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Abstract

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ABSTRACT. This paper uses cointegrated time-series methods to evaluate the effect of timber employment on participation in a major poverty program—Aid to Families with Dependent Children-Unemployed Parent (AFDC-UP). The study is conducted for major timber-producing counties in California. It is shown that a two-sector structural model can be solved to produce an error-correction model. An error-correction model is estimated with time series on state and county AFDC-UP caseload, state employment, county nontimber employment, and county timber employment. Utilizing tests on the cointegrating space, it is shown that there is no long-run relationship between poverty and timber employment in 10 of the 11 counties studied.

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1. INTRODUCTION

In 1989, a federal court order protecting the spotted owl brought timber harvests in pacific northwest national forests to a virtual standstill. Subsequent federal listing of the spotted owl, marbled murrelet, and the proposed listing of several salmonids and the California state endangered listing of the winter run chinook salmon and bull trout has severely restricted the cutting of timber in California, Oregon, and Washington. Forest residents view the costs of these actions as decreased employment and increased poverty:

> Mills don't run, men don't work and families don't eat when politicians cannot give us the assurance that we can log in the nonwilderness areas. (Vincent, 1988)

> And then came the spotted owl, and almost overnight the hauling jobs dried up and we had our electricity turned off and finally we received a foreclosure notice on this farm. (Unidentified woman in: California Forestry Association, 1994)

> They just created Appalachia in the Northwest. (Michael Burrill in: California Senate Office of Research, 1996, p. 20)

> The loss is evident in the lines at the soup kitchens. And the loss is evident in the homes where unemployed workers, anxious, depressed, sunk in despair, lash out at their loved ones or find solace in alcohol or drugs. (Archbishop Thomas Murphy in: California Forestry Association, 1994)

Their message to policymakers is clear: Sustained, indeed increased, levels of timber harvesting are essential to prevent job loss, poverty, and poverty program participation in forest-dependent local economies.

But, in California's timber counties, the facts may not support this message. It is true that a combination of decreased availability of old-growth trees, technical progress in milling, and designation of habitat for endangered wildlife has resulted in smaller timber harvests and fewer timber jobs. What is not clear is how fewer timber jobs translate into overall changes in area employment or poverty program participation.

This article addresses three questions. First, does a decrease in timber employment result in a long-run increase in participation in employment-sensitive poverty programs? Second, are timber jobs better in the short run at reducing poverty program participation or inducing county employment growth than other jobs? And third, are state variables long-run determinants of county employment or participation in poverty programs?

Conventionally, these questions would be examined using multipliers derived from an Input-Output (I-O), extended I-O, or Computable General Equilibrium (CGE) model. This class of models imposes considerable economic structure on the data, including unverifiable assumptions regarding the economy's adjustment through trade or

factor mobility. Hoffmann, Robinson, and Subramanian. (1996) showed that the size of economic multipliers is strongly affected by these assumptions. In contrast, multipliers based on time-series models reflect the actual empirical adjustment that takes place through trade flows, migration, and intersectoral factor movement. The questions we address in this study turn crucially on sectoral and interregional mobility of labor. For this reason, we use cointegrated time-series techniques to examine these questions in 11 of California's major timber counties.

The next section of this article reviews national, state, and metropolitan area studies of the relationship between poverty, employment, and unemployment. These studies find, at best, a weak link between aggregate employment and poverty rates. Section three contains a discussion of economic conditions and environmental policy in the study area during the 1980s and 1990s. Section four describes data used in this study. This study examines the relationship between monthly county timber and nontimber employment and participation in the Aid to Families with Dependent Children-Unemployed Parent (AFDC-UP) program. The AFDC-UP is the only major poverty program targeted directly at poverty caused by recent unemployment. Section five discusses the relationship between the time-series model estimated in this study and structural models. Section six presents a methodology for estimating a cointegrated vector autoregression (VAR) representing economic processes in the study counties. Results of formal tests and simulations of relationships among time series on timber employment, nontimber employment, and AFDC-UP welfare caseload are discussed in section seven. The paper concludes with a brief summary and interpretation of these results.

2. PAST RESEARCH: EMPLOYMENT GROWTH AND POVERTY

Employment growth has the potential to alleviate poverty by reducing unemployment and underemployment. A significant body of literature, summarized by Sawhill (1988), finds that U.S. poverty rates are sensitive to national unemployment rates. Blank and Card (1993) found a positive relationship between unemployment and poverty rates at the level of multistate regions. Tobin (1994) found that states with chronically high unemployment and low wages are likely to suffer high poverty rates and that this relationship can persist despite employment and income growth. It seems likely that reducing unemployment does reduce poverty on a national or multistate level, but the evidence at the state level is not clear.

There is less agreement that increasing state or local employment decreases state or local unemployment. Changes in state or local employment can result in changes in long-term state or local unemployment and/or interregional migration [Greenwood and Hunt (1984) and Marston (1985)]. In a study of U.S. Metropolitan Statistical Areas (MSA), Bartik (1993) concluded that, even in the long run, local residents retained 10 percent to 40 percent of the job growth. In contrast, Blanchard and Katz (1992) found that migrants from outside the region absorb all job growth within five to seven years.

Evidence on the direct relationship between employment growth and poverty is also ambiguous. Nationally, Cutler and Katz (1991) found that lower-income households did not participate proportionately in income gains from employment growth during the 1980s. At a state level, Tobin (1994) found that gains in earnings and employment over a nine-year period did not reduce poor states' poverty to the level found in states with long histories of prosperity. During the 1980s, Bartik (1994) found that a 10-percent increase

in MSA employment increased average family income by only 4 percent to 5 percent but increased average family income in the lowest quintile by 10 percent.

