The Locational Determinants of Western Nonmetro High Tech Manufacturers: An Econometric Analysis

David L. Barkley and John E. Keith

The Tobit estimation procedure was used to determine the factors which influence the location and size of high technology manufacturers in nonmetro areas in the West. The results indicate that high tech branch plants tend to locate in populous counties adjacent to Metropolitan Statistical Areas (MSAs). Percent of local employment in manufacturing and agriculture was inversely related to branch plant employment, and the stock of human capital was not significantly related to employment. High tech unit plants also exhibited a propensity to locate in the more populous counties. Unlike branch plants, the unit concerns were more likely to develop or locate in communities with a highly educated work force and at greater distances from metro areas. The unit plants better fit the perception of high tech plants selecting high amenity locations with abundant skilled labor.

Key words: high tech manufacturing, location, nonmetropolitan, qualitative models.

Declining employment in resource-based activities and mature manufacturing industries has encouraged nonmetropolitan communities to seek alternative sources of basic employment and income. Following the lead of metropolitan areas, many rural communities have investigated the possibility of attracting or generating employment in the rapidly growing and skilled labor-intensive high technology manufacturing industries with some recent evidence of success. High technology industries are decentralizing their manufacturing activities, and as a result, nonmetropolitan employment growth in this sector has increased (Markusen, Hall, and Glasmeier; Barkley; Glasmeier; Miller 1989). For example, Barkley estimated that in 1982 over 511,000 high tech manufacturing jobs were located in nonmetropolitan counties. Moreover, during the period 1975–82, the nonmetropolitan employment growth rate in this sector exceeded 15%.[1]

Nonmetropolitan areas in the West have been successful in attracting or generating employment in high technology manufacturing. Over 27,000 high tech manufacturing jobs were located in the nonmetro West in 1982, and the 1975–82 growth rate exceeded 90% (Barkley, Keith, and Smith). This employment in high tech manufacturing was not, however, distributed uniformly among the 346 western nonmetropolitan counties. In 1982 in 119 of these counties (34.4%), there was no employment in high tech sectors, and only 110 of the nonmetro counties (31.8%) reported more than 50 persons employed in high tech manufacturing. These percentages suggest that western nonmetro high tech employment is relatively concentrated, and thus the economic development

David L. Barkley is a professor and an economic development specialist in the Department of Agricultural and Applied Economics, Clemson University; John E. Keith is a professor in the Economics Department, Utah State University. Seniority of authorship is not implied by the order of authors' names.

This research was supported in part by the Western Rural Development Center, Oregon State University, and the Utah and Arizona Agricultural Experiment Stations, Regional Project W-165.

The authors gratefully acknowledge helpful comments from the editor, Bruce Weber, and anonymous reviewers. Any remaining errors or omissions are, of course, the responsibility of the authors.

[1] Throughout this article, "metropolitan" and "urban" refer to Metropolitan Statistical Areas (MSAs). "Rural" and "nonmetropolitan" are used interchangeably to refer to nonMetropolitan Statistical Areas (nonMSAs).

Western Journal of Agricultural Economics, 16(2): 331–344

Table 1. High Technology Manufacturing Industries

Standard Industrial Code[a]	Industry Group
281	Industrial inorganic chemicals
282	Plastic materials, synthetics
283	Drugs
286	Industrial organic chemicals
289	Miscellaneous chemical products
291	Petroleum refining
348	Ordnance and accessories, n.e.c.
351	Engines and turbines
353	Construction and related machinery
356	General industrial machinery
358	Office and computing machines
362	Electrical industrial apparatus
365	Radio and TV receiving equipment
366	Communication equipment
367	Electronic components, accessories
372	Aircraft and parts
376	Guided missiles, space vehicles
381	Engineering, scientific instruments
382	Measuring and control devices
383	Optical instruments and lenses
384	Medical instruments and supplies
385	Ophthalmic goods
386	Photographic equipment and supplies
387	Watches and clocks

[a] 1977 Standard Industrial Classifications from Armington, Harris, and Odle.

benefits associated with the decentralization of these firms are spatially limited.

The purpose of this study is to determine the distinguishing characteristics of western nonmetropolitan counties in which high tech manufacturing has located. Insight into factors associated with high tech plant locations and employment should enable rural communities to (*a*) better assess their potential as locations for high tech firms and (*b*) identify program areas which may augment the communities' competitive advantages in attracting or generating high tech activity. The article is organized as follows. First, high technology manufacturers are identified and the characteristics and locations of western nonmetro high tech firms are summarized. For this study, the West is defined as the 11 contiguous states in the Mountain and Pacific census divisions (Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming). Second, an econometric analysis of county-level data is undertaken to determine if the existence and magnitude of high tech employment are associated significantly with selected nonmetropolitan county characteristics. The Tobit estimation procedure was used to estimate the relationships between high tech employment and county characteristics from the censored data. The nonmetropolitan high tech employment data were disaggregated by plant ownership type (branch plants vs. unit plants) to determine if community factors associated with plant location varied by locus of control. Finally, the findings are summarized and policy implications are suggested.

Overview of Western High Tech Manufacturing

High Tech Manufacturing

Definitions of high technology industries vary; however, they generally are based on the following criteria (Etzioni and Jargowsky):

(*a*) a high percentage of an industry's gross revenue or output is dedicated to research and development,
(*b*) the industry's workforce includes a high percentage of scientists and engineers, and/or
(*c*) a high percentage of laborers characterized as highly skilled.

The definition used in this study is that developed in 1983 by Armington, Harris, and Odle of the Brookings Institution. This definition (based on national data) classified an industry as high technology if (*a*) more than 8% of its employees were in scientific, engineering, and technical occupations, and at least 5% of industry employment was in the more narrow class of scientific and engineering occupations; or (*b*) expenditures for research and development were a relatively large percent (greater than 5%) of product sales. Twenty-four manufacturing industries were identified under these criteria (table 1).

