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REGIONAL EMPLOYMENT IMPLICATIONS FOR GEOTHERMAL ENERGY DEVELOPMENT, IMPERIAL COUNTY, CALIFORNIA*

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ABSTRACT

A study of employment effects from prospective geothermal development in Imperial County is based on regression analysis of Census enumeration district data. The study reveals potential for reduction of broad age-structural unemployment through a more favorable age structure accompanying reduced fertility, increased labor force participation through greater income, and reduced unemployment through greater income and less poverty.

INTRODUCTION

Economists, sociologists, and demographers have for years advised that more new industry should be located in areas of rural underemployment. They claim that new industries will increase the utilization of local labor supply, thereby reducing unemployment. Yet examination of employment by industry in the various labor markets shows a wide difference in the types of industries that are located in specific communities [1].

This paper is concerned with local labor market analysis. Its main focus is on employment and associated local labor market effects of geothermal

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development in Imperial County, California. The paper will first discuss available historical evidence from similar past research and will then examine studies relating to the prospect of geothermal development in Imperial County. Next we discuss regression findings of U.S. Census statistics on the county in order to understand its socioeconomic characteristics and to project potential employment effects of geothermal development. Finally, the applicability and potential usefulness of regression results to prospective geothermal development is addressed.

Imperial County, a rural agricultural region in southeastern California with a 1970 population of 74,492, is anticipating a rise in geothermal energy capacity from the present 10MW, consisting of a pilot plant, to 1250-8500 MW in the year 2020 [2]. Current local installed energy power sources are 150 MW hydroelectric and 350 MW fossil fuel. It is of importance to the county to be able to predict direct and indirect effects on county employment resulting from installation of geothermal power capacity, which will probably be added in 100-150 MW/year increments beginning sometime before 1985.

The present research does not examine total county employment shifts, but rather analyzes intracounty sub-regional (enumeration district) differentials in employment. Discussions of countywide effects have appeared elsewhere [3, 4]. A design close to that of the present study was employed in a regression analysis of fertility by Heer and Boynton [5]. The sample consisted of 591 U.S. counties in 1960, with a sampling ratio of .188—close to that in the present research.

Baer performed a stepwise regression analysis of seven age-specific male labor force participation rates [6]. These dependent variables were each defined as the ratio of the number of males in the civilian age-specific labor force to the male noninstitutional age-specific population. Independent variables consisted of a mixture of age-aggregated and age-specific measures, including age-specific migration, age-specific per cent in the military, ratio of age group in total population, median earnings of labor force males, education of males 25 + years, and male unemployment for the whole labor force. For most age groups, significant positive relationships were obtained for education and earnings, and inverse results were obtained for unemployment—the latter validating the "discouraged worker theory," in which worker discouragement in the face of high unemployment is postulated to reduce participation in the work force.

For sizeable geographical areas (above, say, average U.S. county size) female labor force participation has been shown to have been nearly always lower than for males, most likely due to childbearing and family alternatives of women. In an international comparison, Collver and Langlois [7] give such figures for female labor force participation (defined as the ratio of number of people in the labor force to number of people 15-64) as .48 for France 1954, .37 for the U.S. 1950, .54 for Jamaica 1953, and .12 for Egypt 1947. Since the date of this study, these figures have risen in many countries. For comparison, female participation, as defined above, is .48 for California 1970 and .39 for Imperial County 1970.

In a regional multivariate study, Sweet [8] used the 1/1000 sample from the 1960 U.S. Census to study differences in employment of rural farm wives. He used the dummy regression method of multiple classification analysis, which revealed effects on rural farm wife employment for such variables as southern location (positive), metropolitan county (positive), age range twenty to thirty-nine (positive), Spanish-American (negative), elementary school education (negative), high income (negative), children under five (negative), blue collar occupation (positive), and wage and salary income only (negative). All the major results correspond closely to results for urban women.

There are few studies which apply employment statistics to rural industrialization. One such study [9] examined the following important question that also could be raised in connection with employment effects of industrial change in a rural area—when a plant actually does locate in a rural area, who will be employed?

When geothermal industries are established in Imperial County, employment opportunities may not open up for local workers. If the industry is capital-intensive, employment may be available only for skilled workers. If local unemployed workers do not possess the requisite job skills—which is likely—there will be few employment opportunities available. This would mean, of course, that the industry would bring in most of its workers from outside areas, thus leaving the local unemployed unaffected. Although additional peripheral jobs are created by the location of an industry, they may well be in the service or professional categories.

A rather similar result was noted by Rose in a study of geothermal development on requirements for direct and indirect employment in Imperial County [4]. Rose calculated the direct employment effect for all phases of a 50 MW development. These phases, with the number of required direct employees, both permanent and temporary residents, in parentheses, are exploration (15.2), field development (46.8), power plant construction (129.9), field operation (.4), and power plant operation (5.2).

Of the total of 197.5 direct employees required, 76.2 were projected to be permanent residents. Likewise, the 50 MW development was estimated to result in 16.5 indirect and induced, resident employees. On the scale of a geothermal development process to an eventual 2,000 MW capacity, such figures would imply 3,048 direct, resident employees and 660 indirect and induced, resident employees. These numbers are small relative to the 1970 County employment base of 23,479 workers. It should be noted that the above figures do not include an estimated 4,852 non-resident, temporary geothermal workers. Rose attributes such relatively small overall employment effects to "leakages in the economy and the absence of specialized goods, services, and personnel required in the exploration, drilling, and construction phases of geothermal development." He notes that such figures might be increased by up to a factor of five, if new industries, especially construction-related ones, were attracted into the County permanently.