The relative efficacy of different types of employment in promoting regional growth and presumably in reducing poverty is also an issue. Typically, states and localities have been most concerned about creation or loss of skilled industrial jobs. In pacific northwest forest policy debates, interest has focused on employment in timber-related industries. Three of the four studies of spotted-owl-caused job losses in the pacific northwest, cited in Sample and Le Master (1992), used a multiplier of one derived from an I-O model so that an additional timber job produced two total new jobs; the other study used zero.

In summary, there is substantial agreement that decreasing unemployment alleviates poverty but conflicting evidence that additional regional employment alleviates regional unemployment or poverty. The only existing evidence that directly addresses the questions posed in this paper is estimates of the employment multiplier impact of timber employment on total employment in the spotted-owl region.

3. THE CALIFORNIA TIMBER REGION: ECONOMICS AND ENVIRONMENTAL POLICY

Over the past 40 years, 11 counties have produced between 70 percent and 80 percent of timber harvested in California. During the 1980s, timber-related businesses provided at least 4 percent of total county employment and closer to 10 percent of total employment in most of these counties.[1] Timber is the most visible industry in these counties and, as illustrated by the quotes above, residents perceive their economic fortunes as being locally—particularly timber industry—determined. More than half of the commercial timberland in the study counties is publicly owned and managed,

primarily by the U.S Forest Service (USFS). As a result, federal and state policy affecting forests, particularly national forests, is of considerable local concern.

Through the 1960s, federal forest policy in the pacific northwest was relatively uncontroversial. The Multiple Use Sustained Yield Act of 1960 mandated management of national forests for timber supply, jobs, and recreation (hunting, fishing, hiking, and scenic beauty). Because substantial areas had not been cut, these objectives did not conflict. Increased timber harvests resulted in more jobs, and a more open forest meant more game. Passage of the Wilderness Act in 1964 signaled the beginning of a profound change in way the U.S. public valued forest resources. In the pacific northwest, an urbanizing population placed increasing value on the forest as an ecological system rather than primarily as timber supply. This change in public values combined with a trend in forest management toward larger clear-cuts and shorter rotations portended a major political confrontation (Curtis and Carey, 1996).

Similar changes in public values nationally brought passage of the National Environmental Policy Act (NEPA) (1970), Endangered Species Act (ESA) (1973), Resource Planning Act (RPA) (1974), and National Forest Management Act (NFMA) (1976) in the early 1970s. Actions taken under these acts were to bring pacific northwest forest management to a crisis point by the late 1980s. The NEPA and the ESA opened forest planning to public scrutiny and allowed citizens to sue to ensure enforcement of the acts. The ESA prohibition on direct takings and destruction of critical habitat proved a strong weapon for environmental advocates and expanded public influence on activities on private lands. Given past management practices, national forests in the pacific

northwest would have to reduce harvests and preserve old growth in order to meet the NFMA requirement of nondeclining even flows of timber from national forest lands.

Pressure from the timber industry to avoid reductions in the cut and from environmentalists who believed proposed National Forest Plans were not protective enough dragged out the RPA planning process and maintained historical harvest levels for nearly a decade. In August, 1986, the USFS finally released a draft plan calling for a 5-percent reduction in cut to protect owls in pacific northwest national forests. Environmentalists sued on the grounds that this was inadequate under the ESA and in March, 1989, obtained a temporary order restraining the USFS from offering 139 planned timber sales.

From this point forward, the northern spotted owl and, subsequently, other coastal species moved to center stage in pacific northwest forest politics (Yaffee, 1994). In June, 1989, the U.S. Department of Interior (USDI) proposed and in June, 1990, listed the spotted owl as an endangered species. In May, 1991, it listed 11.6 million acres of pacific coast forest, three million of which was private, as critical habitat off bounds to timber harvesting under the ESA. In October, 1992, USDI listed another old-growth redwood inhabitant, the marbled murrelet, as a threatened species. It was clear that federal or state governments would soon list several species of salmon and trout as threatened or endangered.[2]

An already heated controversy boiled over. In California, militant environmentalists called for a "Redwood Summer" and some spiked trees and sabotaged logging operations. In Oregon, the USFS reportedly received death threats against Smokey the Bear and Woodsy the Owl and refused to send employees dressed as these

USFS mascots to the annual Portland Rose Festival parade (Yaffee, 1994). In April, 1993, President Clinton called a "Forest Summit" bringing together representatives of timber industry, local communities, environmental organizations, and the scientific community to air concerns about the future of coastal forests in the pacific northwest. The President responded with a plan, released in July, 1995, calling for significantly decreased timber cuts to protect ecosystems, an additional $22 million in Job Training Partnership Act funding for the region, a nearly $100 million increase in financial assistance to timber counties, and decoupling of this assistance from federal timber sales receipts. The recent government purchase of the Headwaters forest from the Maxxam corporation involved lengthy negotiation over environmental restrictions on other Maxxam lands. Currently, Congress is considering adoption of proposals negotiated among local environmental and industry interests in Quincy, California. The legislation is opposed by many national environmental groups. Controversy over timber policy has hardly ended.

In the midst of this controversy, 1982 to 1993, timber harvests and timber employment went through a pronounced cycle of boom and bust (Figure 1). Unlike previous cycles, the decline in timber harvest did not stop when U.S. housing starts bottomed out. Housing starts reached bottom in 1991, but harvests continued to fall in California's major timber counties, finally leveling out at about 1.65 billion board feet. Almost certainly, this continued drop is attributable to final acceptance of Forest Plans under the RPA, listing of the spotted owl and marbled murrelet, and public opposition to old-growth logging. Ultimately, a decline was inevitable due to reduced timber stocks (see California Department of Finance, various years).