Employment Patterns

Metropolitan areas in the 11 contiguous western states have been relatively successful in attracting and generating high technology manufacturing employment (table 2). The 1975–82 metropolitan high tech growth rate exceeded 50%, and total high tech employ-

Table 2. High Technology Manufacturing Employment in the Western States, 1975-82

State	Metropolitan			Nonmetropolitan		
	1975	1982	% Change	1975	1982	% Change
Arizona	39,728	73,836	85.9	956	1,777	85.9
California	538,498	782,101	45.2	2,029	4,175	105.8
Colorado	30,727	65,532	113.3	1,142	1,596	39.8
Idaho	189	1,647	771.4	1,545	2,807	81.7
Montana	766	925	20.8	392	718	83.2
Nevada	817	2,906	255.7	597	301	−49.6
New Mexico	4,061	7,791	91.8	1,182	2,110	78.5
Oregon	14,730	21,071	43.0	1,250	4,498	259.8
Utah	14,274	26,218	83.7	2,881	5,605	94.6
Washington	61,550	90,393	46.9	2,064	2,744	32.9
Wyoming	829	1,285	55.0	447	1,279	186.1
Total	706,169	1,073,705	52.0	14,485	27,610	90.6

Source: Enhanced County Business Patterns, 1975 and 1982. The Enhanced County Business Patterns is a data file created by the National Planning Data Corporation (Ithaca, New York) by additional processing of the U.S. Department of Commerce County Business Pattern Series, which involves estimating suppressed data.

ment in the region's urban areas was in excess of one million jobs in 1982. This employment was concentrated in California; however, Arizona, Colorado, and Washington also developed significant employment in this sector by 1982.

Nonmetropolitan counties in the West also benefited from the region's growth in high technology employment. All states except Nevada experienced rapid nonmetro employment growth in these industries from 1975 to 1982, and over 13,000 high tech jobs were added to western rural areas during this period. Nonmetropolitan areas in Oregon, Wyoming, California, Utah, Arizona, Montana, Idaho, and New Mexico experienced the greatest relative gains in high technology employment, all exceeding 75%. Despite this recent success of some areas, high technology manufacturers were not a major source of employment in the nonmetropolitan areas of most western states. Only 27,610 high tech jobs existed in the nonmetro West in 1982, and 14,278 (52%) of these jobs were in nonmetro counties in California, Oregon, and Utah.[2]

Preliminary analysis of the employment data indicates that western nonmetro high tech manufacturing was concentrated in the more populous counties and in counties adjacent to metropolitan areas (table 3). Specifically, only 96 of the 346 nonmetro counties (28%) had populations exceeding 25,000, yet almost 80% of the high tech employment was located in these counties. At the other extreme, 41% of the nonmetro counties had populations less than 10,000, yet only 5.4% of the high tech employment was located there. Also, the 264 nonadjacent counties (76%) and the 82 adjacent counties (24%) each had approximately 50% of the employment in this sector.

This proclivity for locating in large and adjacent counties held for both unit plants and the branches of multiplant operations (table 3). For example, 57.3% of the nonmetro high tech employment was in the branches of multiplant firms. Of this branch employment, 50% was distributed among the counties which were adjacent to metro areas (24% of the total), and 82% was located in the 96 counties with populations greater than 25,000 (28% of the total). The pattern for unit plants was only slightly less concentrated with 74.9% located in the larger counties (25,000 plus) and 47.8% in counties adjacent to metro areas.

[2] Nonmetro areas in the West differed in the types of high tech manufacturing represented. Enhanced County Business Patterns employment data indicate that in three of the 11 western states (New Mexico, Washington, Wyoming), nonmetropolitan high tech employment was largely the result of the significant presence of the petrochemical industries. Nonmetropolitan areas in California, Colorado, Idaho, Montana, and Nevada were similar in that electronic components, accessories, and apparatus manufacturers were important employers. Other employers of significance in these five states include the manufacturers of measuring and control devices, construction machinery, and communication equipment. Nonmetropolitan areas in Oregon, Arizona, and Utah have developed high tech sectors unlike other western states. Arizona's nonmetropolitan technical sector was relatively diversified with the medical instruments and plastics materials industries providing the greatest employment. The office and computing machines industry dominated nonmetropolitan high tech employment in Oregon, while guided missile and space vehicle industries were dominant in Utah.

Table 3. Distribution of Nonmetro High Tech Employment by County Size and Adjacency Status, Western States, 1982

Population	Unit Plants		Branch Plants		All Plants		
	Adjacent	Non-adjacent	Adjacent	Non-adjacent	Adjacent	Non-adjacent	All Counties
	%						
Small	.9[a]	1.4	.3	2.8	1.2	4.2	5.4
(0–10,000)	(5.0)[b]	(36.2)	(5.0)	(36.2)	(5.0)	(36.2)	(41.2)
Medium	1.1	6.6	1.7	5.5	2.8	12.1	14.9
(10,000–25,000)	(5.9)	(24.7)	(5.9)	(24.7)	(5.9)	(24.7)	(30.6)
Large	18.4	14.4	27.5	19.5	45.9	33.9	79.8
(25,000+)	(13.2)	(15.0)	(13.2)	(15.0)	(13.2)	(15.0)	(28.2)
Total	20.4	22.4	29.5	27.8	49.9	50.2	100.1
	(24.1)	(75.9)	(24.1)	(75.9)	(24.1)	(75.9)	(100.0)

Source: Compiled from Enhanced County Business Patterns, 1982.
[a] Percent of total western nonmetro high tech employment in the size-adjacency category.
[b] Percent of the 340 western nonmetro counties in the size-adjacency category.

Community Characteristics and Industrial Location

Previous research on the locational determinants of manufacturers found that nonmetro plant locations were influenced by labor and industrial site availability, access to markets, labor costs, and, at times, local taxes.[3] These findings are consistent with the product life cycle and spatial division of labor theories (Vernon; Thompson; Suarez-Villa; Markusen). According to these theories, rural areas are viable locations for the slowly growing, low-profit, mature manufacturers. Such industries generally have standardized production processes, and thus can significantly reduce production costs by locating in areas with low-cost labor and land.

