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# Poverty and Employment in Forest-Dependent Counties

Peter Berck, Christopher Costello, Louise Fortmann, and Sandra Hoffmann

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**ABSTRACT.** One of the most controversial aspects of federal and state policies aimed at protecting old-growth ecosystems is the potential effect of job losses on local economic conditions. A fundamental question for historically forest-dependent areas is whether these policies will result in local economic stagnation and enduring pockets of poverty. This study uses monthly, multicounty time series data to estimate a vector autoregressive model of the experience of northern California counties during the 1980s and 1990s. It examines the long-run impact of changes in timber-related employment on other employment and participation in major federal poverty programs. It finds that employment base-multiplier effects of timber employment on other county employment are small and state economic conditions rather than local employment conditions are the principal driver behind local poverty. *FOR. SCI.* 49(5):763–777.

**Key Words:** Forest policy, old-growth, vector autoregressive analysis.

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**T**HE 1989 ANNOUNCEMENT of a federal court order protecting the northern spotted owl and President Clinton's subsequent 1994 forest plan restricting national forest harvests marked the end of a decade-long boom and the beginning of a decade of transformation in the Pacific Northwest timber industry (Tuchmann 1995). In California, area residents and state officials have argued that sustained, if not increased, timber harvests are essential to prevent economic stagnation in forest-dependent areas of northern California, with accompanying high unemployment and poverty rates (California Senate Office of Research 1996, California Forestry Association 1994, and Vincent

1988). These debates reflect long-standing concerns over the impact of forest policy on the economic health of resource-dependent regions (Waggener 1977, Schallau 1989, Sample and LeMaster 1992, Ohman 1999, Associated Press 1999).

This article uses vector autoregressive analysis to examine the influence that changes in timber employment have on the economic health of forest-dependent areas in California. We use two measures of economic health: nontimber employment and participation in poverty relief programs. County data are used. In California, and much of the rural United States, county governments have responsibility for local economic development policy. County supervisors were the

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Peter Berck, Professor, Giannini Foundation of Agricultural Economics, Department of Agricultural and Resource Economics, University of California, Berkeley, Berkeley, CA 94720-3310—Phone: 510-642-7238; Fax: 510-643-8911; E-mail: pberck@uclink4.berkeley.edu. Christopher Costello, Assistant Professor, Bren School of Environmental Science and Management, University of California, Santa Barbara, Santa Barbara, Calif. 93106—Phone: (805) 893-5802; E-mail: costello@bren.ucsb.edu. Louise P. Fortmann, Rudy Grah Professor of Forestry and Sustainable Development, Department of Environmental Sciences, Policy and Management, University of California, Berkeley, Berkeley, CA 94720—(510) 642-7018; E-mail: fortmann@nature.berkeley.edu. Sandra Hoffmann, Fellow, Resources for the Future, 1616 P St. NW, Washington, DC 20036—Phone: 202-328-5022; E-mail: hoffmann@rff.org.

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principal government officials in California involved in the USDA Forest Service Northwest Community Adjustment Initiative's Community Economic Revitalization Teams (Stanley 1999). The analysis is also run on three multicounty areas.[1] Multicounty analysis is included to help control for intercounty commuting and for employment data being reported by employer rather than employee address. These areas are large enough and geographically separate enough to constitute distinct economic service areas. They also have different timber species and different capitalization and labor utilization rates in their wood products industries (Sullivan and Gilliss 1989).

We examine three questions. First, are timber jobs better at inducing local employment growth or reducing local poverty than other jobs? Second, does a decrease in local timber employment result in a long-run increase in local poverty? Third, are state factors or county factors the long-run determinants of county employment and poverty?

### **California's Timber Region: Economics and Environmental Policy**

From 1983 to 1993, the 11 counties included in this study[2] produced 72% of California's annual timber harvest. During the 1980s, lumber and wood products industries provided 10 to 20% of total employment in these counties (McWilliams and Goldman 1994).

California timber harvests during the 1980s were affected by the forest planning process mandated by the National Forest Management Act (NFMA 1976) and the Resource Planning Act (RPA 1974). Timber harvests in national forests in California were maintained at historically high levels exceeding federal nondeclining even-flow requirements throughout the 1980s (Yaffee 1994). In 1987, total timber harvests in the study counties peaked at almost 3.4 million thousand-board foot (mbf), up from 1.8 million mbf in 1984. From 1989 on, a series of federal and state judicial and administrative actions aimed at protecting endangered bird and fish species forced reconsideration of the harvest plans for national forest and private land and resulted in a rapid decline in California timber harvests.[3] By 1994, timber harvest in these counties had dropped back to 2 million mbf.

During the 1980s, average monthly wood-products employment in the study counties increased, despite increasing labor productivity, peaking at 17,072 in 1988 (Sullivan and Gilliss 1989). By 1993, following a decline in harvest, wood-products employment fell to 13,213 (California Department of Finance, various years). Total county employment grew steadily in the study counties during the 1980s, paralleling statewide employment growth. Surprisingly, when statewide employment stagnated in the early 1990s and local timber-related employment declined, total employment in these counties continued to grow (California Department of Finance, various years). In contrast, poverty in the study counties worsened relative to state levels throughout the 1980s. The average annual poverty rate in 1979 for the study counties was slightly lower than for the state as a whole (11.5% compared to 11.8%). By the 1990 census, the average study county poverty rate of 13.8% exceeded the statewide rate of

12.5% (U.S. Department of Commerce, Bureau of the Census 1980, 1990). The story that these basic statistics reveal about California's forest counties is complex and does not easily fit into conventional models used to assess the economic impact of changes in timber harvest.

### **Models of Regional Economic Growth**

The view that sustained, if not increased, timber harvest is essential to the economic health of forest-dependent regions reflects a harvest-driven view of local economic growth. Timber harvest drives timber employment, which in turn drives nontimber local employment, which in turn determines the economic health of the region. This view reflects an economic-base model in which the timber industry is the region's economic base.[4] Given that timber production drives local economic activity, steady timber production should contribute to economic stability. The community and employment stability goals of the Sustained Yield Forest Management Act of 1944 and the nondeclining, even-flow harvest policy of the NFMA of 1976 were justified by this view of economic structure in forest-dependent regions (Burton 1997).

This harvest-driven view of local economic activity in forest-dependent areas also underlies conventional economic impact assessment. Impact Analysis for Planning (IMPLAN), the input-output model used to analyze impacts of the forestry sector on other local economic activity, assumes a fixed relationship between timber harvest, timber-related employment, employment and income in other sectors, and income (Alward and Palmer 1983). Changes in harvest or timber-related employment are then modeled as proportional to changes in timber demand. Impacts on employment and income can be calculated by multiplying input-output multipliers from an IMPLAN model by the calculated change in timber demand (Waters et al. 1994).

Recently, economic studies have begun to test empirically the validity of these assumptions. A series of studies using structural models has examined the interaction of timber harvest and demand for wood products in order to investigate the extent to which economic activity in forested areas is driven by local timber supply (harvest) or by demand for local wood products. Adams and Haynes (1980) pioneered early use of econometric models that allow for timber supply-demand interactions in forest economic impact analysis. Adams (1989) found evidence that timber-related economic activity is primarily driven by the impact of national economic policies on wood product demand. Luppold (1984) also found evidence that demand drives economic activity in U.S. hardwood markets. Using a general equilibrium model to simulate economic activity in western Montana, Daniels et al. (1991) showed that even perfectly stable harvest flows cannot stabilize wood product employment and wage income in the face of significant external demand shocks.

More recently, nonstructural econometric models have been used to test empirically the competing hypotheses that local economic activity in forested regions is primarily demand or harvest driven. Burton and Berck (1996) found that national macroeconomic variables, which influence wood

products demand, “Granger cause”[5] forest sector employment in Oregon and not vice versa. Using a Markov chain analysis of annual data for Oregon from 1953 to 1988, Burton (1997) found that neither national forest timber cut nor sold affected employment in forest-related sectors in Oregon, but real gross national product and housing starts (both indicators of wood product demand) did. Neither of these studies examined the linkages between forest employment and other employment or other aspects of local economic health that are the focus of this article.