Despite this boom cycle in timber employment, the long-run trend in the sector has been one of steady job loss to technological progress (Stewart, 1993). At the same time, total county employment grew steadily, paralleling statewide growth throughout the 1980s and early 1990s (California Department of Finance, various years). Even when statewide employment stagnated in the early 1990s, total employment kept growing in these study counties. Thus, timber harvest and employment have been reduced by environmental constraints and technological change and yet the overall employment in these remote counties has grown.

In contrast, poverty in these counties worsened relative to the whole of California during the 1980s. In the 1979 census, the percent of average study-county population with incomes below the official poverty line was actually lower than for the State as a whole, 11.5 percent compared to 11.8 percent for the State (U.S. Department of Commerce, 1980). But by the 1990 census, the average study-county poverty rate of 13.8 percent exceeded the statewide rate of 12.5 percent (U.S. Department of Commerce, 1980). In contrast, participation in AFDC-UP in the subject counties did not, however, follow exactly the opposite pattern from timber employment. As shown in Figure 1, AFDC-UP caseload increased with timber employment from 1985-1987 and decreased with it from 1988-1990. The relationship among these variables bears further analysis.

4. DATA

This study uses monthly time-series data to examine county timber employment and welfare dependence during the period 1984 through 1993. Use of monthly data makes it possible to capture the marked seasonality that characterizes timber-related employment and therefore its potential effect on poverty. Both the need to use monthly

data and, more critically, the focus on small rural counties severely constrains data availability. A secondary goal of this study is to examine the feasibility of estimating economic multipliers for nonmetropolitan counties using only primary data. Much of the data commonly used to calculate multipliers in rural counties is actually national or state data apportioned to counties on the basis of the primary data used in this study. This section describes the administrative and program data used in this study.

The AFDC-UP caseload is used as an indicator of state- and county-level unemployment-related poverty (California Department of Social Services, various years). The AFDC-UP program is available to two-parent households with an unemployed principal earner who has a history of recent employment. Data on poverty indicators, particularly the official poverty rate, are unavailable at a county level on a monthly basis.[3] As importantly, AFDC-UP may be a better indicator of poverty trends relevant to this study than the official poverty rate. Unlike the official poverty rate or participation in other major federal programs, AFDC-UP targets households with recently employed adults. The AFDC-UP was set up to be a countercyclical force in the employment cycle and has proven to be so at a national level (Blank, 1989). The AFDC-UP participation should, therefore, reflect trends in the number of households in or near poverty whose economic well-being is most affected by changes in employment demand.

County timber and nontimber employment levels are taken from the U.S. Bureau of Labor Statistics (BLS) series on employment covered by unemployment insurance (California Employment Development Department, various years). Timber-related employment is represented by employment in lumber and wood-products industries [Standard Industrial Classification (SIC) 24]. We do not include employment in forestry

(SIC 08, e.g., tree planting and fire suppression) or pulp and paper employment (SIC 26). None of these sectors represent a significant fraction of the work force in the study counties. Furthermore, BLS does not make forestry employment data available for most of the study counties for reasons of business confidentiality.

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 longest series available began in January, 1984, creating a limit on the length of our time series.

Total monthly state employment is also taken from the BLS ES-202 series (California Employment Development Department, various years). Total state employment provides a proxy for state output of goods and services, which are believed to be significant factors driving demand for local employment and ultimately willingness of unemployed labor to migrate. Data on alternative state-level measures of economic activity, such as gross state product, are ultimately derived from this employment data and assumptions regarding the ratio of output to employment, which will introduce measurement errors into statistical analysis. Furthermore, data on these measures are not available on a monthly basis. As a result, total state employment provided the most reliable measure available of state economic activity.

5. MODEL

The questions addressed in this study are examined in a cointegrated VAR framework. Interest has grown in using time-series models to estimate regional

economic multipliers [Fawson and Criddle (1994) and Wozniak and Babula (1992)]. In one of the earliest studies, Brown, Coulson, and Engle (1992) used cointegration methods to determine MSA-level employment multipliers.[4] Time-series models, such as a VAR model, can be viewed as the solution to a dynamic structural model, like a CGE model (Sims, 1980). There is a trade-off in choosing between these two representations of a regional economy. Structural models, like the I-O/CGE class of models, incorporate significant sectoral and structural richness but impose assumptions regarding economic adjustment. Time-series models measure the actual empirical impact of the adjustment process but lose sectoral detail and structural information that the modeler may have good evidence to believe.

The VAR that we estimate can be viewed as a solution to a two-sector, structural model. This structural model represents the basic economic relationships that would be expected to determine the impact of local employment and unemployment on poverty. It includes equations representing (1) equilibrium in the labor markets for timber and (2) nontimber, (3) AFDC-UP participation as a function of employment and other variables, (4) total state employment, (5) state AFDC-UP program participation depending upon state-level variables, and (6) migration in and out of the county as a function of state and county variables.

Timber industry labor markets are assumed to clear:

$$(1) \qquad T^d(SE, w_T) = T^s(pop, w_T, w_N).$$

Timber industry labor demand (T^d) is a function of wage in that industry, and state employment, which shifts demand for timber and timber workers. The supply of labor to

timber firms depends upon county population, which in turn depends on migration out of the county, and both timber and nontimber wages.