SAMPLE CHARACTERISTICS

Data were obtained for Imperial County from the Fifth Count of the 1970 Census [10]. This sample data is divided into eighty enumeration districts (henceforth abbreviated as ED), which vary in size from eighty-eight to 2,261 persons. For the correlation and regression analysis, the sample is split into the subsamples–geothermal and nongeothermal. Such a division is based on the location of geothermal fields underneath land areas classified by the U.S. Geological Survey as KGRAs (Known Geothermal Resource Areas). Imperial County presently has three KGRAs along the central north-south axis of its irrigated valley portion: the Salton Sea KGRA to the north, the Brawley KGRA in the middle, and the Heber KGRA to the south bordering Mexico. In addition, a fourth KGRA, East Mesa, is located underneath a dry mesa to the east of the southeastern border of the irrigated valley. Three towns, Brawley (1970 pop. 13,746), El Centro (pop. 19,272), and Calexico (pop. 10,625), which contain 58.5 per cent of the county population, border KGRAs and for the purposes of this analysis are uniformly classified as geothermal even though Calexico is slightly outside the Heber KGRA. EDs not in the above three towns are classified as geothermal or nongeothermal according to the following rule: if more than 50 per cent of an ED is within a KGRA, it is classified as geothermal. No ED is associated with the East Mesa KGRA, since this KGRA is wholly contained in less than 50 per cent of one large ED. Detailed maps showing major towns and ED-KGRA boundary superimpositions were included in a general demographic analysis [11]. The above classification method results in 48 geothermal EDs and 32 nongeothermal EDs. There is fairly strong similarity in these classes to urban-rural categories, since the geothermal EDs are 87.5 per cent urban and the nongeothermal ones are 68.7 per cent rural.

An important factor underlying this sample design is the independence of the county's economy of adjacent counties, so that it may be considered to form one U.S. labor pool. In the first place, Imperial County is geographically isolated from adjacent U.S. regions: on the north by the Salton Sea, a drain for agricultural waste water; on the east by slightly populated dry mesa and rugged mountainous areas; and on the west by largely uninhabited dry mesa and desert which extend for hundreds of miles into Arizona. Total imports included in Imperial County in input-output analyses are 41.4 per cent agriculture related; foreign exports included in gross output are 47.2 per cent agriculture related; and other exports included in gross output are 72.9 per cent agriculture related [3].

Imperial County's economy is not, in large part, tied to neighboring counties, but rather to a national and international agricultural distribution network governed by rather unpredictable commodity markets. Thus, the present analyses do not attempt to examine intercounty interactions. Rather, the implications of the present research findings may be as much methodological as generalizable for other geothermal regions. Many areas of the western United States contain large geothermal fields, but only the one in Sonoma and Lake Counties, California, has been developed so far. Thus, the rationale in methodology, including ED data, may prove of benefit to other anticipated non-county regional development locations. If such future studies have the benefit of regional retrospective energy data, they will reach more powerful conclusions than the current prospective study.

An exceptional feature of Imperial County's economy is its independence of its neighbors in the U.S. and its economic and labor force association with Mexico. There are some complex border economic interactions, particularly in regard to the sister cities of Calexico in Imperial County and Mexicali, Mexico. Kjos emphasized the large potential for cooperative economic exchanges at the border, but he considered attempts at such cooperation to have been unsuccessful [12]. A major type of border exchange that occurs currently is a highly seasonal population of Mexican citizens living in Mexicali who commute daily to primarily agricultural farm labor jobs in Imperial County. This largely male labor force is estimated to vary daily between 6,000 and 12,000 people, which translates to 20.3-33.8 per cent of the county labor force. Unfortunately, no detailed socioeconomic information is available on these commuters or on other border economic interactions, thus, the only choice is to regard border effects as a source of error in considering the county as one labor pool.

As the present design uses Census data, sample populations are determined by place of residence rather than by place of work. Place of work might be preferable if the analyses were intended to emphasize characteristics of workers as groups in businesses, industries and public sector work places. However, data on work place are unavailable at the sub-county level. Also, regional socioeconomic characteristics of unemployed persons are probably more meaningful in terms of similar residential locations. Also, in terms of application of this study to energy development, residential groups of unemployed may be more important because businesses tend to plan their prospective work forces at new locations on the basis of commuting distance for workers from their residences [13].

The rationale behind division of the areas into geothermal and nongeothermal ones is the following: certain effects from geothermal energy development will be concentrated on persons in proximity to the geothermal fields. For example, possible hydrogen sulfide emissions, noises associated with geothermal power plants, danger from well blow-outs, and nonelectrical uses of the energy are all localized. Nonelectrical use of the energy includes uses of the hot water brought up to the surface for house heating, air conditioning, food processing, ground warming, extraction of chemicals and health spas. Since there is a technological limit on transport of hot water for non-electrical uses of perhaps fifty miles and a generally much shorter economic limit, geothermal EDs almost certainly will include land areas residentially closer to such uses.

Results of the regression analysis reported in this study may be cautiously utilized in assessing non-electrical employment opportunities; they should be interpreted cautiously for the following reasons: 1. skill requirements for non-electrical industry may override proximity in establishment of labor pools; 2. in future energy development, areas adjacent to geothermal fields may be altered by inmigration or outmigration; and 3. sampling in the regression analyses of only one annual and seasonal timepoint may not apply to later populations.