### **Poverty: Another Measure of Economic Health**

The economic health of a region involves more than employment (Overdest and Green 1994). A forest planner’s goal of maintaining local economic stability includes the goal of avoiding timber-related increases in income inequality and poverty (Wagner 1977, Weeks 1990, Lee et al. 1991, Daniels et al. 1991, Hibbard and Elias 1993).

The belief, frequently expressed in northern California, that old-growth forest protection will lead to increased local poverty, is based on the assumption of a strong inverse relationship between timber employment and local poverty (California Forestry Association 1994, Cook 1995). A substantial body of literature identifies a strong, positive relationship between unemployment rates and both poverty rates and poverty program participation levels at the state and national level (Blank and Blinder 1986, Sawhill 1988, Blank and Card 1993, Blank 1997, Wallace and Blank 1999, Blank 2000, Hoynes 2000). The question for forest planners and forest-dependent counties is whether this relationship holds at the substate level. It is not clear that such a relationship must hold for small, open, local economies. Theoretically, one might expect that some adjustment process, such as migration, could equilibrate poverty across a nation or state.

Yet, geographically concentrated pockets of rural poverty have persisted in the United States for decades. A significant body of literature has sought explanations for this phenomenon (Brown and Warner 1991, Lyson and Falk 1993, Rural Sociological Society Task Force on Persistent Rural Poverty 1993). Several hypotheses have been advanced, focusing on migration as the key explanatory factor. Neoclassical theory sees migration as an equilibrating mechanism that reduces the spatial inequality in the returns to labor created by structural economic change. This theory predicts a smaller, but not poorer, population in the aftermath of a natural resource “bust.” Adjustment delays or unwillingness of individuals to migrate may create areas with higher poverty rates (Schuh 1977, Lyson and Falk 1993). Human capital theories view migration as an investment in human capital whose return is higher for individuals with more education and experience (Becker 1962, Schultz 1961). These theories predict that, during an economic downturn, people with more skills will be more likely to emigrate. This implies that, when there is a decline in timber-related employment, forest-dependent regions will be left stranded with their poorer, less-skilled population. Nord (1994, 1998) offers a third explanation based on different geographic locations offering

distinct economic opportunities to migrants. In Nord’s model, not only the skilled and well-off, but also the poor migrate. The poor migrate to areas that offer entry-level, low-skilled employment opportunities and low-income survival opportunities, particularly low-cost housing. This suggests an even grimmer picture for forested regions after a bust. Not only may they lose their high-skilled population, but they may also attract low-skilled residents.

### **Modeling the Adjustment Process**

As recent research on county growth shows, migration also can affect employment (Carlino and Mills 1987, Clark and Murphy 1996, Mulligan et al. 1999). Therefore, the impact of changes in harvest on local economic health, whether measured by employment or poverty, likely will depend on migration. Geographic proximity and transportation linkages affect the ease of labor market adjustment. In general, California’s timber counties are not remote from major urban areas. The major service centers for the northern timber counties, Eureka and Redding, are each within a 4–5 hr drive of San Francisco and Sacramento. The central Sierra study counties, Amador and Tuolumne, are within a 2 hr drive of either Sacramento or San Francisco.

Structural models conventionally used to assess the economic impact of changes in timber harvest, such as input-output or computable general equilibrium models, depend on strong assumptions about migration, factor mobility, and openness to trade. Hoffmann et al. (1996) showed that the size of economic impact multipliers from these structural models is strongly affected by assumptions about local factor market adjustment. Sensitivity analysis can help identify the extent to which these assumptions affect economic impact assessments but cannot measure their actual effect.

Time-series methods can capture empirically the impact of this migration/employment adjustment process. Partial adjustment models have been used to clarify the direction and nature of population-employment interactions at a regional level (Carlino and Mills 1987, Clark and Hunter 1992, Vias and Mulligan 1999). These models have been used to examine the effect of endangered species policy, wilderness policy, and of the noncommodity benefits of forests on local economic growth. In these models, changes in economic growth are caused either by attracting population or by attracting employers (Brannlund 1991, Duffy-Deno 1997, Duffy-Deno 1998, Lewis and Plantinga 2002). Nonstructural vector autoregression (VAR) analysis or cointegration tests have been used to identify sources of local growth as is done in this paper (Connaughton et al. 1985, Wozniak and Babula 1992, Coulson 1993, 1999). They also have been used to estimate regional economic multipliers and to forecast regional growth (Lesage and Reed 1989, Brown et al. 1992, Harris et al. 1999).

Time-series models, such as the VAR model used in this study, can be viewed as the solution to a dynamic structural model, such as models of the input-output/computable general equilibrium (I-O/CGE) class (Sims 1980). There is a trade-off in choosing between these two representations of a region’s economy. Structural models, like the I-O/CGE class

of models, incorporate significant sectoral and structural richness but impose assumptions regarding economic adjustment and the relationships between timber and nontimber economic activity. Time-series models measure the actual empirical impact of the adjustment process but lose sectoral detail and structural information for which good evidence may be available. Because our focus is on measuring the results of the actual adjustment process in the study counties, we use nonstructural time-series analysis.

### Theoretical Model

The questions addressed in this study are examined in a cointegrated VAR framework. A VAR is a set of simultaneous equations in which each variable in the system is regressed on its own lagged values and the lagged values of all other variables in the system. The VAR that we estimate can be viewed as a solution to a two-sector, structural model of a regional economy. It includes equations representing: (1) equilibrium in county timber and nontimber labor markets, (2) county poverty program caseload as a function of employment and other variables, (3) total state employment and state poverty program caseload as a function of other state-level variables, and (4) county-level migration as a function of county and state variables. Solving this model yields a VAR model defined over five variables: local (county or multicounty) timber-related employment ( $T$ ), local nontimber-related employment ( $N$ ), local poverty program participation ( $POV$ ), state employment ( $SEMP$ ), and state poverty program participation ( $SPOV$ ). We estimate a VAR model of five equations, one for each variable in the model,  $N$ ,  $T$ ,  $SEMP$ ,  $SPOV$ , and  $POV$ .

We estimate two sets of VAR models, one using the county as the unit of analysis and the other using multicounty areas. Three VAR models, one for each of three poverty programs, Food Stamps (FS), Aid to Families with Dependent Children-Unemployed Parent (AFDC-UP), and Aid to Families with Dependent Children-Family Group (AFDC-FG) caseload, were estimated for each of the 11 counties and each of the 3 multicounty areas. A total of 33 county VAR models and 9 multicounty area VAR models were estimated. Each of these VAR models has five equations. Estimating these VARs allows us to conduct a series of hypothesis tests to identify long-run relationships between local timber employment, other local employment, and local poverty program participation and to identify the relative roles of local versus state economic conditions in determining local employment and poverty program participation. We also use the county-level VAR models to estimate the multiplier impact of county timber and nontimber employment on poverty program participation.

### Data

The models are estimated using monthly data for 1983–1993. Over this time period, there was significant variation in all of the variables used in our study. This variation allows us to use time series methods to test for relationships between variables in our model. Conventionally, economic analysis at the county level uses national or state level data that is then disaggregated to the county level. This disaggregation is

based on assumptions about the relationship between county economic activity and state or national activity. These include relationships that we seek to measure. To avoid imposing these assumptions on our analysis, we use primary data gathered at the county level, frequently for program administration purposes (see Hoynes 2000 on use of administrative data for substate analysis).