The equation for labor-market equilibrium in the nontimber sector is of nearly the same form. Here, however, state employment and county timber employment are both good choices as demand-shift variables. According to base theory, total labor demand in these "timber-dependent" counties should be driven by employment in the timber sector (T) because it is the primary exporting (or base) industry. Assuming markets clear,

$$(2) \qquad NT^d(SE,T, w_T) = NT^s(pop, w_T, w_N),$$

where NT^d and NT^s are demand and supply for county workers in nontimber industries.

The third equation of the structural model defines the relationship between county AFDC-UP caseload and other variables in the system. The literature suggests a strong relationship between county AFDC-UP participation (UP) and county employment rates (N, T, pop). Since emigration from the county is an alternative to unemployment, county net migration (mig) should also be a determinant of caseload. State participation in AFDC-UP (SUP) is a proxy for noncounty factors influencing AFDC-UP participation, including variables such as benefits level. Thus,

$$(3) \qquad UP = UP(N, T, pop, SUP).$$

The state-level variables are not of primary interest here and are simply modeled as a vector autoregressive process.

$$(4) \qquad SE = SE(SE_{t-1}, SE_{t-2},\ldots,).$$

$$(5) \qquad SUP = SUP(SE_{t-1}, SE_{t-2},\ldots,SUP_{t-1}, SUP_{t-2},\ldots.).$$

By definition, county population is

$$(6) \qquad pop_t = g \cdot pop_{t-1} + mig_t,$$

where g is an exogenously determined net rate of county population growth. Equation (6) can be solved for current population as a function of initial population and a growth-rate weighted sum of past migration. From the point of view of this study, initial population is a constant; as a result, lagged values of migration can be substituted for population wherever it appears in the model.

Finally, county immigration depends upon employment and on state and county poverty:

$$(7) \qquad mig = mig(SE, N, T, UP, SUP).$$

We seek to develop a model that can be estimated using only primary county data. Since monthly county wage and migration data are unavailable and county population data are directly measured only decennially, and annual estimates would introduce unnecessary measurement error, we solve the system to eliminate the migration, population, and wage variables.[5] This leaves a vector autoregressive model in which N, T, SE, SUP, and UP are each a function of current and lagged values of all five of these variables. While the estimation of this time-series model will not permit reconstruction of the structural model, it does allow explicit empirical testing of a hypothesis about the long-run relationship between poverty and employment.

6. ESTIMATION

One cointegrated VAR is estimated for each county in the study. Cointegrated VARs are regressions of the first difference of the variables on their levels and lagged

values of the first differences. The estimation process limits the inclusion of the lagged values of variables to particular linear combinations of the variables. Those linear combinations are cointegrating relationships and define the long-run relationships among the variables. Tests involving these cointegrating relationships provide evidence on the relation between poverty and employment. The first step in producing this evidence is to estimate a (possibly) cointegrated VAR. The estimated VARs are then subjected to standard specification tests.

Following Engle and Granger (1987), the VAR model is written in error correction form as

$$(8) \qquad \Delta \mathbf{y}_t = \phi + \Gamma_1 \Delta \mathbf{y}_{t-1} + \cdots + \Gamma_{k-1} \Delta \mathbf{y}_{t-k+1} + \Pi \mathbf{y}_{t-1} + \Psi \mathbf{D}_t + \varepsilon_t,$$

where $\mathbf{y}_t$ is a five-column vector of the variables included in the study at time t, $\mathbf{y}_t' = (NT_t, T_t, UP_t, SE_t, SUP_t)$. The Δ indicates the first difference of variables (e.g., $\Delta \mathbf{y}_t = \mathbf{y}_t - \mathbf{y}_{t-1}$). The Γ_t are matrices of parameters of the t-times lagged difference of $\mathbf{y}$. The $\mathbf{D}_t$ is a matrix of 11 monthly dummy variables and Ψ is the corresponding parameter. The ϕ is a vector of constant terms. The ε is a vector of mean zero errors. Finally, Π is a parameter matrix containing information about the cointegrating vectors.

The parameters of (8) are estimated in a three-step statistical analysis. First, the number of lagged difference terms to be included in the estimated equation is determined. Next, cointegration tests are used to find the number of cointegrating vectors. Finally, the values of the parameter matrices are estimated.

The number of lagged difference terms was determined using a likelihood ratio test. The null hypothesis is that there is no improvement in fit going from t lags to t + 1

lags. Beginning with one lag versus two lags, consecutive tests are repeated until one can accept the null hypothesis. Optimal lag lengths were found to be between one and four months and are reported in Table 1.

Next, the rank of the cointegrating spaces in the models was determined.[6] The number of linearly independent cointegrating relationships, r, is found through cointegration tests. Following Johansen and Juselius (1990), the hypothesis of cointegration of rank r among the p (in this case five) series is the hypothesis that the rank of Π is r:

$$(9) \qquad H_1(r): \Pi = \alpha\beta',$$

where α and β are pxr (and rxp) matrices of full rank. The elements of $\mathbf{y}_t$ are cointegrated when the rank r of the matrix Π is greater than zero but less than the number of endogenous variables, p. In this formulation β is the matrix of coefficients for r stationary cointegrating relationships $\beta'\mathbf{y}_t$, which are interpreted as stationary relations among nonstationary variables. It is known that $\mathbf{y}(t)$ tends toward the cointegrating space; as t becomes large, $\mathbf{y}(t)$ satisfies each of the cointegrating relationships $\beta'\mathbf{y}_t$. This is the sense in which cointegration gives long-run relationships among variables. The rates at which the variables, y, adjust toward the cointegrating space is given by α. Some variables may adjust quickly while others may not change at all.