In this study, a regression analysis of broad unemployment variables is done, using 1970 Census ED data. A general caution on the regression approach is that these studies, done with 1970 data, precede the installation of any geothermal capacity, electrical or direct use. Hence geothermal variables eligible for introduction into the regressions are limited in this study to variables for geothermal exploration, i.e., the KGRA boundaries. As the geothermal development process unfolds, more meaningful regression studies will be possible.

VARIABLES

The thirty-three independent variables, which are listed in Table 1, were carefully selected using the following selection criteria: (I) variables of direct economic importance to unemployment (variables 10-12, 19-31 in Table 1), (II) intermediate variables found to have been of importance in prior U.S. regional population studies [5, 6, 8, 14, 15], such as density, fertility, and mobility variables (variables 3, 4, 6-9, 13-15, 32, 33), and (III) an ethnic variable (per cent Spanish speaking), dependency ratio and utility variables (variables 1, 2, 16-18), which were found to be of critical importance in a general demographic study of Imperial County [11].

All definitions of variables which are unusual or defined in several ways in the literature are clarified below, using the above threefold classification of variables: (I) White collar (variable 10) comprises the occupation categories professional workers, farmers and farm managers, other managers, clerical workers, and sales workers. Blue collar (11) comprises the categories craftsmen, operatives, and service workers. Rentals (19-21) is the proportion of number of renter-occupied monthly gross rents of a certain value to all renter-occupied units. Income (22-24) is for families and unrelated individuals fourteen years and older. Poverty (25) is the proportion of families below poverty level to all families. Spanish tenure (28) refers to the ratio of Spanish American owner-occupied housing units to all Spanish American occupied housing units. Henceforth, Spanish American is abbreviated as SA. Structural history of housing (29-31) is the ratio of year-round housing units built in certain periods

Table 1. Means and Coefficients of Variation for Independent Variables.

Variables	Entire		Geothermal		Nongeothermal		Calif.[a]
	Mean	Coeff. Var.	Mean	Coeff. Var.	Mean	Coeff. Var.	Mean
1. P†† Spanish Am.	.455	.606	.541	.568	.323	.456	.137
2. Dep. Ratio	.957	.258	.952	.291	.964	.205	.606
3. White Fert. Ratio	.465	.391	.457	.339	.477	.456	.378
4. Span. Fert. Ratio	.646	.669	.535	.580	.812	.655	.528
5. P. Now Married	.613	.106	.601	.121	.631	.074	.595
6. P. Diff. House 1965	.549	.250	.547	.246	.552	.260	.434
7. P. Diff County 1965	.107	1.025	.092	.700	.130	1.179	.200
8. P. Diff State 1965	.075	1.485	.084	1.441	.062	1.551	.092
9. P. Abroad 1965	.051	2.115	.061	2.207	.035	.955	.025
10. P. White Collar	.432	.428	.444	.446	.413	.398	.550
11. P. Blue Collar	.428	.404	.425	.399	.433	.418	.435
12. P. Farm Worker	.140	.974	.132	1.115	.154	.790	.015
13. Density A*	.577	.266	.547	.264	.623	.254	.672
14. Density B** (Anglo)	.807	.137	.794	.161	.826	.093	.920[b]
15. Density B (Span. Am.)	.632	.282	.646	.303	.611	.243	
16. P. Utility Gas	.519	.535	.649	.307	.325	.823	.859
17. P. Bottled Gas	.098	1.597	.041	1.656	.182	1.135	.031
18. P. Electricity	.315	.628	.257	.677	.402	.503	.086
19. P. Rentals 0-99	.405	.574	.403	.644	.408	.462	.400
20. P. Rentals 100-149	.426	.420	.399	.404	.465	.427	.365
21. P. Rentals 150+	.144	1.074	.166	1.034	.110	1.072	.234
22. P. Income 0-3.9†	.194	.751	.189	.754	.201	.756	.265
23. P. Income 4-9.9†	.431	.350	.431	.362	.432	.336	.328
24. P. Income 10-24.9†	.372	.597	.376	.636	.365	.539	.407
25. P. Below Poverty	.169	.803	.180	.773	.152	.858	.084

Note: *3 or less persons per unit
**1 or less person per room
†in thousands
††per cent
[a]Statewide crude statistics from U.S. Census (1973)
[b]Density B for the entire population
[c]Tenure for the entire population

Source: U.S. Census [10, 17]

Table 1. (Cont'd.)

Variables	*Entire*		*Geothermal*		*Nongeothermal*		*Calif.*[a]
	Mean	*Coeff. Var.*	*Mean*	*Coeff. Var.*	*Mean*	*Coeff. Var.*	*Mean*
26. P. House Value 0-9.9†	.290	.855	.252	.873	.348	.803	.047
27. P. House Value 25+†	.074	1.779	.081	1.799	.063	1.712	.412
28. P Spanish Tenure	.506	.549	.539	.482	.458	.658	.549[c]
29. P. House Built 1965-70	.131	1.165	.137	1.346	.122	.721	.135
30. P. House Built 1960-65	.129	1.015	.125	.982	.136	1.066	.178
31. P. House Built 1965	.727	.339	.737	.351	.711	.323	.687
32. P. Elem. Educ.	.299	.711	.308	.736	.285	.674	.258
33. P. H.S. Educ.	.469	.323	.443	.328	.508	.305	.549

Note: †in thousands
[a]Statewide crude statistics from U.S. Census (1973)
[b]Density B for the entire population
[c]Tenure for the entire population
Source: U.S. Census [10, 17]

to total year-round housing units. (II) Fertility ratios (3, 4) are the ratios of persons under five to females fifteen to forty-four. Mobility indices (6-9) refer to the proportion of 1970 population five years and older in a certain mobility category in 1965 to all persons five years and older in 1970. Education variables (32, 33) are proportions in the populations twenty-five years +. (III) Per cent SA (1) is defined as the ratio, (persons of Spanish language or surname)/all persons. Dependency ratio (2) is defined as (persons under eighteen plus persons sixty-five and over)/persons 18-64. Per cent now married (5) is the ratio of presently married persons fourteen plus to total population fourteen plus. The utility variables (16-18) refer to the proportion, (particular fuel type in occupied housing units)/all occupied housing units.