County timber and nontimber employment levels are taken from the U.S. Bureau of Labor Statistics (BLS) series on employment covered by unemployment insurance (BLS ES-202 series, California Employment Development Department, various years).[6] This series reports the number of workers on payroll during the pay period including the 12th day of each month in firms covered by unemployment insurance (U.S. Department of Labor, Bureau of Labor Statistics 1992). Timber-related employment is represented by employment in lumber and wood-products industries, Standard Industrial Classification (SIC) 24.[7]

No information is available on whether these are full or part time jobs. As a point of reference, at the state level, manufacturing employment averaged 40.7 hr per week in 1989 with an average wage of \$11.16 (California Department of Finance 1990). In the study counties, almost all of lumber and wood products work (SIC 24) was in millwork and plywood milling rather than logging. Statewide, millwork and plywood workers averaged 40.8 hr of work with an average wage of \$8.41/hr in 1989. In contrast, logging averaged 43.1 hr of work per week with an average hourly wage of \$11.55 and marked seasonality in weekly hours worked. In those study counties where data was available, logging accounted for less than 0.5% of total county employment. Since the study counties account for most of the state SIC 24 employment, these numbers are arguably representative of the study counties. Other industries are not as concentrated in the study counties. It seems safe to conclude that most county SIC 24 employment was full-time work. Clearly, other sectors present in the study counties, such as retail trade, did involve part-time work. It is more difficult to draw conclusions from the available secondary data on relative wage levels across industries in the study counties.

Total state employment (also BLS ES-202 series) provides a proxy for total state output of goods and services, which is believed to be a significant factor driving statewide demand for employment and ultimately willingness of unemployed workers in forest counties to migrate. Data on alternative measures of state-level economic activity, such as gross state product, are ultimately constructed from the employment data and assumptions regarding the ratio of value added to employment. As a result, use of gross state product (GSP) figures would distort the signal that employment provides about fluctuations in statewide economic activity over time.

County poverty is represented by monthly caseloads of three major federal poverty programs. Recent federal legislation on poverty-targeted school funding has stimulated considerable research on intercensal estimation of small-area poverty rates (Improving America's Schools Act of 1994, P.L. 103-382). Directly measured county-level poverty rates for most rural counties are available only decennially from

the U.S. census.[8] Yet the level and geographic distribution of poverty can vary markedly in intercensal periods (Citro and Kalton 1999). The Current Population Survey offers intercensal estimates of poverty and income statistics, but its sample is designed to provide accurate estimates only at the national level (U.S. Department of Commerce, Bureau of the Census 2000). As a result, Census Bureau/National Science Foundation studies have recommended the use of administrative data on poverty program participation in estimating county-level poverty during intercensal periods (Siegel 1997, Citro and Kalton 1999).

We use data on participation in the Food Stamp program and in two different AFDC programs: AFDC-UP and AFDC-FG. AFDC-FG, the better known of the pre-1996 welfare reform AFDC programs, was only available to children in single-parent households. These were predominantly female-headed households. AFDC-UP was a smaller program for children in households with two unemployed parents, at least one of whom had a history of recent employment. We use all three programs because eligibility requirements and prior studies suggest that they drew different segments of the low-income population.

In many ways, all three programs were similar. Eligibility in all programs was tied to federal poverty guidelines and asset tests (U.S. House of Representatives, Ways and Means Committee 1992). In California the eligibility requirements used to administer these programs did not change over the study period. However, the three programs differed in their requirements regarding recent labor-force participation and the stringency of the poverty test. AFDC-UP was designed to be an antirecessionary program for two-parent families and required at least one parent to have a recent work history (U.S. House of Representatives, Ways and Means Committee 1992). In contrast, neither the AFDC-FG nor Food Stamp programs had work history requirements (U.S. House of Representatives, Ways and Means Committee 1992). Food Stamps had less stringent means tests than either AFDC program and were available to many more employed persons.

Studies have found that the impact of changes in employment conditions on program participation varied across programs. Blank (1997) found that unemployment-induced changes in AFDC-UP caseloads were large but not as permanent as those induced in AFDC-FG caseloads. Recent studies indicate a strong relationship between both Food Stamp and AFDC-UP caseload and unemployment rates and a weaker relationship between unemployment rates and AFDC-FG at state and national levels (Blank 1997, Blank 2000, Wallace and Blank 1999, and Wilde et al. 2000). In a study of the AFDC program in California, Hoynes (2000) finds that two-parent households and ethnic minorities were the groups most sensitive to changes in local labor market conditions. Based on these studies, we expect results in each of our sets of VAR models to differ.

### Cointegration: An Example

We next present a simple example to explain the fundamental features of a cointegrated system. A set of two or more time series is cointegrated if there are linear combinations of

the variables that are stationary, although the variables are not individually stationary. A time series is stationary when the mean, variance, and covariance of its error term do not change over time. That is, the series has neither an upward or downward trend nor increased nor decreased spread around its mean over time. Intuitively, when two time series are cointegrated, they move in tandem over time. They have a stable, linear, long-run relationship over time.

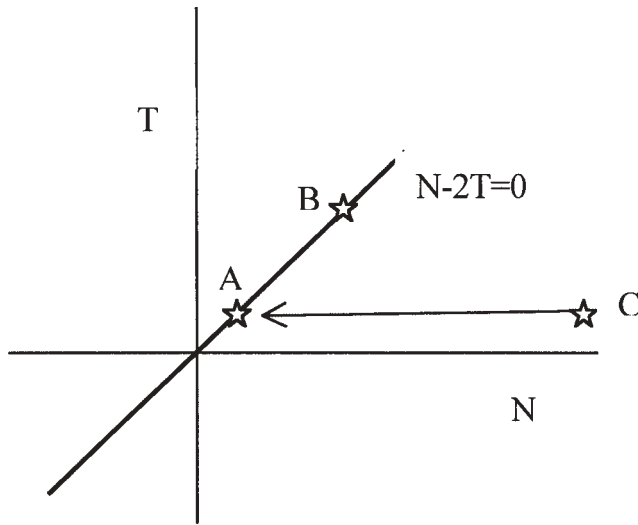
For illustrative purposes, consider a simplified model using only two variables, timber employment ( $T$ ) and nontimber employment ( $N$ ). For the sake of exposition, assume that the long-run relationship between these variables is an employment multiplier of 2 for the impact of  $N$  on  $T$ . Letting  $\beta' = (1, -2)$ , this long-run relationship is  $\beta' (N, T)' = N - 2T = 0$ . The vector  $\beta'$  is called a cointegrating vector. When  $N$  and  $T$  do not satisfy this long-run relationship, they must be adjusting towards it. The speed at which they adjust toward their long-run relationship is given by a speed of adjustment vector,  $\alpha$ . For the sake of argument suppose that  $\alpha' = (-1/2, 0)$ .

With these preliminaries, we can construct a hypothetical error corrected VAR. There are two equations in this hypothetical VAR, and each equation has an error term,  $\epsilon$ , representing random shocks to the system. Denoting the first difference of a variable by  $\Delta$  (so  $\Delta T_t = T_t - T_{t-1}$ , where the subscript is with respect to time, measured in months), the VAR for hypothetical example would be:

$$\begin{pmatrix} \Delta N_t \\ \Delta T_t \end{pmatrix} = \begin{bmatrix} -1/2 & \\ & 0 \end{bmatrix} \begin{pmatrix} 1 & -2 \end{pmatrix} \begin{pmatrix} N_{t-1} \\ T_{t-1} \end{pmatrix} + \begin{pmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{pmatrix} \quad (1)$$

The matrix premultiplying  $(N_{T-1}, T_{T-1})'$  is denoted  $\Pi$ , where  $\Pi = \alpha\beta'$ . The rank of  $\Pi$  is the number of cointegrating vectors, which is the number of long-run relationships among the model's variables. In this example, the rank of  $\Pi$  is 1. This is not true in general; where  $\Pi$  is a  $2 \times 2$  matrix, there could be zero, one (as in the example), or two cointegrating vectors. In the case of two cointegrating vectors,  $\beta$  would be a matrix with two linearly independent rows, one for each cointegrating vector, and  $\alpha$  would be a matrix with two linearly independent columns, one column for the speed of adjustment to each of the cointegrating relationships. In our estimated model below, there are five variables and so there can be zero to five cointegrating relationships, i.e., zero to five linearly independent rows in  $\beta'$ .