Johansen and Juselius (1990) derive two useful tests for the hypothesis of r cointegrating vectors. The first is a likelihood ratio test for the reduced rank of Π hypothesis called the Trace statistic. The null hypothesis is H_0: rank (Π) $\leq$ r (or, equivalently, that the system has p - r unit roots) versus the alternative that the rank is

greater than r. An alternative, called the maximum eigenvalue test, computes the λ_{max} statistic and is based on the ratio of the likelihood of $H_1(r)$ to $H_1(r + 1)$. The null hypothesis is that the rank of Π is r or less while the alternate is r + 1 or less. The asymptotic distributions of the rank and trace test statistics are nonstandard and depend on deterministic components included in the model.[7] 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 .95 significance level, the test is repeated for r = 1, 2, ..., p - 1 cointegrating vectors. The first accepted rank was the reported estimate of rank presented in Table 1. 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. Finally, parameter matrices were estimated given the number of lags, k, found in step one and the cointegrating rank found in step two. These parameter matrices are too voluminous to present.

Validation

After the models were estimated, model appropriateness was assessed by testing for autocorrelation and by examining R^2. As reported in Table 1, the R^2 of the equations describing county-level variables, nontimber jobs, timber jobs, and AFDC-UP caseload are on average over all study counties .78, .59, and .53, respectively. The equations fit nontimber employment better than timber employment and timber employment slightly better than AFDC-UP caseload.

Several additional tests were conducted to assess model validity. Two different Lagrange multiplier tests were used to test for residual autocorrelation [see Hansen and

Juselius (1995) for a description of tests]. In 4 of the 11 counties, there was measurable autocorrelation in at least one equation. Auto correlograms showed no systematic pattern in these correlations. In three of these four counties, adding an additional lag whitened the residual series but did not change the series' estimated cointegrating rank. A desire for parsimony drove the final model choice. The decision was made to tolerate the slight and nonsystematic residual correlation rather than lose predictive power by adding 25 more estimated parameters to each model.

Two tests using one-step-ahead predictions were conducted to assess out-of-sample model validity. First, the model was estimated using data from the first 72 months of the study period. We calculated one-month-ahead forecasts and found that the resulting fit was nearly the same as the in sample fit. Finally, the constancy of the Π matrix over the last four years of the data was tested by methods developed by Hansen and Johansen (1993). On average, the hypothesis of constancy was rejected in about three of the 48 forecast periods for each county. There were no patterns to these rejections indicating that there is sufficient stability to the model.

Testing Hypotheses: The Theory

Once the cointegrating relationships $\Pi = \alpha\beta'$ are determined, the long-run behavior of the model is analyzed. Hypotheses about the long-run behavior of this system are formalized as hypotheses about α and β, which are summarized in Table 2. These hypotheses fall into three categories. First, county poverty, nontimber jobs, or state variables are excluded from the system's long-run relationships. Second, poverty is weakly exogenous to these long-run relationships. Finding that poverty is weakly exogenous to the system implies that the long-run adjustment of poverty to a

perturbation in the other variables is zero. And third, there are two specific long-run relationships among particular variables in the system: (a) county timber and nontimber jobs and poverty grow in proportion to one another in the long run and (b) a one-job increase in timber and nontimber jobs has the same long-run impact on the other variables.

All of these hypotheses are formalized as linear restrictions on α and β and are tested using likelihood ratio tests that follow a χ^2 distribution [Johansen (1995)]. The test for exclusion of the *i*th variable in **y** is

$$H_0: R'\beta = 0, \tag{10}$$

where $\mathbf{R}'$ is a vector of zeros with a one in the *i*th position. Similarly, a test of whether two variables are both exogenous to the system is conducted using a 2 x p matrix $\mathbf{R}'$ and proceeding as above. The test for weak exogeneity of the *i*th variable in **y** is

$$H_0: J'\alpha = 0, \tag{11}$$

where $\mathbf{J}'$ is a vector of zeros except for the *i*th position, which is one. Long-run relationships among particular variables in the system are tested as linear restrictions on β formalized by an appropriate matrix R' in equation (10). For example, the test of whether county timber and nontimber jobs and poverty grow in proportion to one another is tested as the restriction $R' = [1\ 1\ 1\ 0\ 0]$, where the places occupied by the ones correspond to the three variables of interest. Table 2 describes the specific form of the $\mathbf{R}'$ and $\mathbf{J}'$ matrices that formalize these six hypotheses.

7. RESULTS

The results of these hypothesis tests together with the short-run dynamics of the estimated VAR provide evidence that addresses three important economic questions raised in the ongoing debate over timber policy. First, does a decrease in timber employment result in a long-run increase in unemployment-related poverty? Second, are timber jobs better in the short run at reducing unemployment-related poverty or inducing county employment growth than other jobs? And third, are state variables long-run determinants of county employment or unemployment-related poverty? These results improve our understanding of the impact of timber policy in California's major timber counties.

Timber Employment and Unemployment-Related Poverty

Test results show evidence of timber employment reducing long-run AFDC-UP caseload in only 1 of the 11 study counties. There are four possible tests for lack of long-run impact on unemployment-related poverty: exclusion, weak exogeneity, proportionality, and cointegrating rank of three. Only 1 county survives all 4 of these tests at the 90-percent level of significance (Table 3). The first test examines the hypothesis that either AFDC-UP caseload or timber can be excluded from the cointegrating space. If either timber or AFDC-UP caseload is not part of any long-run relationship, then there can be no long-run relationship between them. The exclusion of AFDC-UP caseload cannot be rejected for Humboldt or Siskiou counties. The exclusion of timber employment cannot be rejected for Trinity, Del Norte, Amador, or Tuolomne counties. This leaves only 5 counties in which there can be a long-run relationship between timber employment and AFDC-UP caseload.