In regard to the SA (Spanish American) designation, it should be noted that SA used in this study refers to the designation, Spanish language or surname. The SA designation is the broadest census designation for Spanish population. The white designation used later in this study refers to the entire county population minus negros and other races (i.e., Indian, Japanese, Chinese, Filipino, and other). Hence it includes most of the SA population, The anglo designation referred to several times represents the entire population minus SAs. Hence, it includes negros and other races.

Twelve dependent variables were selected and are given in Table 2.

Table 2. Means and Coefficients of Variation for Dependent Variables

Variables	*Entire*		*Geothermal*		*Nongeothermal*		*Calif.*
	Mean	*Coeff. Var.*	*Mean*	*Coeff. Var.*	*Mean*	*Coeff. Var.*	*Mean*
34. Age Eligibility (male)	.640	.171	.621	.148	.669	.189	.693
35. Age Eligibility (female)	.651	.143	.633	.117	.677	.166	.713
36. Age Eligibility (Spanish Am.)	.553	.188	.560	.175	.544	.172	.604
37. Age Eligibility (white)	.645	.150	.624	.123	.675	.209	.709
38. L. Force Partic. (male)	.721	.228	.760	.150	.661	.315	.767
39. L. Force Partic. (female)	.358	.380	.373	.341	.335	.439	.421
40. L. Force Partic. (Spanish Am.)	.495	.401	.546	.235	.418	.255	.583
41. L. Force Partic. (white)	.532	.246	.555	.196	.497	.310	.567
42. Unemployment (male)	.031	.897	.079	.724	.084	1.097	.043
43. Unemployment (female)	.061	1.074	.058	.918	.066	1.240	.029
44. Unemployment (Spanish Am.)	.071	1.035	.061	1.283	.077	.903	.046
45. Unemployment (white)	.072	.802	.071	.701	.075	.930	.034

Source: U.S. Census [10,17]

The rationale for choice of these is as follows. Imperial County has an unusual age structure. Forty-five per cent of males and 44.3 per cent of females are below age twenty, compared to respective California figures of 38.2 per cent and 35.6 per cent. Also, the county historically has had high sex ratios (1.19 in 1950 and 1.24 in 1960), although these dropped to .98 in 1970. These sex ratios, combined with sharp out-migration in young adult age groups, have caused a highly irregular county population pyramid [11]. Another irregularity is the very sharp difference between the SA and anglo pyraminds: 54.9 per cent of the SA population is under twenty, compared to 34.7 per cent for anglos. To assess the broad age-structural forces of unemployment, three related unemployment variables were chosen. The first, henceforth referred to as age-eligibility (variables 34-37 in Table 2), is the ratio of persons sixteen plus to total population, which indicates the population segment encompassed by the labor pool. The strict Census definition of labor pool, which includes all aged persons, was adhered to in this study, because aged employed persons are counted by the Census as employed. For the analysis, age eligibility was categorized separately by sex and ethnic category. The reason for twice dividing the entire category into two subcategories rather than dividing it into four subcategories, such as SA male, was to avoid statistical error from additional halving of sample units, and to allow broader comparisons by sex and ethnic group. As noted above, the categories white and SA are not mutually exclusive.

Labor force participation variables (38-41) are defined as the ratio of civilian labor force to all persons sixteen plus. These introduce the small error of inclusion of military personnel in the denominator, but not in the numerator. This error is justified because the military category is not a subject of the analysis—the military is assumed independent of geothermal effects. The above exclusion allows the three sets of dependent variables to multiply to the ratio of unemployed to total population. A third set of dependent variables for unemployment (42-45) is defined in the standard manner as the ratio of unemployed persons to labor force.

Major differences between geothermal and nongeothermal areas include lower per cent SA in the nongeothermal region, higher SA fertility ratio, higher county mobility, lower state and international mobility, and a utility house heating mix with greater use of bottled gas and electricity. This fertility difference, although it is for only two regions, corresponds to national results in Pick [14] which show a significant inverse relationship between non-white fertility and per cent non-white.

Values of the dependent variables (Table 2) show lower county age eligibility than for California—a reflection of the younger county age pyramid, lower age eligibility for SA compared to whites, labor force participation for males approximately twice that for females (a standard result—see Collver [15]), lower county work participation than for the state, higher unemployment for males than for females and for SAs than for whites, and significantly higher unemployment in all categories than for the states. The latter difference, in general, may be due to a tighter labor market in the county, and is discussed in greater detail with the regression results.

RESULTS

After preparation of the data with the authors' sorting and tabulation computer programs, correlation and stepwise regression analysis was performed by a standard routine BMDP-02R [16]. Values for the independent variables (Table 1) reveal most of the important socioeconomic features of the county [11]. Perhaps the most important feature is the large SA segment of the population—45 per cent for the average ED. Overall county fertility is 22 per cent higher than for the state for both ethnic groups, and is 38.9 per cent higher for SA than for whites. Other variables significantly different from statewide trends are mobility, which is higher for the county for the household and international mobility categories and lower for the county and state categories, utilities usage, which is higher for electrical and lower for gas heating, and poverty and housing, which reveal greater poverty and lower housing values than for California.