Again, returning to the two-dimensional example, Figure 1 shows the cointegrating space, which is just a vector. Starting at point A in the diagram, which is on the cointegrating vector, suppose an external event caused a permanent change (say, an increase) in both  $T$  and  $N$ , but the long-run relationship of one to two was preserved. This corresponds to a situation where the error terms of this example were initially positive and, thereafter, zero. The result would be that the system would occupy a new point on the cointegrating vector, say, B. If, on the other hand, the error terms displace the system from the cointegrating vector to a point like C, the system will return towards that vector. The example has one



**Figure 1.** An example of a cointegrating space between timber (*T*) and nontimber (*N*) employment.

other special property: The second variable, *T*, does none of the adjusting back towards the long-run relationship (its  $\alpha_t$  is zero in this example). Hence, the arrows show only *N* as adjusting towards the cointegrating space. The variable *T* is said to be weakly exogenous.

The model here adds three additional features to the example just described: a constant term,  $\phi$ , seasonal dummies, **D**, and lagged values of the differenced variables with their associated coefficient matrices  $\Gamma_k$ . These additions do not change the interpretation of the  $\beta$  as the long-run relationships in the system and the  $\alpha$  as the speed at which variables adjust to equilibrium.

### Estimation

Following Engle and Granger (1987), the VARs in this study are estimated in error correction form using first differences of lagged variables:

$$\Delta \mathbf{y}_t = \phi + \Gamma_1 \Delta \mathbf{y}_{t-1} + \dots + \Gamma_{k-1} \Delta \mathbf{y}_{t-k+1} + \Pi \mathbf{y}_{t-1} + \Psi \mathbf{D}_t + \varepsilon_t \quad (2)$$

where  $\mathbf{y}_t$  is a  $5 \times 1$  column vector of the model's five endogenous variables (*N*, *T*, *SE*, *SPOV*, and *POV*) at time *t*. Variables are transformed to natural log form so that  $\Delta \mathbf{y}_t$  represents the monthly growth rate in the variables in **y**. The  $\Gamma_t$  are  $5 \times 5$  matrices of parameters of the *t*-times lagged difference of **y**. **D**<sub>*t*</sub> is a vector of 11 monthly dummy variables at time, *t*, and  $\Psi$  is a  $5 \times 11$  matrix of corresponding parameters. The parameters  $\Gamma_t$  and  $\Psi$  capture short-run be-

havior of the model. Estimates of the long-run relationships,  $\alpha$  and  $\beta'$ , are recovered from the  $5 \times 5$  parameter matrix  $\Pi$ . Finally,  $\phi$  is a vector of constant terms and  $\varepsilon$  is a vector of mean zero errors.

### Estimation Procedure

The parameters of (2) are estimated in a three-step statistical analysis. First, iterative likelihood ratio tests are used to determine the number of lagged difference terms to be included in the estimated equations. Next, cointegration tests are used to find the number of cointegrating vectors, i.e., the rank, *r*, of the matrix,  $\Pi$ . We test for the rank, *r*, of the matrix  $\Pi$  (or number of cointegrating vectors in  $\Pi$ ) using a trace statistic test and a maximum eigenvalue test (Johansen and Juselius 1990).[9] The trace statistic is a likelihood ratio test for the hypothesis that the rank of  $\Pi$  is *r*. The null hypothesis is  $H_0: \text{rank}(\Pi) \leq r$  versus the alternative that the rank is greater than *r*. The maximum eigenvalue test computes the  $\lambda_{\max}$  statistic and is based on the ratio of the likelihood of *r* cointegrating vectors versus *r* + 1 cointegrating vectors. The null hypothesis is that the rank of  $\Pi$  is *r* or less while the alternative is *r* + 1 or less.[10] The asymptotic distributions of the rank and trace test statistics are nonstandard and depend on deterministic components included in the model (Johansen 1995). The first accepted rank based on both these tests is reported as the estimate of rank of  $\Pi$  in Table 1. Finally, parameter matrices,  $\Pi$ ,  $\alpha$ ,  $\beta$ ,  $\Gamma_t$ ,  $\phi$ , and  $\Psi$ , are estimated given the number of lags, *k*, found in step one and the cointegrating rank found in step two.

### Testing the Model

Four tests of the model are conducted. Model appropriateness is assessed by examining  $R^2$ , testing for residual autocorrelation, and testing for out-of-sample model fit. Model stability is determined by testing for constancy of the  $\Pi$  matrix.

The  $R^2$  of the equations for nontimber jobs, averaged across counties and regions, is just over 78% for all three sets of VARs. For timber jobs, it is approximately 61%. The  $R^2$  averaged over counties and multicounty areas is 36% for AFDC-FG, 54% for AFDC-UP, and 58% for Food Stamps. Of the equations for state variables, the lowest  $R^2$  is for state Food Stamps, 62%, and the highest is for state AFDC-UP, 80%. On the whole, the VAR models fit well, with the poorest fits for AFDC-FG, which is not surprising, since, of the three programs examined, this program is believed to be the least influenced by employment conditions.

**Table 1.** Rank of the cointegrating space for models run with alternative poverty indicators.

Model	Rank						
	County or Multicounty Region						
	Amador	Del Norte	Humboldt	Lassen	Mendocino	Plumas	Shasta
AFDC-UP	2	2	2	1	2	3	2
AFDC-FG	2	1	1	1	2	2	1
Food stamps	1	2	1	1	1	2	2
	Siskiyou	Tehama	Trinity	Tuolumne	NW	NE	SE
AFDC-UP	1	2	2	2	2	2	1
AFDC-FG	2	2	2	3	1	2	3
Food stamps	1	2	3	2	2	2	2

NOTE: Poverty indicator variables include: Aid to Families with Dependent Children–Unemployed Parent caseload (AFDC-UP); AFDC–Family Group caseload (AFDC-FG); and Food Stamps. Multicounty regions are defined as: NW (Del Norte, Humboldt, Trinity, Mendocino); NE (Lassen, Plumas, Siskiyou, Shasta, Tehama); and SE (Amador, Tuolumne).

Another measure of the adequacy of a VAR model is the lack of residual autocorrelation. Two different Lagrange multiplier tests are used to test for residual autocorrelation (Hansen and Juselius 1995). No counties or multicounty areas test positive for residual autocorrelation using AFDC-UP as the poverty indicator variable. When AFDC-FG is used, only one county and no multicounty area displays residual autocorrelation. Autocorrelation is detected in only one county and one region when Food Stamps program caseload was used as the poverty indicator. From the standpoint of residual autocorrelation, the estimated models are reasonable. In general there is little evidence of autocorrelation in the residuals of the cointegrated models.

Out-of-sample model validity is assessed using one-step-ahead predictions. The model is first estimated using data from the first 72 months of the study period. We then calculate one-month-ahead forecasts and find that the resulting out-of-sample fit is nearly the same as the in-sample fit.

Finally, we examine the stability of the models by testing the constancy of the  $\Pi$  matrix over the last 4 yr of the data using methods developed by Hansen and Johansen (1993). On average, the hypothesis of constancy is rejected in only 3 of the 48 forecast periods for each county. There are no patterns to these rejections, indicating that there is sufficient stability to the model.

Based on  $R^2$ , residual autocorrelation, one-step-ahead prediction, and the constancy of the  $\Pi$  matrix, the estimated VARs appear to provide a reasonable approximation of the underlying economic conditions.