Weak exogeneity of unemployment-related poverty variables indicates that changes in employment do not influence the level of AFDC-UP participation in the long run in Plumas and Mendocino counties. In Tehama, 1 of the 3 remaining counties, an increase in timber employment leads to a proportional increase (not decrease) in AFDC-UP cases. This is a finding of balanced growth in the county. More people work in all types of employment, and the additional people have the same long-run incidence of unemployment-related poverty as the existing residents. Of the remaining 2 counties in which county timber employment could have a long-run relationship to AFDC-UP participation, Shasta has 3 cointegrating vectors. If state-level variables are held at a constant level, then the 2 constant state variables and 3 cointegrating relationships completely determine the long-run levels of the county variables. Without change in the state variables, temporary changes in timber employment will have no long-run effects whatsoever. Only for Lassen county is there evidence that timber employment may act to decrease AFDC-UP caseload in the long run.[8]

Impact of Timber vs. Nontimber Employment

The next question to be addressed is whether timber and nontimber employment play the same role in the county economy. The null hypothesis is that timber jobs do not function as the "base" in a base-multiplier model. This hypothesis is examined in the long run with a formal test on the cointegrating space and in the short run by comparing job and poverty multipliers from model simulations. Formally, this hypothesis is tested for the long run by testing the hypothesis that an increase in timber jobs causes the same shift in the cointegrating vectors as an increase in nontimber jobs. This hypothesis cannot be rejected at the 90-percent confidence level in 4 of the 11 counties (Table 4). In

these counties, nontimber and timber employment have the same long-run impact on county AFDC-UP participation.

While evidence indicates that in 10 of 11 counties timber employment did not decrease long-run AFDC-UP participation and nontimber employment had no better success in 4 of the 11 counties, local residents also care about short-run impacts. Short-run employment multipliers for both timber and nontimber sectors were estimated by forecasting the model forward 24 months under 2 different conditions. In the first case, the forecast was made using the actual values of all variables. In the second case, the number of jobs (either timber or nontimber) was increased by 100 jobs in the last period before the forecast. The difference between these two forecasts gives the short-run job increases or AFDC-UP caseload decrease resulting from an increase in timber or nontimber jobs.

Increasing timber employment by 100 jobs in each of the 11 counties results in there being an average of 78 more total county jobs 2 years later. Thus, timber employment has a total job multiplier less than 1. This is consistent with jobs in timber being transitory, possibly because they are limited by the available timber. In contrast, increasing nontimber employment by 100 jobs in each of the 11 counties results in an average increase in employment of 100 jobs after 2 years, a total job multiplier of 1. These county employment multipliers are smaller than conventionally thought for both timber and nontimber jobs.

On average across the study counties, increasing timber employment by 100 jobs leads to a decrease of 3 cases of AFDC-UP after 24 months. In percentage terms, a 1-percent increase in timber jobs leads to a $14/100^{ths}$ of a percent decrease in county

AFDC-UP caseload, on average. A 100-job increase in county nontimber employment leads to a decrease in county AFDC-UP caseload of 0.28 cases, on average. That is, a 1-percent increase in nontimber employment leads to an average decrease in AFDC-UP caseload of a $23/100^{ths}$ of a percent. These estimates likely overstate the short-run impact of county employment on total county poverty since AFDC-UP participants are likely to be among the poor most closely attached to the labor force.

County governments are likely to be as concerned about their dependency ratios as poverty level, because this informs them about their financial ability to support these programs.[9] In this study, the dependency ratio is approximated by county AFDC-UP caseload relative to total county employment. On average across the study counties, a 1-percent increase in total employment leads to approximately a 1.2-percent decrease in the dependency ratio. However, since most of this decrease comes from simply increasing the size of the labor force, there is little evidence to suggest that county job growth in either timber or nontimber sectors is very effective at moving people out of poverty programs.

Do State Variables Matter?

In all 11 study counties, both AFDC-UP caseload and employment are influenced by statewide economic conditions. An exclusion test is again used to determine whether statewide variables affect long-run levels of county employment and poverty. In only 2 counties (Humboldt and Tehama) is the hypothesis of long-run exclusion of statewide employment and statewide caseload supported at a 90-percent confidence level. In all other counties, it is rejected, suggesting a long-run relationship does exist between state and county variables in these 9 counties. Again, forecasting ahead 24 months, a 1-

percent increase in statewide jobs leads to an average increase of 75/100^{ths} of a percent in county jobs in the study counties, both timber and nontimber jobs increasing by about the same proportion. A 1-percent increase in statewide AFDC-UP caseload leads to an average increase of 72/100^{ths} of a percent in county AFDC-UP caseload in the study counties.

8. CONCLUSION

This statistical analysis found little evidence that decreases in timber employment have increased poverty in California's timber country. The AFDC-UP caseload, participation in the poverty program most directly targeted at the out-of-work family, was only minimally affected by increasing timber jobs in California's 11 major timber counties. If increasing timber harvest actually created additional jobs, only 3 out of 100 would go to AFDC-UP recipients. The remaining 97 jobs would most likely be taken by unemployed county workers who are not in the program, county workers employed in the nontimber sector, and people from outside of the county. Changes in timber employment had no *long-run* impact on AFDC-UP participation in 10 of 11 major timber counties. Together this means that changes in timber employment simply do not have much impact in helping impoverished county residents, even those who have recent ties to the workforce, move out of or drift into welfare dependence.