Correlations among the independent variables for the entire sample reveal several pivotal variables which are highly intercorrelated— per cent SA, per cent white collar, and white room density of 1.0 or less. There is a positive correlation (r = .44) between SA and dependency ratio, reflecting higher SA fertility. Per cent SA has a negative relationship (r = -.61) with per cent now married, a result also of the significantly younger SA age structure. SA predominance in farm labor category is reflected by a correlation between these of .48.

SA population and high income levels are strongly inversely related—r(% SA, % below poverty) = .62 and r (% SA, % income $10,000-$24,999) = -.51, and the same type of effect holds for education—r (% SA, % elem. school educ.) = .62, r (% SA, % high school educ.) = -.64. All the above SA correlations remain strong, but reversed in sign if per cent white collar or per cent anglo room density 1.0 or less is substituted for per cent SA. This reversal is not surprising for per cent white collar, as Imperial County has an occupational structure proportionately more whites in the higher categories. However, the reversal with anglo density is surprising, and is surely due to more than mere economies of house size. Density variables are important for the age eligibility regressions discussed further below.

The groups of dependent variables show strong positive group intercorrelations, except for unemployment which has a strong inverse correlation (r = -.38) between male and female unemployment—a result of differing social forces, as revealed in highly different regression results for unemployment by sex. For males, there are directional reversals on correlations for the three dependent variables: r (age eligibility, participation) = -.50, r (participation, unemployment) = -.37, and r (age eligibility, unemployment) = .52. This sequence underscores the difficulty in analyzing broadly unemployment relative to age structure—favorable age eligibility is related to poor work force participation, which in turn is related to high unemployment. The above pattern also holds to a lesser extent for whites.

Results of the regression analysis for the three samples are presented in Tables 3 through 5. For the entire county, age eligibility is strongly (positively) related to housing densities and strongly inversely related to fertility. This effect reflects composite demographic forces in the county—high fertility, a resultant large population proportion of children and adolescents, and consequent high housing densities. The inverse effect of fertility for females and SAs (versus little or no effect for males and whites) may reflect lower ED mobility, resulting in more stable ED fertility characteristics. Nineteen-seventy SA household and county mobility values are .40 and .08 versus .45 and .22 for non-SAs [17]. The argument that stability of residential location leads to more accurate measurement of period fertility (and mortality also) was used to justify a national study of vital rates [15]. This residential stability is even more necessary in the present case for fertility to cause age eligibility changes, since to do so, the following line of reasoning is necessary: 1. present fertility in an ED is assumed highly correlated with the past birth sequence in an ED: 2. low mobility implies that the fewer babies born survived as ED residents; and 3. in a system more closed to migration, fewer past birth would result in an older age structure.

For the geothermal sample, the above conclusions hold, with the addition of several economic results. For males, high income has a significant positive effect on age eligibility. Imperial County is estimated to have had an average annual net outmigration rate of .7 per cent for 1930-1970. Thus, this income effect may be due to lesser net outmigration of males from high income EDs, relative to low income EDs—perhaps there are advantages for higher income males to remain in the county.

Nongeothermal sample results for age eligibility differ from those of the entire sample only for SAs. For SAs, the additional independent variable of county mobility has a negative effect, due perhaps to added fertility from assumed young (18-mid 30) county inmigrant parents combined with infants accompanying them.

Labor force participation for the whole sample has a significant inverse relationship with low income and poverty, and for females and whites, a positive relationship with high income. These results correspond closely to those of Baer which showed for all male age groups, except fifteen through nineteen and sixty-five plus, significant positive effect on labor force participation of median earnings of the labor force [6]. The interpretation is direct and obvious.

Since 1970, this effect may have dimished, due to the tendency for low income workers who have lost their jobs to remain in the labor force (i.e., because they are looking for work, they are categorized as in the work force), in order to obtain unemployment benefits. For the geothermal sample the above income effects and interpretations hold with three additional specific effects. For females there is a positive relationship with per cent electrical house heating. This is probably the result of urban gradients of significantly greater electrical usage in the higher income areas of the three major towns. These gradients are reflected in correlations of electrical heating with income 0-3999, income 4000-9999 and income 10,000-24,999 of -.49, -.35, and .51. A related effect is a positive effect for males and whites from recent (1965-1970) house construction. This also reflects an income effect, as the above respective income correlations for housing construction 1965-1970 are -.28, -.37, and .42.

Table 3. Beta Coefficients, Multiple Correlation Coefficients and Per Cent of Variance Explained by Selected Enumeration District Characteristics for Dependent Variables, Entire Sample

	Age Eligibility				*Labor Force Participation*				*Unemployment*			
Variables	*M*	*F*	*W*	*SA*	*M*	*F*	*W*	*SA*	*M*	*F*	*W*	*SA*
P. Spanish Am.					.212							
Dep. Ratio										-.346^{2}		
White Fert. Ratio		-.303^{4}	-.155									.362^{3}
Sp. Fert. Ratio				-.564^{4}								
P. Now Married												
P. Diff. House '65					-.206^{1}							
P. Diff. County '65												
P. Diff. State '65					-.189		-.183^{1}					
P. Abroad 1965												
P. White Collar												
P. Blue Collar												
P. Farm Worker			.187^{1}									
Density A^{a}	.795^{4}	.395^{4}	.629^{4}						.350^{4}			
Density B^{b} (Anglo)			.286^{2}									
Density B (Sp. Am.)				.412^{4}								
P. Utility Gas						.223^{2}						
P. Bottled Gas				.266^{2}							.256^{1}	
P. Electricity									-.211			-.242^{1}
P. Rentals 0-99										.290^{2}		
P. Rentals 100-149												
P. Rentals 150+												
P. Income 0-3.9^{c}					-.712^{4}		-.413^{4}	-.658^{4}				
P. Income 4-9.9^{c}				.223^{1}	-.263^{2}							
P. Income 10-24.9^{c}						.506^{4}	.216^{2}					
P. Below Poverty						-.449^{4}			.477^{4}		.362^{3}	
P. House Val. 0-9.9^{c}									-.234^{1}			
P. House Val. 25+^{c}								-.364				
P. Span. Tenure												
P. House Blt. '65-70												