### Testing Hypotheses: Application

We examine long-run economic relationships in the study counties through three sets of hypotheses. The hypotheses are formalized as linear restrictions on  $\alpha$  and  $\beta$  in the cointegrating relationships captured in  $\Pi = \alpha\beta'$ . Regressions are run with and without the restrictions on the coefficients  $\alpha$  or  $\beta$  and are compared using likelihood ratio tests that follow a  $\chi^2$  distribution (Johansen 1995).

We run a total of eight hypothesis tests in each county. They are summarized in Table 2, and, for the sake of discussion, are broken into three sets. The first set of three hypotheses concerns the existence of a long-run relationship between local poverty and local employment. The first two hypotheses examine whether poverty (hypothesis 1) or timber employment (hypothesis 2) can be excluded from the long-run (cointegrating) relationship with the other variables. Accepting the exclusion of either poverty program caseload or timber employment may be regarded as evidence of a broken long-run link between local poverty program caseload and local timber employment. The third test in this set examines whether local poverty program participation is weakly exogenous to long-run relationships among other variables (hypothesis 3). A positive finding here implies that, following any shock to the system, all adjustment back to the cointegrated space is done by variables other than the local poverty variable, implying that long-run change in the poverty variable is independent of changes in other variables in the system, including timber employment. Each of these three hypotheses tests an independent place where the causal bridge between long-run changes in timber employment and poverty can fail. Failure to reject any one of these hypotheses represents a break in that bridge.

In the second set of hypothesis tests, we examine the nature of long-run relationships among variables in the system. Three long-run relationships are of particular interest. First, county timber and nontimber jobs and poverty program participation could grow in proportion to one another in the long run (hypothesis 4). Accepting this test suggests that a long-run increase in timber employment is associated with an increase (not decrease) in poverty. Second, a one-job increase in timber and nontimber jobs could have the same long-run impact on the other variables. This would imply that timber jobs do not play a special role in the local economy. In essence, this tests whether timber employment is part of the region's economic "base" (hypothesis 5). Finally, there may be three cointegrating relationships among the county vari-

**Table 2. Hypothesis tests.**

Test	Description	Econometric Formulation
1. Exclude $P$	Tests whether it is appropriate to exclude county poverty ( $P$ ) from the cointegrating space.	$R' = [0 \ 0 \ 1 \ 0 \ 0]$
2. Exclude $T$	Tests whether it is appropriate to exclude county timber jobs ( $T$ ) from the cointegrating space.	$R' = [0 \ 1 \ 0 \ 0 \ 0]$
3. Exogeneity of $P$	Tests whether county poverty is weakly exogenous to the cointegrating space.	$J' = [0 \ 0 \ 1 \ 0 \ 0]$
4. Proportionality	Tests whether county jobs and poverty grow in proportion to one another.	$R' = [1 \ 1 \ 1 \ 0 \ 0]$
5. Job is a job	Tests whether, in the long run, a one county job increase in timber jobs is exactly offset by a one job decrease in county nontimber jobs.	$R' = [1 \ -N/T \ 0 \ 0 \ 0]$ . Where $N/T$ is the average proportion of nontimber to timber jobs in a county.
6. Rank = 3	Tests whether county conditions are determined entirely by state conditions.	Trace and Maximum Eigenvalue tests.
7. Exclude $SPOV$	Tests whether it is appropriate to exclude state poverty ( $SPOV$ ) from the cointegrating space.	$R' = [0 \ 0 \ 0 \ 0 \ 1]$
8. Exclude $SPOV$ and $SEMP$	Tests whether it is appropriate to exclude both state variables (employment and poverty) from the cointegrating space.	$R' = \begin{bmatrix} 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$

NOTE:  $R'$  and  $J'$  test restrictions on the vector of explanatory variables  $y' = [N, T, POV, SE, SPOV]$ .

ables (hypothesis 6, see also Table 1). If the two state variables are held constant (e.g., the state economy does not grow), and there are three cointegrating relationships among the five variables in the VAR, then the values of county variables must return to their original values following a perturbation. County residents want to know what will happen if extra jobs are dropped into the county, perhaps through a federal regulation permitting increased timber harvest. The answer is that, in counties with a cointegrating rank of three, county variables will return to their original long-run values: If the state does not grow, the “rank-3” counties in this model cannot grow. Failure to reject the null hypothesis that there are three cointegrating relationships provides a piece of evidence that statewide factors, not changes in any one local factor, drive local growth.

In some cases we find that an exclusion test cannot be rejected and that the coefficient on a test of the nature of the long-run relationship is significant. This can be viewed as analogous to the case of finding an insignificant regression coefficient in cross-sectional analysis but still being interested in the sign of coefficient.

The final set consists of two hypothesis tests about the long-run relationship between statewide and local economic conditions. We test for exclusion of statewide poverty (hypothesis 7) and both state variables (poverty and employment—hypothesis 8). If state variables are not part of the cointegrating relationship with the county variables, then statewide economic conditions cannot influence county employment or poverty program participation in the long run.

These specific long-run relationships among variables in the system are tested as linear restrictions on  $\alpha$  and  $\beta$ , formalized by an appropriate matrix  $\mathbf{R}'$  in Equation (3) below. For example, the test for exclusion of the  $i$ th variable in  $\mathbf{y}$  from a cointegrating relationship is

$$H_0: \mathbf{R}'\beta = 0, \quad (3)$$

where  $\mathbf{R}'$  is a vector of zeros with a one in the  $i$ th position. Table 2 provides a summary explanation, as well as the  $\mathbf{J}'$  and  $\mathbf{R}'$  vectors, for each hypothesis test. For example, the hypothesis that poverty is excluded from the cointegrating vectors (or long-run relationships) is tested by imposing the restriction that  $\mathbf{R}' = [0 \ 0 \ 1 \ 0 \ 0]$ , where  $\mathbf{y}' = [N, T, POV, SEMP, SPOV]$ .

The hypothesis of weak exogeneity of the  $i$ th variable in  $\mathbf{y}$  is tested as linear restrictions on  $\alpha$  formalized by an appropriate matrix  $\mathbf{J}'$  in Equation (4):

$$H_0: \mathbf{J}'\alpha = 0, \quad (4)$$

where  $\mathbf{J}'$  is a vector of zeros except for the  $i$ th position which is one. Formally, this is a test that the  $i$ th variable adjusts to a cointegrated relationship with the other variables in  $\mathbf{y}$  at a rate of zero. The test that poverty is weakly exogenous is formalized as the restriction  $\mathbf{J}' = [0 \ 0 \ 1 \ 0 \ 0]$ .

## Results

Tables 3a–3c give the  $P$ -values for the hypothesis tests described in Table 2 using different poverty measures [UP (Table 3a), FG (Table 3b), and Food Stamp (Table 3c)], and are organized as follows. The first four rows give  $P$ -values for hypothesis tests where  $P$ -values greater than 0.1 (failure to reject) are interpreted as evidence of a broken link between increases in local timber jobs and decreases in local poverty program participation. Row 5 gives results for tests of the hypothesis that local timber and nontimber employment have different impacts on the estimated system. The last three rows give results of tests of the relative role of state and local factors in determining local outcomes. Row 6 refers back to rank tests in Table 1. Rows 7–8 give  $P$ -values for hypothesis

**Table 3a. Results of tests on hypotheses about long-run relationships among county and state variables in models using aid to families with dependent children-unemployed parent caseloads as a poverty indicator.**