Schmenner, Huber, and Cook demonstrated, however, that the locational attributes considered important to manufacturers vary significantly depending on product type, mission of the plant, and production process. Thus, community characteristics found to be important to mature manufacturers (labor and industrial site availability, proximity to markets, community infrastructure) may not reflect locational factors important to firms in the high tech sector. Nonmetropolitan high tech firms generally are more skilled-labor intensive than manufacturers in other sectors (Barkley, Dahlgran, and Smith). As a result, communities with abundant low-skill, low-cost labor may not be attractive locations to high tech firms. Moreover, nonmetropolitan high tech manufacturers may be less sensitive to transportation costs and less dependent on local markets than other firms. Oakey, and Smith and Barkley found that nonlocal purchases are extensive in high tech industries. These nonlocal inputs often come from numerous locations (Hagey and Malecki). In addition, the intermediate manufactured inputs of many high tech firms such as electronic components manufacturers are relatively inexpensive to transport, and the value of the final product is high relative to transportation costs. In this case, as Goode points out, factors that normally reflect proximity to input and output markets (e.g., distance from MSA, proximity to interstate highways and rail lines, local availability of intermediate inputs) may be of limited importance to high tech manufacturers. In the following sections, the characteristics of nonmetropolitan high tech manufacturing locations in the West are analyzed to determine if the locational factors associated with nonmetro high tech firms differ from those noted in earlier studies of rural plant locations.

[3] Earlier studies of manufacturing locations in nonmetropolitan areas include: Dorf and Emerson; Cromley and Leinbach; Miller 1980; Erickson; Luloff and Chittenden; Erickson and Leinbach; Fisher; McNamara, Kriesel, and Deaton; and Walker and Calzonetti.

Data

The manufacturing plant location decision is viewed by neoclassical location theory as selecting the production function–location combination that maximizes the owner's profit or utility function (Blair and Premus). This perspective suggests that firms quantify and compare the costs and benefits associated with a finite number of alternative locations. Locational factors included in this comparison are access to input and product markets; labor costs, availability, and quality; industrial site availability and quality; external economies (urbanization and localization); and perceptions of the quality of life. Thus, location theory suggests that the volume of high tech manufacturing employment in nonmetro communities is related to subsets of community characteristics. Specifically,

$$HTE^i = f(LF^i, LOC^i, EXEC^i, QOL^i),$$

where HTE^i denotes high tech manufacturing employment in county i, LF^i is a vector of labor force characteristics in county i, LOC^i is a vector of locational characteristics, $EXEC^i$ is a vector of variables representing availability of external economies, and QOL^i is a vector of local quality of life attributes.

Employment Data

1982 nonmetropolitan county employment data for manufacturers in the high tech sector were available in the U.S. Establishment Enterprise Microdata file (USEEM). USEEM is a proprietary data set developed by the Brookings Institution from Dun and Bradstreet's DUNS Market Identifier files. County-level employment is provided by plant ownership type (branch vs. unit plant) thus permitting a comparison of locational factors by locus of control. Unfortunately, disclosure laws prevented the acquisition of county-level employment for specific high tech industries. However, the aggregated data should provide insight into factors affecting location and growth.

County Characteristics

Measures for nonmetropolitan county characteristics were obtained from the Montana State University City and County Data Base, a computerized collection of data from the City and County Data series published by the U.S. Department of Commerce. The independent variables selected for this research were those factors found to be significant in earlier nonmetro industrial location studies plus characteristics suggested by case studies and "common knowledge" (e.g., universities and climate). County characteristics for 1970 were selected to insure a reasonable lag between local attributes and the development of a high tech sector. Quite clearly, some simultaneity would exist in those counties having significant high tech manufacturing employment in 1970. Much of the growth in high tech employment is relatively recent; thus, this simultaneity should not be a serious problem.[4]

In total, over 70 measures were chosen to represent the counties' socio-, demographic, and economic environments (appendix, table A1). Obviously, much redundancy and correlation exists among these characteristics. As an aid to selecting uncorrelated explanatory variables, a factor analysis was completed for the variables using the SAS Factor program with standard parameters (Dorf and Emerson). Table 4 provides the factors and associated variables with their factor weightings. The results indicate that the community characteristics clustered fairly "cleanly" into 11 principal categories. That is, differences among the 346 western nonmetro counties may be represented by 11 characteristic groupings or factors. Specifically, factor 1 included county characteristics closely associated with county size and urbanization (e.g., number of doctors, dentists, and hospital beds; existence of colleges or universities; employment in specific industrial sectors; and government expenditures per capita). Thus, county population (*POP*) was selected as the proxy variable for (*a*) the availability of a broad array of public and private services and (*b*) labor availability. A positive relationship between *POP* and *HTE* is expected.

Note that it would have been desirable to include "university present" and "government expenditures per capita" as separate explanatory variables. The factor analysis demonstrates, however, that for the nonmetro West these variables are highly correlated with county population. To avoid estimation problems inherent with correlated explanatory variables, *POP* was selected to represent the "basket of goods" available in different coun-

[4] Over 50% of the West's nonmetro high tech employment has developed since 1975. Thus, the simultaneity problem should be minimized by using 1970 community characteristics to explain 1982 employment.

Table 4. Factors and Loading Variables

Factor 1	Factor 2	Factor 3	Factor 4
POP .99	*MDSCYR* .79	*FRMLAB* .79	*JANHT* −.50
Fem Emp .99	*% Hi Sch* .85	*Farm Sales* .64	*Rural Frm Pop* .39
NW Pop .98	*Per Cap Inc* .71	*Ag & For Emp* .74	*Jul Cool* .35
Tot W Pop .90	*Med Fam Inc* .6	*FRMOWN* .38	
Universities .89	*White Pov* −.51		
Val Fam Hs .87	*Prop Tax* .71		
Dentst .80	*Med Gross Rent* .72		
Govt Expend .89	*% Urban* .54		
Hosp Beds .54	*NW Pov* −.46		
Rural Nonfarm Pop .84			
MFG .95			

Factor 5	Factor 6	Factor 7	Factor 8
Fem Emp .92	*MIN* .47	*% Urban* .52	*MIN* .40
Male Emp .94	*% 18 +* .41	*NETMIG* .50	
Fem Unemp .91	*Land Area* .48	*% 4 +* .40	
Male Unemp .92	*% Frm Land* .46	*Work Out* .39	
	Farm Size .47		

Factor 9	Factor 10	Factor 11	
MILB −.41	*% 18 +* .49	*ADJ* −.42	
MILEM −.44	*% 65 +* .59		

Note: Variable definitions are provided in appendix table A1.

ty-size groups. Unfortunately, we cannot isolate the relative importance of the items in the basket.