^{a}3 or less persons per unit
^{b}1 or less person per room
^{c}in thousands

Levels of significance: *1* = 0.025
2 = 0.01
3 = 0.001
4 = 0.0005

Table 3. (Cont'd.)

Variables	Age Eligibility				Labor Force Participation				Unemployment			
	M	*F*	*W*	*SA*	*M*	*F*	*W*	*SA*	*M*	*F*	*W*	*SA*
P. House Blt. '60-65	.167							$-.422^{2}$				
P. House Blt. 1965												
P. Elem. Educ.						$.294^{1}$						
P. H.S. Educ.												
P. Age Eligibility^{d}										$-.476^{4}$		
Multiple Correlation Coeff.	$.775^{4}$	$.760^{4}$	$.834^{4}$	$.732^{4}$	$.734^{4}$	$.738^{4}$	$.753^{4}$	$.501^{2}$	$.617^{4}$	$.464^{4}$	$.490^{4}$	$.441^{4}$
P. of Variance Explained (R^2)	.601	.577	.695	.530	.539	.545	.567	.251	.381	.215	.240	.195

^{d}only included for female unemployment

Levels of significance: *1* = 0.025
2 = 0.01
3 = 0.001
4 = 0.0005

Table 4. Beta Coefficients, Multiple Correlation Coefficients and Per Cent of Variance Explained by Selected Enumeration District Characteristics for Dependent Variables, Geothermal Sample

	Age Eligibility				Labor Force Participation				Unemployment			
Variables	*M*	*F*	*W*	*SA*	*M*	*F*	*W*	*SA*	*M*	*F*	*W*	*SA*
P. Spanish Am.												
Dep. Ratio										-.280^{2}		
White Fert. Ratio			-.299^{2}						.309^{1}	.428^{2}	.347^{2}	.511^{4}
Sp. Fert. Ratio				-.442^{4}								
P. Now Married												
P. Diff. House '65		-.312^{2}									.303^{2}	.300^{2}
P. Diff County '65												-.442^{2}
P. Diff State '65												
P. Abroad 1965												
P. White Collar												
P. Blue Collar												
P. Farm Worker	.486^{4}				.292^{1}							
Density A[a]	.668^{4}	.760^{4}	.772^{4}	.523^{4}								
Density B[b] (Anglo)				-.461^{2}								
Density B[b] (Sp. Am.)				-.480^{4}								
P. Utility Gas											.398^{2}	
P. Bottled Gas		-.206	-.228^{1}								.540^{4}	
P. Electricity							.481^{4}		-.662^{4}			
P. Rentals 0-99[c]												
P. Rentals 100-149[c]												
P. Rentals 150+[c]												
P. Income 0-3.9[c]							-.481^{2}					
P. Income 4-9.9[c]		-.412^{4}	-.270^{2}									
P. Income 10-24.9[c]	.528^{4}											
P. Below Poverty					-.453^{4}		-.692^{4}		.349^{1}			

[a] 3 or less persons per unit
[b] 1 or less person per room
[c] in thousands

Levels of significance: *1* = 0.025
2 = 0.01
3 = 0.001
4 = 0.0005

Table 4. (Cont'd.)

Variables	Age Eligibility				Labor Force Participation				Unemployment			
	M	*F*	*W*	*SA*	*M*	*F*	*W*	*SA*	*M*	*F*	*W*	*SA*
P. House Val. 0-9.9^{c}												
P. House Val. 25+												
P. Span. Tenure				.264								
P. House Blt. '65-70					.258^{2}		.271^{2}					
P. House Blt. '60-65								-.203				
P. House Blt. 1965												
P. Elem. Educ.							.370					
P. H. S. Educ.						.283	.453^{2}	.243				
Multiple Correlation Coeff.	.790^{4}	.801^{4}	.832^{4}	.829^{4}	.820^{4}	.701^{4}	.836^{4}	.810^{4}	.534^{3}	.452^{2}	.681^{4}	.635^{4}
P. of Variance Explained (R^2)	.623	.641	.692	.687	.672	.492	.670	.656	.285	.204	.463	.403

^{c}in thousands

Levels of significance: *1* = 0.025
2 = 0.01
3 = 0.001
4 = 0.0005

Table 5. Beta Coefficients, Multiple Correlation, Coefficients and Per Cent of Variance Explained by Selected Enumeration District Characteristics for Dependent Variables, Nongeothermal Sample