Null hypothesis	<i>P</i> value						
	County or multicounty region						
	Amador	Del Norte	Humboldt	Lassen	Mendocino	Plumas	Shasta
1. Exclude <i>P</i>	0	0.01	0.03	0.02	0.01	0.40	0.01
2. Exclude <i>T</i>	0	0.96	0.08	0.08	0.04	0	0.54
3. Exogeneity of <i>P</i>	0	0.01	0.10	0	0.17	0.74	0.94
4. Proportionality	0	0	0.02	0.62	0	0.05	0.01
5. A-job-is-a-job	0	0.50	0.03	0.05	0.01	0	0.71
6. Rank 3	See Table 1 for results.						
7. Exclude <i>SPOV</i>	0	0	0.04	0.26	0.06	0	0
8. Exclude <i>SPOV</i> and <i>SEMP</i>	0.01	0	0	0	0	0	0
	Siskiyou	Tehama	Trinity	Tuolumne	NW	NE	SE
1. Exclude <i>P</i>	0.50	0.68	0	0.04	0.65	0.50	0
2. Exclude <i>T</i>	0.02	0	0.27	0.07	0.24	0	0.72
3. Exogeneity of <i>P</i>	0.61	0.05	0.20	0.01	0.01	0.10	0.01
4. Proportionality	0	0.03	0.71	0.09	0.01	0.02	0
5. A-job-is-a-job	0	0	0.08	0.16	0.03	0	0.96
6. Rank 3	See Table 1 for results.						
7. Exclude <i>SPOV</i>	0.34	0.03	0	0.01	0	0.48	0
8. Exclude <i>SPOV</i> and <i>SEMP</i>	0	0	0	0.05	0	0.01	0

NOTE: *P* = county poverty indicator; *T* = county timber employment; *SPOV* = state poverty indicator; *SEMP* = state employment level. Multicounty regions are defined as: NW (Del Norte, Humboldt, Trinity, Mendocino); NE (Lassen, Plumas, Siskiyou, Shasta, Tehama); and SE (Amador, Tuolumne).

**Table 3b. Results of tests on hypotheses about long-run relationships among county and state variables in models using aid to families with dependent children-family group caseloads as a poverty indicator.**

Null hypothesis	P value						
	County or multicounty region						
	Amador	Del Norte	Humboldt	Lassen	Mendocino	Plumas	Shasta
1. Exclude <i>P</i>	0.04	0	0	0.05	0.03	0.86	0.01
2. Exclude <i>T</i>	0	0.10	0	0	0	0	0
3. Exogeneity of P	0.25	0.06	0.56	0.29	0.57	0.49	0.17
4. Proportionality	0	0.05	0.01	0.76	0	0.14	0.59
5. A-job-is-a-job	0	0.04	0.06	0	0	0	0
6. Rank 3	See Table 1 for results.						
7. Exclude <i>SPOV</i>	0	0	0.08	0.11	0	0	0.89
8. Exclude <i>SPOV</i> and <i>SEMP</i>	0	0	0	0.06	0	0	0.22
	Siskiyou	Tehama	Trinity	Tuolumne	NW	NE	SE
1. Exclude <i>P</i>	0	0.42	0.02	0	0.23	0.18	0.01
2. Exclude <i>T</i>	0	0.69	0	0	0	0	0.04
3. Exogeneity of P	0.92	0.36	0.03	0	0.25	0.29	0.07
4. Proportionality	0	0.01	0	0	0.51	0.01	0
5. A-job-is-a-job	0.01	0.12	0	0	0	0	0.02
6. Rank 3	See Table 1 for results.						
7. Exclude <i>SPOV</i>	0.01	0.02	0.01	0	0.01	0.02	0
8. Exclude <i>SPOV</i> and <i>SEMP</i>	0	0	0.05	0	0	0	0

NOTE: *P* = county poverty indicator; *T* = county timber employment; *SPOV* = state poverty indicator; *SEMP* = state employment level. Multicounty regions are defined as: NW (Del Norte, Humboldt, Trinity, Mendocino); NE (Lassen, Plumas, Siskiyou, Shasta, Tehama); and SE (Amador, Tuolumne).

tests about excluding statewide variables from the long-run relationship. Failing to reject these hypotheses suggests a broken link between statewide and local economic conditions. Although we report *P*-values, we use a 10% level of significance in our discussion of results.

**AFDC-UP**

Table 3a reports results from models using AFDC-UP caseload as a poverty measure. Looking in detail at results for a few counties in Table 3a provides a guide to reading and interpreting these tables.

In Plumas County, exclusion and weak exogeneity of local AFDC-UP participation from the cointegrated system of long-run relationships cannot be rejected at a 10% significance level, but the hypothesis of local timber employment exclusion is rejected. This provides evidence that local timber employment plays a role in long-run adjustment in Plumas County but that factors affecting local AFDC-UP participation (as opposed to statewide participation) do not. The hypotheses that local timber employment and local AFDC-UP caseload grow proportionately and that local

**Table 3c. Results of tests on hypotheses about long-run relationships among county and state variables in models using food stamp caseloads as a poverty indicator.**

Null hypothesis	P value						
	County or multicounty region						
	Amador	Del Norte	Humboldt	Lassen	Mendocino	Plumas	Shasta
1. Exclude <i>P</i>	0.01	0	0.01	0.96	0.22	0.02	0
2. Exclude <i>T</i>	0.90	0.20	0.04	0	0	0	0.01
3. Exogeneity of P	0.01	0	0.53	0.15	0.27	0.09	0
4. Proportionality	0.78	0	0.22	0.01	0.07	0.01	0
5. A-job-is-a-job	0.90	0.12	0.05	0	0	0	0.01
6. Rank 3	See Table 1 for results.						
7. Exclude <i>SPOV</i>	0.04	0	0	0.26	0.03	0	0
8. Exclude <i>SPOV</i> and <i>SEMP</i>	0.11	0	0	0	0	0	0
	Siskiyou	Tehama	Trinity	Tuolumne	NW	NE	SE
1. Exclude <i>P</i>	0.31	0	0	0.01	0	0.02	0.08
2. Exclude <i>T</i>	0	0.04	0	0.07	0.01	0	0
3. Exogeneity of P	0.50	0	0.03	0	0.03	0.02	0
4. Proportionality	0.02	0.01	0	0.04	0.01	0.21	0.38
5. A-job-is-a-job	0						
6. Rank 3	See Table 1 for results.						
7. Exclude <i>SPOV</i>	0.33	0.03	0.01	0.01	0	0.02	0.09
8. Exclude <i>SPOV</i> and <i>SEMP</i>							

NOTE: *P* = county poverty indicator; *T* = county timber employment; *SPOV* = state poverty indicator; *SEMP* = state employment level. Multicounty regions are defined as: NW (Del Norte, Humboldt, Trinity, Mendocino); NE (Lassen, Plumas, Siskiyou, Shasta, Tehama); and SE (Amador, Tuolumne).

timber and local nontimber employment play a similar role in the model are rejected. Looking back to Table 1, AFDC-UP has a rank of three. Looking again at Table 3a, state AFDC-UP participation and state AFDC-UP participation together with state employment cannot be excluded from the cointegrating relationship at a 10% significance level. These three tests provide evidence that state growth and factors determining AFDC-UP participation statewide are important to long-run county employment and poverty outcomes in Plumas County. Together, we interpret these results as evidence that local timber employment plays a distinct role in Plumas county but that local poverty is more likely determined by factors affecting statewide poverty program participation than local factors. The results also suggest that state growth, rather than local increases in timber supply, drives economic outcomes in Plumas County.

In contrast, in Amador County all hypotheses are rejected at a 10% significance level. Amador has a cointegrating rank of 2 not 3. These results suggest that local timber and nontimber employment both play distinct roles in the system's cointegrating relationships. Factors affecting local AFDC-UP participation also play a role that is distinct from factors affecting state participation. Decreases in Amador county timber employment are associated with an increase in county AFDC-UP participation. Finally, while state variables play a role in the system, the fact that local timber employment and poverty program participation are not excluded from the model indicates that state variables are not the exclusive drivers of long-run local outcomes.