Factor 2 is an interesting mix of education, income, and property value measures. This grouping of characteristics was interpreted to represent the economic "well-being" of the county. Median School Years (*MDSCYR*) was chosen as the proxy variable for this factor, and a positive relationship between *MDSCYR* and *HTE* should be evident if high tech firms seek locations with abundant skilled labor or strong economies. Again, we would have preferred to enter "median school years," "per capita income," and "mean property values" as proxies for "stock of human capital," "labor costs," and "land costs," respectively. As noted above, the factor analysis demonstrates that this was not practical given the highly correlated nature of the variables.

Factor 3 included variables associated with farm employment and sales. This factor should represent the importance of agriculture in the local economy. Because of high correlations between total farm employment and total employment in other sectors, agricultural employment [the sum of farm laborers and foremen (*FRMLAB*) and farmers and farm managers (*FRMOWN*)] was divided by total employment to get agricultural employment as a percentage of total employment (*AGEMP*), which was then used as a proxy variable for this factor. Agricultural counties may provide a surplus labor pool. On the other hand, areas in the West which are dominated by agricultural employment appear to have relatively fewer recreational opportunities and natural amenities than counties less suitable for agriculture. In addition, the agricultural sector uses few high tech inputs with the possible exception of chemicals. Therefore, there is no a priori expectation about the sign of this variable.

Factor 4 was the climatic factor. January heating degree days (*JANHT*) (indicating the amount of heating required in the month of January) was selected as the proxy variable for climate. While this variable does not necessarily reflect economic theory, a test of the popular perception of high tech industry moving to the "Sun Belt" was provided by this measure. No sign for the coefficient of *JANHT* was hypothesized a priori.[5]

Factor 5 included total employment and unemployment by sex (*Fem Emp, Fem Unemp, Male Emp, Male Unemp*). The rate of unemployment (*UNEMP*) was selected to represent this grouping, again because the correlation matrix indicated a very high correlation of total employment and unemployment to population. The unemployment rate was calculated by dividing the sum of male and female unemployment by the sum of male and female employment and unemployment in a given county. This "rate" variable represents the relative "tightness" of the labor market in a county, and a positive relationship between *UNEMP* and *HTE* should exist if high tech firms are attracted to areas with surplus labor.

Factor 8 related to total mining employment. Again, because this employment was closely related to total population, mining employment (*MIN*) was divided by total employment to obtain a ratio (*MINEMP*) which was used in the analysis. This variable represents the impact of petroleum and other mineral and nonmineral sectors on high tech locations and employment. Mining industries are major markets for high tech products; therefore, it was hypothesized that the *MINEMP* variable and *HTE* would be positively correlated.

Factor 11 identified counties adjacent to metro areas. A dummy variable for this adjacency was included (*ADJ*). Since metro areas provide both markets for and spill overs from high tech industries, a positive correlation between *ADJ* and *HTE* was anticipated.

Finally,[6] factors 6 and 7 included relatively heterogeneous collections of community characteristics and not very strong factor loadings. Moreover, the measures for agricultural and mining activity in factor 6 and urbanization, commuting, and education in factor 7 were accounted for in other factors. Thus, the only variable selected from these two characteristic groupings was 1960 to 1970 net migration (*NETMIG*). Net migration is defined as in-migration minus out-migration and the difference could be positive, zero, or negative. This variable reflects the past growth history of the county and, indirectly, the general attractiveness of the area to outsiders. A positive relationship is hypothesized between *HTE* and *NETMIG*.

In summary, the factor analysis identified eight distinct county characteristics groupings which were considered relevant to firm location decisions. The characteristics identified were very similar to those selected in earlier location studies. Specifically, the availability of public and private services, the availability of labor, presence of a university, and levels of government expenditures have been shown to influence firm location decisions. In the nonmetro West, these characteristics were highly correlated with county population and thus represented by one variable (*POP*). County income, education, and property values are also anticipated to affect location decisions. Again, however, these measures were highly correlated, and thus, must be represented by one measure (*MDSCYR*).

Labor force characteristics identified were unemployment rate (*UNEMP*), agricultural employment as a percent of total employment (*AGEMP*), and mining employment as a percent of total (*MINEMP*). To these was added manufacturing employment as a percent of total (*MFGEMP*), calculated by dividing total manufacturing employment (*MFG*) by total employment. The *MINEMP* and *MFGEMP* variables are proxies for proximity to potential markets, and positive relationships between *HTE* and *MFGEMP* and *MINEMP* are anticipated. Bender et al. have shown that most nonmetropolitan communities are highly specialized, that is, readily characterized as farming, mining, or manufacturing towns. The coefficients of the *MFGEMP, MINEMP* and *AGEMP* variables should provide insight into the attractiveness of specialized economies to high tech firms.

To the locational characteristics identified by factor analysis (*ADJ* and *JANHT*) we added a dummy variable for adjacency to an interstate highway (*HWY*). Past studies have found a positive relationship between interstate access and economic development. Finally, local quality of life is an umbrella concept for which

---

[5] Metropolitan centers of high tech activity exist in both the "warmer" climates (Phoenix, Tucson, Los Angeles, Albuquerque) and the "cooler" climates (San Francisco, Portland, Seattle, Denver) of the West. Thus, neither the "northern" nor "southern" nonmetropolitan areas appears to be isolated from high tech markets.

[6] Factors 9 and 10 related to the existence or size of military activity (*MILB* and *MILEM*) and the percentage of population over 18 and over 65 (*% 18+, % 65+*), respectively. In earlier tests of various models, these variables were highly correlated with other included variables and never significantly related to *HTE* and, therefore, were not used in the final model.

no one variable can adequately account. A number of the characteristic groupings do, however, provide some insight into quality of life. For example, *POP* reflects the availability of local services and government spending per capita, *MDSCYR* is positively correlated with family income and property values and negatively related to the local incidence of poverty, *ADJ* reflects proximity to metropolitan goods and services, and *NETMIG* is a proxy for the attractiveness of the county to outsiders.[7]

Estimation Procedure

The empirical models to be estimated are:

HTEu = *f*(*POP, HWY, ADJ, MDSCYR, JANHT, UNEMP, NETMIG, MFGEMP, AGEMP, MINEMP*)

and

HTEb = *f*(*POP, HWY, ADJ, MDSCYR, JANHT, UNEMP, NETMIG, MFGEMP, AGEMP, MINEMP*)

where *HTEu* denotes county high tech manufacturing employment in unit plants during 1982 and *HTEb* denotes county high tech manufacturing employment in branch plants during 1982.