	Age Eligibility				Labor Force Participation				Unemployment			
Variables	*M*	*F*	*W*	*SA*	*M*	*F*	*W*	*SA*	*M*	*F*	*W*	*SA*
P. Spanish Am.												
Dep. Ratio												
White Fert. Ratio				-.570[4]								
Sp. Fert. Ratio												
P. Now Married												-.577[2]
P. Diff. House '65												.478[2]
P. Diff. County '65				-.483[3]								
P. Diff. State '65					-.488[4]		-.411[4]	-.408[2]				
P. Abroad 1965										.326		
P. White Collar												
P. Blue Collar												
P. Farm Worker												
Density A[a]	.688[4]	.603[4]	.491[4]				-.278[2]					
Density B[b] (Anglo)		.370[2]	.472[4]	.507[4]								
Density B[b] (Sp. Am.)												
P. Utility Gas												
P. Bottled Gas				.474[4]								
P. Electricity									-.366[2]			
P. Rentals 0-99								-.478[2]			.284[1]	
P. Rentals 100-149												
P. Rentals 150+												
P. Income 0-3.9[c]					-.667[4]							
P. Income 4-9.9[c]												
P. Income 10-24.9[c]			-.258[2]			.784[4]	.647[4]		-.461			
P. Below Poverty											.845[4]	

[a] 3 or less persons per unit
[b] 1 or less person per room
[c] in thousands

Levels of significance: *1* = 0.025
2 = 0.01
3 = 0.001
4 = 0.0005

Table 5. (Cont'd.)

	Age Eligibility				Labor Force Participation				Unemployment			
	M	*F*	*W*	*SA*	*M*	*F*	*W*	*SA*	*M*	*F*	*W*	*SA*
P. House Val. 0-9.9^{c}								$-.634^{4}$			$-.740^{4}$	
P. House Val. 25+												$.467^{2}$
P. Span. Tenure												
P. House Blt. '65-70												
P. House Blt. '60-65								$-.723^{4}$				
P. House Blt. 1965								$-.455^{1}$		$-.440^{2}$		
P. Elem. Educ.			$.220^{1}$						$.573^{4}$			
P. H.S. Educ.												
Multiple Correlation Coeff.	$.858^{4}$	$.835^{4}$	$.931^{4}$	$.835^{4}$	$.833^{4}$	$.784^{4}$	$.871^{4}$	$.743^{4}$	$.826^{4}$	$.548^{2}$	$.821^{4}$	$.637^{2}$
P. of Variance Explained (R^2)	.736	.697	.867	.698	.695	.615	.758	.552	.683	.301	.674	.406

^{c}in thousands

Levels of significance: *1* = 0.025
2 = 0.01
3 = 0.001
4 = 0.0005

Also, in geothermal areas, there is a positive relationship except for males, of labor force participation with high school education. This result also corresponds to consistent positive correlations of age-specific labor force participation with age-specific education (median school years completed) in the Baer study [6]. Although present results are not for males, the arguments of Baer, emphasizing the importance of education to employers in job hiring, are applicable.

For the nongeothermal sample, the above effects for income (and highly correlated low rental variable) are interpreted as before. The significant inverse effect from interstate migration for males and whites is perhaps due to aged interstate inmigrants–mostly retirees–selectively locating more rural areas of the county. This inmigration of older residents is substantial–estimates of net migration 1960-1970 for males and females ages sixty-five plus are 9.7 per cent and 9.2 per cent.

Not surprisingly, results for employment for the whole sample support, in general, a standard hypothesis that poverty and low income are associated with unemployment. For males, the most significant effect is a positive one with poverty. The significant positive effect from an increased proportion housing unit densities of three persons or less may be due to positive effects on employment from the higher housing unit densitites associated with families– family responsibilities would lead to greater employment. Since regression analysis for female unemployment against the independent variables was nonsignificant for the entire sample, it was decided, in this single instance, to include the nonunemployment dependent varibles as independent variables. The resultant inverse effect of female age eligibility may well be due to a positive effect with fertility–*r* (female age eligibility, white fertility) = -.41; *r* (female age eligibility, SA fertility) = -.13. Sweet demonstrated the positive effect on unemployment of young children for rural farm wives, corroborating his own results for urban wives [8]. The positive unemployment effect of rentals 0-99 corresponds to the basic unemployment hypothesis of this paper, but is contrary to Sweet's results for rural farm wives, as well as to results cited by Sweet on urban wives. The inverse dependency ratio effect would appear contrary to the age eligibility effect, and may be due to a regression error. For whites, the positive effect of poverty corresponds to the explanation given above for males. The positive effect of bottled gas is likely due to the greater presence of bottled gas for house heating in poorer areas (*r* bottled gas, income 0-3999) = .31.

SA unemployment is most strongly (positively) related to the white fertility ratio. This is likely the result of high SA fertility–*r* (SA fertility, white fertility) = .36, with an explanation corresponding to that of Sweet referred to before in the discussion of female unemployment. The negative effect from electrical heating likely follows the same reasoning for electrical heating given above for female work participation in the geothermal sample. Unemployment shows greater differences between geothermal and nongeothermal than did the previous sets of dependent variables. For geothermal areas, all categories have positive relationships with fertility—as explained above. However, the reason for the greater importance of fertility in geothermal, as opposed to nongeothermal areas, is unexplained. The positive relationships with poverty for males and with gas heating usage for whites are direct economic effects, since gas usage follows a pattern opposite to that for electricity.

For the nongeothermal region, economic-related variables and migration variables are dominant for the non-SA categories. These are mostly self-evident. For example, for women, the per cent below poverty exerts a positive effect on unemployment. One unexplained effect, for males and whites, is the positive employment effect of low house values. This appears contradictory and may be spurious.

For nongeothermal SA, the positive effect of per cent married on employment is ascribed to marital pressures for economic support. The lack of such an effect in the geothermal (more urban) areas may possibly be due to increased welfare support and a larger job market easing the risks of unemployment. There is a significant negative employment effect from household mobility, the result perhaps of mobility-associated job disruption. Finally, the reduction in employment from increased percentage of owners of $25,000 + homes would appear contradictory, and perhaps is spurious.