The inefficacy of increased timber employment in reducing AFDC-UP caseloads is most likely due to the fact that sectoral employment multipliers are small in these rural economies. The average total employment multiplier from timber employment in these counties is less than 1. This result is surprising from the perspective of base-driven growth theory, but it makes sense as a labor-market story. People work at nontimber jobs

during downturns in timber markets and shift to working in timber jobs when timber markets recover. The total employment multiplier from timber employment is small because the nontimber employment declines when timber employment increases. The total job multiplier from nontimber employment is also small, about 1. A county's nontimber employment includes both base and nonbase employment. It therefore should not be surprising that a 1-percent increase in nontimber employment leads to a 1-percent increase in total county employment. Finally, changes in nontimber employment have even less short-run impact on AFDC-UP caseload than changes in timber employment. After 2 years, 100 new nontimber jobs in a county would result, on average, in only .28 fewer AFDC-UP cases. Since the total employment multipliers of sectoral employment are small, they cannot make up for the small direct impact that changes in total employment have on unemployment-related poverty.

County dependency ratios and AFDC-UP participation rates fall with employment growth as long as there is no rise in the number of welfare cases. This occurs simply because the dependency ratio is the number of welfare cases per employed worker. As the number of employed workers increases, the dependency ratio falls. On average, a 1-percent increase in county nontimber jobs decreased the AFDC-UP dependency ratio to 98.8 percent of its previous value. If nontimber employment had no effect on AFDC-UP caseload, the dependency ratio would be 99.1 percent of its previous value. As a result, adding jobs decreases county dependency ratios without any appreciable change in the number of people participating in county AFDC-UP.

In contrast, statewide economic conditions do have a long-run effect on both employment and unemployment-related poverty in the study area. A 1-percent increase

in statewide employment increases average county employment by .75 percent while a 1-percent increase in statewide AFDC-UP caseload increases county AFDC-UP caseload by .72 percent, respectively. Clearly, programs that decrease state caseload will have similar, but smaller impacts in these rural counties.

At best, then, the relationship between county timber employment and unemployment-related poverty, as represented by AFDC-UP caseload, is tenuous. Timber extraction is not a strong expansionary force even in California's major timber counties. Solutions to rural unemployment and poverty will not be found in expanded timber harvests. To the extent that rural counties are concerned about reducing poverty or participation in poverty programs in their counties, it appears that they would do better to focus on poverty programs themselves and perhaps education or other social predictors of poverty rather than on employment growth in timber-related industries.

FOOTNOTES

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[1]The counties in order of percent of employment in timber are: Trinity, Plumas, Tehama, Mendocino, Del Norte, Humboldt, Siskiou, Amador, Lassen Shasta, and Tuolumne. Percent of employment in timber ranges from 14.8 in Trinity to 4.3 in Tuolumne.

[2]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 14. Natural Resources Division 1. Subdivision 3. Chapter 3. Section.670.5 for state listings of salmonids.

[3]For a discussion of poverty measurement, see Sawhill (1988).

[4]Using 12 years of employment data from Philadelphia, they separated employment into a "base" sector by five different methods. The total employment was then regressed on each of the definitions of base, and the residuals were tested for integration of order one. The best of these relationships gives a multiplier of 2.4, where traditional methods (Isserman, 1980) gives an answer less than four.

[5]Labor-supply and demand equations are used to eliminate w. Migration is determined by employment and poverty variables, so lagged values of these variables can be substituted everywhere migration appears. Population is just a constant plus a weighted sum of lagged migration, so anywhere that population appears, one substitutes lagged values of migration.

[6]Preliminary testing using augmented Dickey-Fuller tests strongly suggested that all the time series are integrated of order one.

[7]Asymptotic distributions are calculated via Monte Carlo estimation by Johansen (1995).

[8]There is some evidence of weak exogeneity for Lassen county ($p = .09$).

[9]The dependency ratio is the proportion of residents participating in welfare programs relative to tax-paying employed residents.

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TABLE 1. Lag Length, Cointegrating Rank and R^2

County	Lag Length	Cointegrating Rank	County Nontimber	County Timber	County Poverty
Amador	1	1	0.49	0.19	0.25
Del Norte	1	2	0.74	0.28	0.52
Humboldt	2	1	0.88	0.71	0.53
Lassen	1	2	0.64	0.69	0.43
Mendocino	2	2	0.72	0.77	0.60
Plumas	3	3	0.86	0.88	0.73
Shasta	3	3	0.90	0.68	0.63
Siskiou	4	1	0.92	0.69	0.38
Tehama	4	1	0.92	0.44	0.68
Trinity	3	1	0.79	0.68	0.49
Tuolumne	3		0.70	0.48	0.58
Average			0.78	0.59	0.53

Note: Computed, see text. The R^2 for state variable equations not shown.