In many earlier location studies, ordinary least squares (or generalized least squares) approaches were used to estimate the relationships between local characteristics and local employment in a specific sector. Peddle has pointed out, however, that employment data may be censored, in the sense that there may be significant numbers of counties (or other locational identifications) in which no observed employment occurs. As Amemiya, among others, has noted, the use of a least-squares estimator for censored data results in estimators which are inconsistent. The problem is a significant one in nonmetro high tech location analysis, as indicated by the fact that 119 of the 346 counties had no high tech employment.

The statistical approach used to correct for censored data estimation problems is the Tobit model. According to Peddle (p. 304), the Tobit procedure recognizes the special nature of threshold values of independent variables and makes use of the information contained in counties with zero employment. The Tobit model analyzes first the difference between zero and nonzero values and then differentiating on the basis of explanatory variables, between varying nonzero levels of employment.

[7] Data on miles of seacoast, number of lakes, number of amusement parks, and other variables for specific amenities were available. However, none of these measures were found to be significantly correlated with location in estimations not reported herein.

Estimation Results

The Tobit estimation results are presented in table 5 for high tech branch plants and table 6 for high tech unit plants. Also provided are the means and standard deviations of the independent variables. Note that the estimation software which was used (LIMDEP as developed by Green) eliminated all observations with missing variables. As a result, the estimations were based on 318 rather than 346 counties. Maximum likelihood estimations were used in order to provide the most consistent and efficient estimators (although heteroskedasticity may remain a problem).

Branch Plants

The results of the Tobit analysis indicate interesting differences between the locational determinants of high tech branch and unit plants. High tech branch plant employment was positively related to county population, net migration rates, and proximity to metropolitan areas. Thus, branch plants were attracted to areas with abundant and growing labor markets, readily available public and private services, and access to the product and input markets of metropolitan areas. In addition, branch plants were more likely to locate in the northern rather than southern areas of the West.

The labor market characteristics of counties with high tech branches were somewhat unexpected. Branch plant employment was negatively related to the local concentrations of agricultural and manufacturing employment, yet the coefficient for concentration of mining activity was not significant. These findings would seem to indicate that, with the possible exception of firms supplying the mining industries, branch plants tended to locate in economies not dominated by manufacturing or agriculture. More specifically, the negative correlation between "percent of employment in manufacturing" and high tech employment may be interpreted as indicating that local

Table 5. Determinants of High Tech Manufacturing Employment, Branch Plants, Nonmetropolitan West, 1982

Exogenous Variables	Mean	Std. Dev.	Tobit	Adjusted Tobit Employment Estimate
Intercept			−2,327.34 (−1.97)**	−597.74
Population (*POP*)	20,752.0	23,666.0	0.017 (5.85)***	0.0044
Adjacent to MSA (*ADJ*)[a]	0.289	0.454	465.01 (3.03)***	119.43
Interstate Highway (*HWY*)[a]	0.384	0.487	−112.39 (−0.84)	−28.866
Heating Degree Days in January (*JANHT*)	1,093.0	294.0	1.06 (3.90)***	0.27
Median School Years (*MDSCYR*)	11.99	0.68	39.69 (0.40)	10.19
Unemployment Rate (*UNEMP*)	0.108	0.111	−560.07 (0.86)	−143.84
Net Migration Rate (*NETMIG*)	31.54	26.43	4.63 (1.49)	1.19
Agricultural Employment as a Percent of Total (*AGEMP*)	0.157	0.109	−2,457.94 (−2.71)**	−631.28
Manufacturing Employment as a Percent of Total (*MFGEMP*)	0.107	0.087	−2,002.47 (−2.18)***	−514.30
Mining Employment as a Percent of Total (*MINEMP*)	0.038	0.075	599.46 (0.67)	153.96
Sigma			790.50 (13.17)***	
R^2			.16	
Number			318[a]	

Note: Triple asterisks indicate significance at the .01 level, double asterisks indicate significance at the .05 level, and an asterisk indicates significance at the .10 level.
[a] Binary variable.

manufacturing markets were not important to these plants, or alternatively, competition for labor in manufacturing communities discouraged high tech branch plant locations. The reluctance of high tech branch plants to locate in agricultural counties may reflect the isolation or low natural amenities (fewer mountains, lakes, canyons, etc.) of these areas relative to other western locations. Finally, the county unemployment rate was inversely but not significantly related to high tech branch employment. Thus, high tech branches do not appear to be attracted to "slack" rural labor markets as were many of the early nonmetro manufacturers.

The final variable of interest is median school years, our principal proxy for local income levels and quality (stock) of human capital. The coefficient on this variable was positive but not significant at the .10 level. Thus, while the branches were not attracted to economically stagnant communities (as evidenced by the coefficients on unemployment and net migration rates), no strong association was found with communities with high incomes and educational levels.[8]

Unit Plants

The locational determinants for locally owned high tech plants were similar to those just discussed for branch plants, but with some interesting exceptions (table 6). The unit plants also preferred locations in populous counties, adjacent to metro areas, in northern states, with no concentration in agriculture or manufac-

[8] The significance of sigma in the regression results is of interest. Sigma reflects the importance of censoring in the data in estimation.