IMPLICATIONS OF GEOTHERMAL DEVELOPMENT ON REGIONAL EMPLOYMENT

Imperial County has had a stable agricultural-dominated economy for decades. For these years, the county work force has had lower age and educational levels than the state. Subject to a .7 per cent annual outmigration, the county work force has lost many of its skilled and trained youth—lowering the average skill levels of the county. Finally, there is a large, highly seasonal, and currently about half non-U.S.-resident farm labor work force commuting from Mexico. The prospective advent of geothermal energy development may alter each of the above fundamental county economic factors. The dominance of agriculture may be reduced or displaced by a large-scale energy-industrialization process. It is also necessary to consider concurrent trends, such as rising salinity of the Cororado River, virtually the sole source of county agricultural water, which may reduce crop yields and cause further shifts to salt-tolerant but often less profitable crops.

The second fundamental feature, the presence of a large and partly non-resident farm labor segment—may be somewhat altered by energy development. Based on geographical and agricultural data from Johnson [18] and Rose [4], estimates were done of farm laborer displacements for the medium growth scenario of geothermal power plant capacity of Davis [2]. This scenario scales up capacity rapidly beginning in 1990 to a steady level of 3500 MW in 2010. Assuming a maximal agricultural land loss of 35 per cent in well-siting areas from geothermal power plant and well acreage, transmission lines, access roads, possible land subsidence, etc., a total of 150 farm laborers are estimated to be displaced from the land effect alone in 2010, assuming constant 1970 agricultural productivities [19]. Hence, a substantial low-skill farm labor segment will likely remain present in Imperial County even after geothermal development reaches a stable state unless other factors result in a decline of county agriculture or large scale industrialization utilizes extensive agricultural land.

The third major historical influence of persistent net outmigration, especially of young adults, may be altered by the attraction of jobs directly and indirectly created by geothermal energy. However, concurrent migration such as the recent national trend of net return to rural areas, may alter Imperial's migration streams as much or more than geothermal development. Two factors mitigating against substantial inmigration are the county's inhospitable summer climate, and lack of cultural attractions characteristic of the major labor force areas of California. The latter attractions might appear, of course, as the result of energy development. Judging from results of the Gray study [9], a large proportion of potential local geothermal workers probably do not possess the appropriate skills for newly created jobs, and thus may continue to outmigrate. This problem appears to be potentially severe for young SAs, who possess below average education and training. Even in the currently pregeothermal labor market, the high level of unemployment suggests a population pool of employables available, especially SAs, who need to be trained for more skilled jobs. It would appear important for geothermal planners and policy makers to consider establishment of on-the-job training or training centers in order to avoid either continuing departure of lesser-skilled young adults or the necessity for workers to travel outside the labor region to obtain retraining, as was done in West Virginia.

Having detailed several fundamental county economic forces and their likelihood for change, we may ask, how do the results of these analyses help elucidate such future processes? One inability of regression is indication of cause and effect, further complicated by economic processes which are often circular. Nevertheless, one may speculate on several important age eligibility and participation implications as a result of geothermal energy development. The first of these are potential enhancement of age eligibility if future county fertility levels are reduced, potential increases in labor force participation if average county personal income levels rise from geothermal development, potential decreases in participation if inmigration of aged persons for retirement increases, a distinct possibility if current trends continue. Regression implications for unemployment are more complex and must be examined by category. For the male and white categories, a direct reduction in unemployment with more ample personal income and decreased poverty stemming from geothermal development may be inferred. For females, unemployment may be reduced through higher age eligibility, if county fertility levels are indirectly reduced by geothermal development. The mode for this indirect reduction is hypothesized as follows: 1. geothermal development and related industrialization will increase the volume of inmigration into the county; 2. an increase will occur in the county's overall percentage anglo, due to a higher percentage of anglos in the county's inmigration stream from 1. (This would stem from closer correspondence to statewide inmigration percentages); 3. higher per cent anglo will lead to a reduction in the county fertility rate. Finally, SA unemployment may be reduced if fertility lessens, due to the positive SA fertility regression result already discussed.

In general, geothermal influence on the county fertility pattern (see Table 1) by an increasing urban proportion or by high proportions of anglo inmigrants may result in an older age structure. This, combined with the lower fertility and geothermal development related increases in personal income, may effect increases from the present low levels of county employment, relative to total population, age eligible population, and the work force.

A feature of the areal subsamples is geographic specificity for localized effects, such as certain pollutants and nonelectrical uses. If nonelectrical employment increases are even moderately localized in geothermal EDs, the regression differences between geothermal and nongeothermal areas may be of use to planners.

An example of such differences is the greater positive influence of fertility on unemployment in geothermal areas relative to nongeothermal areas. Therefore, the policy implications might be that fertility reduction might contribute towards reducing unemployment in areas of nonelectrical industries (i.e., the area of the geothermal sample). Such an inference is based on the assumption that geothermal energy development would not substantially alter the social forces on unemployment prevailing in the county in 1970.

An improved approach to policy formulation would be to update these regression studies periodically as new data become available during the geothermal development process. In such a case, not only would updated social data become available, but, also, more significant geothermal variables would be available besides the KGRA boundaries used in the present study. It should be reemphasized that the present study is *prospective,* since no geothermal capacity, electrical or direct use, existed in the county in 1970, the year of the data. In future studies, regressions could be performed based on geothermal data for power plant generating capacity, nonelectrical transmission flow rates, geothermal investment, number of geothermal employees and so forth.

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