In aggregate, results reported in Table 3a provide mixed evidence of a persistent link among local timber employment, other local employment, local poverty, and statewide economic conditions. In all counties and multicounty regions, except Amador County, we find evidence of a broken link between local poverty and local timber employment. This link is broken in different ways for different counties. In 7 of 11 counties and 2 of 3 multicounty areas, local AFDC-UP participation is either excluded from or weakly exogenous to the cointegrating relationship at a 10% significance level. In 2 counties and 3 multicounty areas, local timber employment is excluded from the cointegrating relationship. In 2 counties local AFDC caseload changes in direct, not inverse, proportion to local timber employment. This suggests that, overall, factors affecting only local AFDC-UP participation, such as local timber employment, do not play a significant role in determining local AFDC caseload in the long run.

In all but two counties and one multicounty area, the hypothesis that "a-job-is-a-job" is rejected. This finding is evidence that local timber and nontimber employment play distinct roles in the estimated system. Such a finding would be consistent with either sector functioning as the area's economic base. Short-run results shed more light on this question.

Results also suggest that state variables play a significant role in long-run local economic outcomes. In all but two counties and one multicounty area, the null hypothesis that state poverty can be excluded are rejected. So factors that

affect statewide, but not local, AFDC-UP participation affect outcomes in 9 of the 11 study counties. In every county and region, we reject the null hypothesis of excluding both statewide economic variables. These results suggest a long-run link between statewide economic conditions and local conditions. But, in the AFDC-UP models, only Plumas County has a cointegrating rank of three. That is, in Plumas, but not the other 10 study counties or the 3 multicounty areas, if statewide variables are held constant, shocks to county variables will not persist in the long run.

### **AFDC-FG**

Qualitatively, we obtain a similar result using AFDC-FG caseload as the poverty measure (Table 3b). Exclusion of local AFDC-FG caseload is rejected in 9 of 11 study counties and 2 multicounty areas, but exogeneity of AFDC-FG cannot be rejected in 8 of 11 counties and 2 multicounty areas. Exclusion of local timber employment is rejected in 2 counties and no multicounty areas. Proportional change in local timber employment and local poverty cannot be rejected in 2 counties and the northwest multicounty area. So, in 9 of 11 counties (all except Trinity and Tuolumne) and in the 2 northern multicounty areas, the long-run link between local timber employment and local poverty is broken by failing to reject at least one of the first four hypothesis tests. In a few counties, such as Del Norte, the hypothesis is only marginally rejected. In other cases, such as Humboldt County, the link is broken in only 1 place. In such counties one might consider there to be weaker evidence that the link between local poverty and timber is broken. In other counties, such as Tehama, we fail to reject all of the relevant hypotheses with relatively large *p*-values, providing stronger evidence that local poverty program participation and local timber employment are unrelated in the long run.

Using AFDC-FG as the poverty indicator, the hypothesis that a-job-is-a-job is rejected in all but one county, Tehama ( $P = 0.12$ ) and no multicounty area. This strongly suggests that SIC 24 employment plays a different role than other employment in these areas.

Again, in aggregate, statewide economic conditions appear to be related to local conditions in the long run. With AFDC-FG as the poverty measure, Tuolumne County and its multicounty area (Southeast) both have a cointegrating rank of three. In these areas, shocks to local variables cannot persist unless there are also changes in state variables. Using this poverty measure, we also fail to reject exclusion of statewide poverty in only two counties, Lassen ( $P = 0.11$ ) and Shasta ( $P = 0.89$ ), and in no multicounty areas. And in only one county, Shasta, do we fail to reject exclusion of both statewide economic variables, again suggesting an important link between statewide and local economic conditions.

### **Food Stamps**

Results are most mixed when we use Food Stamps as the poverty measure (see Table 3c). In 6 of 11 counties (Amador, Del Norte, Humboldt, Lassen, Mendocino, and Siskiyou) and 2 multicounty areas (Northeast and Southeast), we find evidence of a broken link between local timber jobs and local poverty. As in the cases using UP and

FG as poverty measures, this link is broken for different reasons in different counties. The hypothesis that the local poverty measure can be excluded is rejected in all but three counties and in no multicounty area. Exogeneity of the local Food Stamp participation is rejected in seven counties and all multicounty areas. The hypothesis that local timber employment and local Food Stamp participation change in direct proportion is rejected in nine counties but only one multicounty area. The hypothesis that a-job-is-a-job is rejected in nine study counties and in all multicounty areas. This provides evidence that in models with Food Stamp participation as the poverty measure, that SIC 24 employment plays a distinct role from other employment in determining local economic outcomes.

As in the above cases, using other poverty measures, we find evidence that statewide economic conditions likely play a long-run role in determining local conditions. In only two counties (Lassen and Siskiyou) and in none of the multicounty areas is there evidence that statewide poverty conditions may be exogenous to this long-run system. The test for exclusion of both statewide variables is rejected in all but two places (Amador county and its multicounty region, Southeast), and in those places, evidence is of exclusion is weak ( $P = 0.11$  and  $P = 0.20$ , respectively). On the other hand, only in Trinity county do we find a cointegrating rank of three, suggesting that, in all study counties and multicounty areas except Trinity county, changes in local economic conditions can be sustained in the long run even with statewide variables held constant.

### Short-Run Results

While this modeling approach has been developed to examine long-run relationships, the estimated model does allow simulation of short-run impacts. For each of the 11 counties, the estimated models are used to simulate a 24-month forecast with observed levels of all variables used as initial conditions. The simulated 24-month forecast is run again with a one-time, 100-job increase in either timber or nontimber jobs in the last month before the forecast. The difference between these two forecasts gives the expected short-run changes in county employment or poverty program caseload in response to an increase of 100 timber or 100 nontimber jobs. Table 4 reports the average of these 11 county forecasts using alternative poverty measures.

The experiment that we run is very different from the standard I-O multiplier experiment. The standard I-O multiplier assumes the permanent addition of a job to an economy and looks at its impact on other economic outcomes. On average, the Type II IMPLAN employment multiplier for the 11 study counties is 2.8. We look at

whether one-time shocks to an economy, such as those from a temporary increase in timber harvest, persist. The critical result is that the impact of a 1 month increase in either timber or nontimber employment by 100 jobs persists 2 yr later. On average, across the three poverty models, a 100-job increase in timber jobs results in 85 total extra jobs 2 yr later (Table 4). A 100-job increase in nontimber jobs results in an average of 79 extra jobs 2 yr later. Most of the jobs that persisted were in the sector that was originally shocked.

The short-run simulations also provide expected change in poverty program cases 2 yr after a 1 month shock to employment. In general these changes were small, ranging from  $-0.06$  to  $3.1$ . The one exception is that the Food Stamp caseload seems quite responsive to changes in timber employment. On average, the simulations indicate 61 fewer Food Stamp cases 2 yr after a 1 month increase of 100 timber jobs. This is in part due to very large decreases in four counties (109 to 216 expected Food Stamp cases as compared to 10 or less in the remaining seven counties).

### Discussion

The results from the hypothesis tests and short-run simulations provide evidence that addresses three important economic questions raised in the ongoing debate over timber policy in California. First, are timber jobs better at inducing local employment growth or reducing local poverty than other jobs? Second, does a decrease in local timber employment result in a long-run increase in local poverty? Third, are state factors or county factors the long-run determinants of county employment and poverty?

### Impact of Local Timber Employment versus Local Nontimber Employment

Local concerns about harvest restrictions and most economic analysis of forest policy impacts are based on a view that forestry and wood products industries are an important part of the economic base of heavily forested areas. Our long-run analysis is not designed to identify whether timber is the economic base of these areas, but our results are consistent with the hypothesis that timber is a basic industry in these areas. Local timber employment is excluded in very few county or multicounty models. In 80% of the county models and all but one multicounty model, timber employment plays a different role from nontimber employment in the modeled long-run economic relationships. Our short-run results suggest that, while the multiplier impact after 2 yr of a one-time increase in employment in either sector is not great, neither does such a transitory shock simply dissipate. It is notable that one-time shocks to either employment class persist over a 2 yr period.