Table 6. Determinants of High Tech Manufacturing Employment, Unit Plants, Nonmetropolitan West, 1982

Exogenous Variables	Mean	Std. Dev.	Tobit	Adjusted Tobit Employment Estimate
Intercept			−403.04 (−2.03)**	−142.36
Population (*POP*)	20,752.0	23,666.0	0.0033 (6.56)***	0.0012
Adjacent to MSA (*ADJ*)[a]	0.289	0.454	29.78 (1.20)	10.51
Interstate Highway (*HWY*)[a]	0.384	0.487	−7.96 (−0.36)	−2.81
Heating Degree Days in January (*JANHT*)	1,093.0	294.0	0.06 (1.55)	0.023
Median School Years (*MDSCYR*)	11.99	0.68	27.02 (1.65)*	9.54
Unemployment Rate (*UNEMP*)	0.108	0.111	−93.46 (−0.85)	−33.01
Net Migration Rate (*NETMIG*)	31.54	26.43	0.35 (0.70)	0.12
Agricultural Employment as a Percent of Total (*AGEMP*)	0.157	0.109	−515.21 (−3.58)***	−181.98
Manufacturing Employment as a Percent of Total (*MFGEMP*)	0.107	0.087	−356.94 (2.56)***	−126.08
Mining Employment as a Percent of Total (*MINEMP*)	0.038	0.075	−79.75 (−0.52)	−28.17
Sigma			150.84 (17.11)***	
R^2			.07	
Number			318	

Note: Triple asterisks indicate significance at the .01 level, double asterisks indicate significance at the .05 level, and an asterisk indicates significance at the .10 level.
[a] Binary variable.

turing. Yet, the unit plants' preferences for adjacency to MSAs and the northern regions of the West were much weaker than those observed for branch plants. Most interesting, however, is that the variable representing local income levels and stock of human capital (median school years) is positively and significantly correlated with unit plant locations. This finding supports the hypothesis that an educated/skilled labor force is of greater importance to unit plants than to high tech branches. The positive relationship between educational levels and unit plant employment is consistent with both the product life cycle theory and recent studies in entrepreneurial development (Cooper). The unit plants exhibited characteristics of firms in the earlier stages of the product cycle (Smith and Barkley). These establishments employed a relatively large number of individuals in research and development and in precision production. Thus, a well-educated labor force should be an advantage. Also, the founders of new high tech firms are generally well educated, and communities with a large pool of such individuals should experience a greater likelihood of high tech related entrepreneurial activity.

Decomposition of Tobit Results

McDonald and Moffitt have shown that the Tobit coefficients can provide additional insight with both economic and policy implications. The McDonald-Moffitt technique provides a fraction by which the Tobit coefficients can be decomposed into two effects. Part one of the decomposition represents the effect of a change in an exogenous variable on the probability of the dependent variable being above the limit (i.e., a high tech firm exists in the county). The second part is the effect of a change in an exogenous variable on the dependent variable assuming the dependent variable is already above the limit (i.e., employment is greater than zero). The coefficients provided by the second part more correctly represent the relationship between a change in community characteristics and a change in employment for counties with high tech firms. The amount of the adjustment depends on the proportion of the sample that is not at the limits, with higher proportions resulting in a smaller reduction of the coefficients. In this study, 48.1% of the nonmetro counties had high tech unit plants and 28.3% had high tech branch plants.

The results of applying the McDonald-Moffitt adjustment to the Tobit coefficients are provided in tables 5 and 6 under the heading "Adjusted Tobit Employment Estimate." The coefficients listed under the "Adjusted" heading are the Tobit coefficients for the relationship between a change in the independent variable and the expected value of employment for those observations for which employment is not zero. The adjusted coefficients indicate that levels of high tech employment (among those counties with high tech firms) are much less closely related to changes in county characteristics than indicated by the aggregate Tobit results. Specifically, the adjusted coefficients for the branch plant model were approximately one-fourth the magnitude of the aggregate Tobit estimates and the adjusted unit plant coefficients were only a little over one-third the value of the original estimates. These findings may be interpreted to show that the selected county characteristics were better at differentiating between communities with and without high tech firms than for predicting employment differences among communities with high tech employers. Or, alternatively, changes in select community characteristics will have a much larger impact on the probability of attracting a high tech firm to a community currently without any such plants than on the possibility of increasing employment in a town which already has a high tech sector.[9]

Conclusions and Implications

The locational preferences of nonmetropolitan high tech manufacturers are fairly straightforward. In this study, high tech branch plants preferred populous, rapidly growing counties and locations near metropolitan areas. Counties with relatively large manufacturing or agricultural employment were avoided, possibly to reduce competition for labor. Interestingly enough, counties with high unemployment rates also were avoided. These findings are not representative of branches of mature manufacturers seeking labor surplus locations.

The characteristics of counties with high tech unit plants are less clear, perhaps due to the randomness of entrepreneurial activity. Populous counties with a well-educated labor force were relatively successful in attracting or generating unit plant employment. These locational attributes fit more closely the "common knowledge" perceptions of the type of nonmetropolitan area that might foster high technology employment.

The findings of this study lead to several implications for community industrialization efforts. First, high tech employment in the nonmetro West is relatively concentrated, and the counties which have been most successful in attracting this employment are generally the largest and most prosperous. Thus, the sparsely populated, isolated, low-amenity rural areas will benefit little from development programs targeted at high tech manufacturers. Second, high tech firms prefer locations with diversified economic bases. However, a community without a history as a manufacturing center may not be at a disadvantage in seeking high tech firms since, in this study, the firms avoided locations with high concentrations of man-

[9] A potential shortcoming of the Tobit estimation procedure and the McDonald-Moffitt adjustment is the underlying assumption that the same set of factors has the same influence on the existence of high tech firms and on employment levels in these firms among counties (Norris and Batie). This may not be the case. Heckman (1976, 1979) offers an alternative procedure for dealing with censored data which would allow for the examination of the selection effect (in this case, the choice of a location) independent from the size of the activity (in this case, high tech employment). The Heckman approach is a two-equation procedure involving estimation of a probit model of selection decision for all observations, calculation of a variable representing the sample selection bias effect (Inverse Mills Ratio), and incorporation of the variable representing the selection effect into the estimation for those observations where employment is positive.

The results of the Heckman estimation procedure for branch and unit plants are provided in table A2. The coefficients are not directly comparable to the Tobit results. However, with respect to the independent variables which are significant, the results of the two models are very similar. For unit plants, the community characteristics significantly associated with the existence of a high tech sector were also significantly related to employment levels. For branch plants, however, only county population was significantly associated with the existence of branch plant activity. The second stage of the Heckman procedure for branch plants was very similar to the Tobit results. Thus the Heckman procedure indicates that for branch plants the assumption of similar sets of influencing factors may not be valid.

ufacturing employment. Finally, the high tech manufacturers may be locating in rural areas in an effort to reduce production costs (relative to metro counties), but there is no indication that the lowest-cost rural locations are selected. Indeed, the high tech manufacturers (especially the unit plants) are locating primarily in communities with high median incomes and low unemployment rates. Thus, programs initiated to improve local services, educational attainment, and quality of life could enhance these communities' comparative advantage in the competition for high tech employment.