TABLE 2. Hypothesis Tests

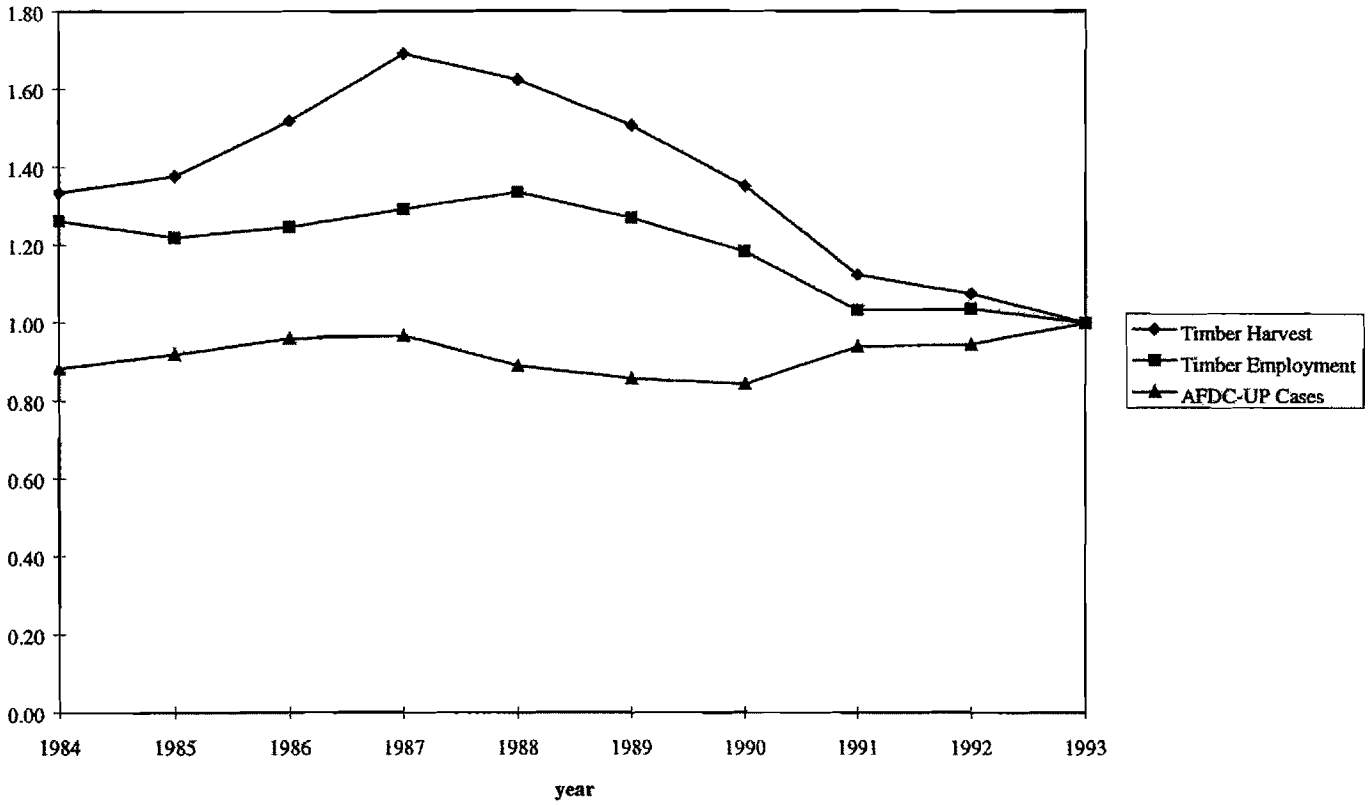
Test	Description	Econometric Formulation
Exclude NT	Tests whether it is appropriate to exclude nontimber jobs from the cointegrating space	$R' = [1\ 0\ 0\ 0\ 0]$
Exclude P	Tests whether it is appropriate to exclude poverty from the cointegrating space	$R' = [0\ 0\ 1\ 0\ 0]$
Exclude State	Tests whether it is appropriate to exclude both state variables (employment and poverty) from the cointegrating space	$R' = \begin{bmatrix} 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$
Proportionality	Tests whether jobs and poverty grow in proportion to one another	$R' = [1\ 1\ 1\ 0\ 0]$
Job is a Job	Tests whether, in the long run, a one-job increase in timber jobs is exactly offset by a one-job decrease in nontimber jobs	$R' = [1\ -N/T\ 0\ 0\ 0]$, where N/T is the average proportion of nontimber to timber jobs in a county
Exogeneity of P	Tests whether poverty is weakly exogenous to the cointegrating space	$J' = [0\ 0\ 1\ 0\ 0]$

TABLE 3. Results of Tests on Hypotheses about Long-Run Relationships among County and State Variables

County	p Values for Tests of Null Hypothesis: A Job Is a Job	County Timber Employment Is Excluded from Long-Run County Relationships	County AFDC-UP Caseload Is Excluded from Long-Run County Relationships	County Timber Employment Is Proportional to Total County Employment	Both State Variables Are Excluded from Long-Run County Relationships	State AFDC-UP Caseload Is Excluded from Long-Run County Relationships
Amador	0.67	0.98	0.00	0.04	0.00	0.07
Del Norte	0.42	0.96	0.01	0.00	0.06	0.01
Humboldt	0.12	0.05	0.28	0.18	0.14	0.28
Lassen	0.00	0.00	0.00	0.00	0.00	0.09
Mendocino	0.01	0.04	0.01	0.00	0.00	0.17
Plumas	0.00	0.00	0.03	0.04	0.00	0.37
Shasta	0.02	0.01	0.00	0.09	0.00	0.07
Siskiou	0.00	0.00	0.72	0.36	0.00	0.99
Tehama	0.02	0.02	0.08	0.28	0.37	0.01
Trinity	0.31	0.74	0.00	0.94	0.00	0.74
Tuolumne	0.04	0.13	0.01	0.00	0.00	0.00

FIGURE 1

Economic Trends in Major California Timber Counties



Note: Index values are average monthly values of each variable for each year in the 1984 through 1993 period divided by the variable's average monthly value for 1993.

Sources: Timber harvest (California Department of Finance, various years), Employment (California Employment Development Department, various years), and AFDC-UP program caseload (California Department of Social Services, various years).