**Table 4. Expected short-run outcomes conditional on 100 additional jobs using var models with alternative poverty indicators.**

Condition	AFDC-UP model Additional:			AFDC-FG model Additional:			Food stamp model Additional:		
	Nontimber jobs	Timber jobs	UP cases	Nontimber jobs	Timber jobs	FG cases	Nontimber jobs	Timber jobs	FS cases
+100 NT	76.6	7.6	0.7	84.0	0.9	-0.6	68.8	-1.6	3.1
+100 T	34.6	104.6	-1.7	-11.0	69.2	2.8	-55.1	113.2	-61.5

### **Timber Employment and Poverty**

In 70% of the county models and 77% of the multicounty area models, the long-run link between decreases in local timber employment and increases in local poverty program participation was broken in at least one place. The long-run relationship between local timber employment and poverty program participation is most often broken because local poverty program participation is not part of, or is weakly exogenous to, the systems' long-run relationships (60% of all county models, 44% of multicounty models). It is much less common for the relationship to be broken because local timber employment is excluded from the model or because timber and poverty program participation change proportionately not inversely (roughly a third of county and multicounty models).

As expected from state and national studies, evidence on the long-run impact of county timber employment on poverty program participation in the study area varies by program. State and national studies indicate that AFDC-UP and Food Stamp participation are strongly counter-cyclical (Blank 1997, Hoynes 2000, Wallace and Blank 1999, Wilde et al. 2000). AFDC-FG participation is the least sensitive of all major poverty programs to changes in macroeconomic conditions at the state and national level (Blank 2000). Our county results provide mixed evidence of these relationships holding at the substate, local level. In 63% of AFDC-UP county models and 73% of AFDC-FG counties, but in only 36% of Food Stamp county models, local poverty program participation was excluded from or weakly exogenous to the systems' long-run relationships. This is evidence that Food Stamp participation is more sensitive to changes in local economic conditions than AFDC participation. It is also limited evidence that, over the long run, at least AFDC program participants are not moving to these local areas in response to changes in local conditions.

Short-run multiplier simulations give an indication of the magnitude of the adjustment underlying these long-run results. When 100 timber jobs are added, there is only a negligible impact in the 24-month forecast of AFDC-UP or AFDC-FG participation. In contrast, Food Stamp participation falls substantially. While the magnitude of the outliers do seem extreme, it would not be surprising that local Food Stamp participation was more sensitive to changes in local conditions than local AFDC participation given the nature of the two programs.

### **Do State Variables Matter?**

Exclusion of state variables from the estimated models is generally rejected. State poverty program participation levels cannot be excluded in 15% of county and 10% of multicounty area models. These results vary little across programs. Since there were few programmatic changes to these programs during the study period, state poverty program data are a proxy for factors, such as state unemployment rates, that may reflect broader macroeconomic factors affecting poverty. But it is also not possible to exclude both state variables in all but 6% of the county models and 20% of the multicounty area models. This is also not surprising since these areas are small and it would be expected that local

economic outcomes fluctuate with wider business cycles, which are reflected in the state variables.

### **Conclusions**

Local concerns that reductions in timber-related employment result in increased poverty are consistent with all the theories of geographic distribution of poverty discussed above except the neoclassical theory. Our results do not show strong inverse relationships between AFDC program participation and local timber employment, during the study period, 1983–1993, in California's timber major counties. Since our results suggest that timber-related employment functions as one would expect a basic industry to function, the lack of a strong inverse relationship between AFDC program participation and local timber employment could be interpreted as consistent with a neoclassical theory of the geographic distribution of poverty. There is stronger evidence from our results of a long-run relationship between local timber employment and local Food Stamp participation. In national studies Food Stamp participation was more pro-cyclical than participation in AFDC-FG. This is because of differences in eligibility requirements and the population targeted by these programs. Poverty is a complex phenomenon with multiple causes, some more related to business cycles and some more embedded in enduring social conditions. These results suggest that a single theory may not be adequate to explain its geographic distribution.

Our results also indicate that local economic outcomes, specifically, local timber and other employment and local poverty program participation, were affected by state economic conditions. To the extent that local concern with poverty has to do with reduction of public poverty program participation, or to the extent that the National Research Council is correct that participation in these programs provides an indicator of changes in poverty more broadly, these results have practical relevance. They suggest that policy that is effective at alleviating poverty at a state level may be more effective in reducing poverty in these local areas than a policy targeted at increasing local timber-related employment.

Our results examine a specific period of time, 1983 to 1993, in a specific location, northern and east-central California. The decade examined by this study saw a period of economic growth bracketed by recession, not untypical of many business cycles. The areas studied are better connected by transportation to major urban areas than are most of the timber-rich areas of the American West. This ease of transportation should be expected to facilitate adjustment. These and other particularities of the study area and time period must be considered in judging the applicability of these results in other areas or other time periods.

### **Endnotes**

- [1] North Coast: Del Norte, Humboldt, Mendocino, and Trinity counties. North Sierra: Lassen, Plumas, Shasta, Tehama, and Siskiyou counties, Central Sierra: Amador and Tuolumne counties.
- [2] The 11 counties are: Amador, Del Norte, Humboldt, Lassen, Mendocino, Plumas, Shasta, Siskiyou, Tehama, Trinity, and Tuolumne.
- [3] See volume 62(182) Federal Register pages 49397–49411 (September 19, 1997) for the proposed listing of the McCloud River redband trout and the bull trout. See also California Code of Regulations, Title 133, Natural Resources, Division 1, Subdivision 3, Chapter 3, Section 670.5 for state listings of salmonids.

- [4] Economic-base theory views regional economic growth as driven by exporting (basic) sectors of the region's economy. Basic-sector industries bring nonlocal income into the local economy by using proceeds from export sales to hire local workers and purchase inputs locally. See Krikelas (1992) for a recent review of economic-base theory.
- [5] A variable  $x$  is said to Granger cause  $y$  if lagged values of  $x$  and  $y$  are a better predictor of  $y$  than lagged variables of  $y$  alone. It is causation in the sense that changes in  $x$  precede changes in  $y$ .
- [6] County employment data were obtained by personal communication with California Employment Development Department personnel responsible for collection and maintenance of employment and hours data for individual counties. Decisions on county-level record retention are made on a county-by-county basis by personnel responsible for that particular county. The shortest of these series began in January, 1983, creating a limit on the length of our time series.
- [7] Employment in forest management (SIC 08) is not used in the study. It represents less than 2% of total timber-related employment (SIC 24 + SIC 08) in California and is blocked in most study counties for reasons of business confidentiality (California Employment Development Department, various years). Employment in pulp and paper (SIC 26 1-3) also was excluded. There is only one pulp and paper mill in any of the study counties and data on employment in this mill also is blocked for reasons of business confidentiality (Professor Keith Gilliss, University of California at Berkeley, pers. comm.).
- [8] Preliminary analysis using comparisons of 1980 and 1990 census data led to inconclusive results, which further motivated us to approach the question using time series analysis (Fortmann et al. 1991).
- [9] A system with 120 observations in 5 series, a lag of 2, 2 cointegrating vectors, 11 monthly dummies, and a constant term has a total of 130 parameters and 470 degrees of freedom. This seems sufficient for the asymptotic properties of maximum likelihood.
- [10] Practically, determination of the cointegration rank is an iterative process where one starts with the hypothesis of  $r = 0$  cointegrating vectors. If this test is rejected by either test at the 0.95 significance level, the test is repeated for  $r = 1, 2, \dots, p-1$  cointegrating vectors. There were several counties where the estimate of cointegrating rank would increase if the .90 level of significance were used. In no county would the extreme hypotheses of no cointegration or stability (five cointegrating vectors) be supported. Parameter matrices are too voluminous to present and are available from the authors on request.

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