supply.

Conclusion

Agriculture is an integral component of the economic base in many rural areas of Wyoming. Energy development within these same rural areas is contributing to the transfer of resources out of agriculture. Such transfers may portend a decline in certain agricultural subsectors, particularly livestock. These effects should be considered with the same degree of interest as that afforded energy-related community structural impacts, given the obvious interrelationships.

Care should be taken in drawing inferences from the included approach and empirical results, given the simplistic nature of this paper. However, a general observation concerning the literature on economic development is that it may be a potentially rich area in terms of addressing regional energy development issues. Development theories, such as the one discussed in this paper, while providing meaningful insights into specific development problems, are sufficiently general to merit consideration as a theoretical framework for this type of analysis.

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