[*Received September 1989; final revision received June 1991.*]

References

Amemiya, T. *Advanced Econometrics.* Cambridge MA: Harvard University Press, 1985.

Armington, C., C. Harris, and M. Odle. "Formation and Growth in High Technology Business: A Regional Assessment." Washington DC: The Brookings Institution, 1983.

Barkley, D. L. "The Decentralization of High-Technology Manufacturing to Nonmetropolitan Areas." *Growth and Change* 19(Winter 1988):13–30.

Barkley, D. L., R. A. Dahlgran, and S. M. Smith. "High-Technology Manufacturing in the Nonmetropolitan West: Gold or Just Glitter." *Amer. J. Agr. Econ.* 70(1988):560–71.

Barkley, D. L., J. E. Keith, and S. M. Smith. "The Potential for High Technology Manufacturing in Nonmetropolitan Communities." WREP 97, Western Rural Development Center, Corvallis OR, 1989.

Bender, L. D., B. L. Green, T. F. Hady, J. A. Kuehn, M. D. Nelson, L. B. Parkinson, and P. Ross. "The Diverse Social and Economic Structure of Nonmetropolitan America." U.S. Department of Agriculture, Economic Research Service Report #49. Washington DC, 1985.

Blair, J. P., and R. Premus. "Major Features in Industrial Location: A Review." *Econ. Develop. Quart.* 1(1987): 72–84.

Cooper, A. C. "Entrepreneurship and High Technology." In *The Art and Science of Entrepreneurship,* eds., D. L. Sexton and R. W. Smilor. Cambridge MA: Ballinger Publishing Co., 1989.

Cromley, R. C., and T. R. Leinbach. "The Pattern and Impact of the Filter Down Process in Nonmetropolitan Kentucky." *Econ. Geography* 57(1981):208–24.

Dorf, R. J., and M. J. Emerson. "Determinant of Manufacturing Plant Location for Nonmetropolitan Communities in the West North Central Region of the U.S." *J. Rgnl. Sci.* 18(1978):109–20.

Erickson, R. A. "The Filtering Down Process: Industrial Location in a Nonmetropolitan Area." *Prof. Geographer* 26(1976):254–60.

Erickson, R. A., and T. R. Leinbach. "Characteristics of Branch Plants Attracted to Nonmetropolitan Areas." In *Non-Metropolitan Industrialization,* eds., R. E. Lonsdale and H. L. Seyler. New York: Halstead Press, 1979.

Etzioni, A., and R. Jargowsky. "The Two Track Society: High Technology Basic Industry and the Future of the American Economy." Paper presented at the Center for Policy Research, Conference for a Growing America, March 1984.

Fisher, J. S. "Manufacturing Additions in Georgia: Metropolitan and Nonmetropolitan Differences from 1961 to 1975." *Growth and Change* 10(April 1979):6–16.

Glasmeier, A. "Bypassing America's Outlands: Rural America and High Technology." Report to Aspen Institute, Ford Foundation, Washington DC, 1988.

Goode, F. M. "Industrial Location Models: The Efficacy of More Refined Demand Variables." *Growth and Change* 17(January 1986):66–75.

Green, W. H. *LIMDEP Version 5.* PC Program and Manual. New York, 1988.

Hagey, M. J., and E. J. Malecki. "Linkages in High Technology Industries: A Florida Case Study." *Environ. and Planning* 18(1986):1477–98.

Heckman, J. J. "Sample Selection Bias as Specification Error." *Econometrica* 47(1979):153–61.

———. "The Common Structure of Statistical Models of Truncation, Sample Selection, and Limited Dependent Variables." *Ann. Econ. and Soc. Measure.* 5(1976):475–92.

Luloff, A. E., and W. H. Chittenden. "Rural Industrialization: A Logit Analysis." *Rural Sociology* 49(1984): 67–88.

Markusen, A. R. *Profit Cycles, Oligopoly, and Regional Development.* Cambridge MA: The M.I.T. Press, 1985.

Markusen, A. R., P. Hall, and A. Glasmeier. *High Tech America.* Boston MA: Allen and Unwin, Inc., 1986.

McDonald, J. F., and R. A. Moffitt. "The Use of Tobit Analysis." *Rev. Econ. and Statist.* 62(1980):318–21.

McNamara, K. T., W. R. Kriesel, and B. J. Deaton. "Manufacturing Location: The Impact of Human Capital Stocks and Flows." *Rev. Rgnl. Stud.* 18(1988): 42–48.

Miller, J. P. "Non-metro Job Growth and Locational Change in Manufacturing Firms." Rural Development Res. Rep. No. 24. U.S. Department of Agriculture, Economic Statistics Cooperative Services, Economic Development Division. Washington DC, 1980.

———. "The Product Cycle and High Technology Industry in Nonmetropolitan Areas, 1976–80." *Rev. Rgnl. Stud.* 19(1989):1–12.

Norris, P. E., and S. S. Batie. "Virginia Farmers' Soil Conservation Decisions: An Application of Tobit Analysis." *S. J. Agr. Econ.* 19(July 1987):79–90.

Oakey, R. P. *High Technology Small Firms: Regional Development in Britain and the United States.* New York: St. Martin's Press, 1984.

Peddle, M. T. "The Appropriate Estimation of Intra-

metropolitan Firm Location Models: An Empirical Note." *Land Econ.* 63(1987):303–05.
Schmenner, R. W., J. C. Huber, and R. L. Cook. "Geographic Differences and the Location of New Manufacturing Facilities." *J. Urban Econ.* 21(1987):83–104.
Smith, S. M., and D. L. Barkley. "Labor Force Characteristics of 'High-Tech' vs. 'Low-Tech' Manufacturing in Nonmetropolitan Counties in the West." *J. Community Develop. Soc.* 19(1988):21–36.
Suarez-Villa, L. "The Manufacturing Process Cycle and the Industrialization of the United States–Mexico Borderlands." *Ann. Rgnl. Sci.* 18(1984):1–23.
Thompson, W. R. "Internal and External Factors in the Development of Urban Economics." In *Issues in Urban Economics,* eds., H. S. Perloff and L. Wingor. Baltimore MD: Johns Hopkins University Press, 1968.
Vernon, R. "International Investment and International Trade in the Product Cycle." *Quart. J. Econ.* 80(May 1966):190–207.
Walker, R., and F. Calzonetti. "Searching for New Manufacturing Plant Locations: A Study of Location Decisions in Central Appalachia." *Rgnl. Stud.* 23(1989)15–20.

Appendix

Table A1. Variable Names for Data from Montana State University City and County Data Base

Variable Name	Abbreviation Used in Text/Tables
Adjacent to a Metropolitan Statistical Area	*ADJ*
Average farm size	*Farm Size*
Crime rate	
Elevation	
Employment in manufacturing firms with 100+ employees	
Expenditure on education	
Government expenditure	*Govt Expend*
Land area	*Land Area*
Male and female employment by job classification in:	
Clerical	
Craftsmen	
Farm laborers and foremen	*FRMLAB*
Farmers and farm managers	*FRMOWM*
Laborer (except farm)	
Managers and administrators (except farm)	
Operators (except transport)	
Private household workers	
Professional and technical	
Service workers	
Not reported	
Male and female employment by sectors (13 categories):	
Agriculture, forestry, and fisheries	*Ag & For Emp*
Business and repair services	
Construction	
Entertainment and recreational services	
Financial and real estate	
Manufacturing	
Durable	
Nondurable	
Total	*MFG*
Mining	
Personal services	
Professional services	
Public administration	
Transportation	
Wholesale and retail trade	
Not reported	
Median family income	*Med Fam Inc*
Median gross rent for family housing	*Med Gross Rent*
Median school years	*MDSCYR*
Metro or nonmetro	
Migration from county	*NETMIG*
Miles of seacoast	
1980 value of family dwellings	
1970 value of family dwellings	*Val Fam Hs*
Nonwhite population below 125% of poverty level	*NW Pov*
Number of amusement parks	
Number of colleges	
Number of commuters	
Number of dentists	*Dentst*
Number of hospital beds	*Hosp Beds*
Number of January heating days	*JANHT*
Number of July cooling days	*Jul Cool*
Number of junior colleges	
Number of medical schools	
Number of military personnel present	*MILEM*
Number of recreation lakes	
Number of universities	*Universities*
Per capita income	*Per Cap Inc*
Percent graduated from high school	*% Hi Sch*
Percent of population over 18 years old	*% 18 +*
Percent of population over 65 years old	*% 65 +*
Percent 25 or older with four or more years of college	*% 4 +*
Percent urban	*% Urban*
Percent working outside county	*Work Out*
Percentage of land in farms	*% Frm Land*

Appendix
Table A1. Continued

Variable Name	Abbreviation Used in Text/Tables
Population	*POP*
Population per square mile	
Presence of a military base	*MILB*
Presence of an airline	
Property taxes	*Prop Tax*
Proximity to an interstate highway	*HWY*
Rural farm population	*Rural Frm Pop*
Rural nonfarm population	*Rural Nonfarm Pop*
Total female employment	*Fem Emp*
Total females unemployed	*Fem Unemp*
Total male employment	*Male Emp*
Total males unemployed	*Male Unemp*
Total nonwhite population	*NW pop*
Total white population	*Total W pop*
Value of farm land per acre	
Value of farm sales	*Farm Sales*
White population below 125% of poverty level	*White Pov*

Table A2. Determinants of High Tech Manufacturing Location and Employment, Unit and Branch Plants, Heckman Estimation Results

	Branch Plants		Unit Plants	
Exogenous Variables	Activity Present[b]	1982 Employment[c]	Activity Present[b]	1982 Employment[c]
Intercept	−2.54	−6,717.03	−3.08	−464.73
	(0.64)	(2.27)**	(−1.51)	(1.36)
Population (*POP*)	0.00003	0.04	0.000026	0.0033
	(2.17)**	(4.79)***	(3.29)***	(6.32)***
Adjacent to MSA (*ADJ*)[a]	0.65	1,127.40	0.26	42.84
	(1.37)	(2.07)**	(1.12)	(1.12)
Interstate Highway (*HWY*)[a]	−1.88	−287.33	−0.10	−10.69
	(−3.99)***	(−0.67)	(−0.49)	(−0.32)
Heating Degree Days in January (*JANHT*)	0.0013	2.52	0.0004	0.075
	(1.34)	(2.83)***	(0.83)	(1.07)
Median School Years (*MDSCYR*)	0.0045	116.30	0.22	32.21
	(0.14)	(0.45)	(1.26)	(1.15)
Unemployment Rate (*UNEMP*)	−0.70	−984.80	−0.73	−93.92
	(0.33)	(−0.53)	(−0.76)	(−0.62)
Net Migration Rate (*NETMIG*)	0.0081	11.69	0.0046	0.62
	0.72	(1.31)	(0.98)	(0.96)
Agricultural Employment as a Percent of Total (*AGEMP*)	−4.21	−6,727.29	−4.11	−699.10
	(−0.94)	(−2.51)**	(−3.49)***	(−3.82)***
Manufacturing Employment as a Percent of Total (*MFGEMP*)	−3.83	−4,968.31	−2.48	−401.66
	(−1.17)	(−1.63)*	(−1.92)**	(−2.01)**
Mining Employment as a Percent of Total (*MINEMP*)	1.12	1,353.13	−0.97	−142.74
	(0.50)	(0.37)	(−0.76)	(−0.70)
Sigma		1,965.13		162.02
		(8.07)***		(6.31)***
R^2	.21	.05	.27	.05
Number	318	90	318	153

Note: Triple asterisks indicate significance at the .01 level, double asterisks indicate significance at the .05 level, and an asterisk indicates significance at the .10 level.
[a] Binary variable.
[b] The probit equation of the Heckman selection procedure.
[c] The selection equation of the Heckman selection procedure (maximum likelihood estimate).