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Employment and output stability in timber industries has always been an objective of the National Forest System. It appears in the Organic Administration Act of 1897 which established the National Forest System (Waggener, 1977, p. 710). The Pinchot Letter of 1905 written by the first chief of the Forest Service, Gifford Pinchot, sets forth a priority of consideration for the local dominant industry (Schallau and Alston, 1987). The Sustained-Yield Forest Management Act of 1944 clearly states forest policy objectives by beginning, "In order to promote the stability of forest industries, of employment, of communities, and of taxable forest wealth, through continuous supplies of timber. . . ." (Waggener, 1977, p. 711). This stability objective is reflected in the sustained yield mandate of the Multiple-Use Sustained Yield Act of 1960, the long-range planning and nondeclining flow provisions of the Forest, the Rangeland Renewable Resources Planning Act of 1974 and the National Forest Management Act of 1976, respectively. These laws and their surrounding administrative policies reflect the extreme dependence of communities on the timber industry (Belzer and Kroll, 1986, p. 18)[2]

Given the attention to instability of forest dependent communities, it is natural to ask what is special about these communities. The second section of this paper examines the meaning of instability. It distinguishes growth or decline from economic fluctuation. The third section presents measures of instability for many industries in Oregon, a state heavily dependent upon the timber industry. From these estimates one can judge whether the timber industry really has less employment stability than other industries. That is a different question from why the community has more or less employment instability than other types of communities.

Studies in the literature concerning the problem of employment and community stability have been largely economic multiplier models or economic base models. In such models, a change in the timber industry employment affects total community employment directly and also through its impact on the employment in supporting industries (Kroll, 1984, Perloff, *et al.*, 1960; Perloff and Wingo, 1961). Economic multipliers can be calculated from the structural equations (e.g., Connaughton and McKillop, 1979). For instance, input-output models have been used to construct multipliers resulting from shifts in demand for timber products (Connaughton and McKillop, 1979) and from shifts in the supply of timber (Schallau and Maki, 1983). They have also been used to assess the impact of different types of pulp mills on a community (Carroll and Milne, 1982). The Forest Service has done extensive research to assess the economic efficiency and to determine the impact of cut decisions (e.g., Schallau and Polzin, 1983; Forest Service, 1982). A recent study by Connaughton, Polzin, and Schallau (1985) demonstrates that the traditional unidirectional approach of most input-output and economic base models misses important feedback from other sectors to the timber sector. Enlarging an input-output study to include such feedbacks creates a Social Accounting Matrix (SAM) which is the approach taken in the third section of this paper. From a SAM one can determine how variance in the demand for a particular economic activity leads to variance in the level of overall output. We use the SAM framework to make estimates of how variable output would be in Humboldt County, California, a very timber dependent community, if it were dependent upon auto production or a diversified basket of the gross national product rather than upon timber. The model allows us to separate the effects of being a small, isolated county with an open economy from the effects of being dependent upon timber, per se.

Stability

For community stability to make sense as a concept, it must be separated from community economic development. Consider the case of the United States, whose GNP growth rate is about 3%. If GNP grew at exactly 3% every year, it would not be described as unstable. Yet, a series with a 3% growth rate for 20 years has a coefficient of variation (CV)—standard deviation divided by mean—of almost 20%, quite a large value. The instability is the "cycles" and fluctuations around these growth rates. By the same token, there is just as little sense in describing a sector whose employment shrinks at a constant .1% per year as an unstable sector. These are not matters of stability, these are logically matters of growth or development, or the lack of it.

Income and employment in forestry dependent communities depend upon both demand conditions and the resource base. Demand for wood products varies across the business cycle, giving rise to instability in income. In the Pacific Northwest, including northern California, the resource base is declining: the region is shifting from an old-growth to a second-growth economy. This secular trend, reinforced by technical progress, leads to the decline of some forest dependent communities. To those living in a forest dependent community, it matters quite a bit whether the mill closes because there is not any more timber or there is not any more demand. Downturns in demand are usually reversed: they are transitory and not permanent. Depletion of the resource base, or technical progress in milling, is more permanent. More generally, changes that are expected to last are logically matters of growth or development or the lack of it. Changes that are not expected to last are the problem of stability.[3]. While there are many possible definitions of stability, each of them separates the growth (or decay) process from some fluctuation around it.

There are three major ways of examining stability. The first is structural equations. Output (or employment) is modeled as depending upon a set of variables, some of which themselves are random and some of which have trends. This gives a decomposition of changes in output into those attributable to permanent and transitory factors. Structural equations do not explain the trends or cycles in the underlying variables, so the other two methods are then relied upon. The second method is regression (or smoothing) on time. Output (or employment) is simply regressed (or smoothed) on time. The residuals are an estimate of what is transitory. The third method is the removal of the stochastic trend. It is the method of Beveridge and Nelson (1981) and is a logical extension of the second method to the case where trend is taken to be a random walk. We now discuss each method in turn.

The structural method requires an econometric model of the sector under consideration. For the old-growth redwood stumpage sector of the Northern California coast, Berck and Bentley(1989) estimated a reduced form model that would serve that purpose. They found that the redwood stumpage inventory elasticity of harvest was .5. Thus the rapid depletion of the old-growth resource causes a similarly rapid deterioration in output, and for that matter, employment. This process has some variation to it, mostly as a result of the establishment of new parks, but most of the variability in output is accounted for by a different set of variables. In the same study, the housing start elasticity of output was .3 and the addition and maintenance elasticity of output was .4. Thus a general 1% increase in the level of housing activity results in a .7% increase in redwood output. Housing activity varies between 1 and 2 million starts within a couple of years, so this is truly a great source of variation in output.

While this structural description is useful in understanding why one should see both trend and cycle in forest related employment and output, it does not solve the problem of trend and cycle. It merely pushes it back to the problem of what is trend and what is cycle in forest inventory and housing. It still leaves the problem of what can reasonably be expected to persist, called trend, and what should wash out in the long run, called cycle.

The simplest way to separate trend from what is transitory (cycle and noise) is to regress the series on a function of time. This is a deterministic trend model. The residuals from the regression are taken as the transitory component—they comprise the cycle and they also comprise any random variation about the cycle. The logic is that the trend tracks the long term processes while the residuals track the shorter term fluctuations. The residuals represent changes in economic activity that are not expected to persist, so they are a measure of the stability of the economic activity. The CV is the summary statistic we use to measure stability.

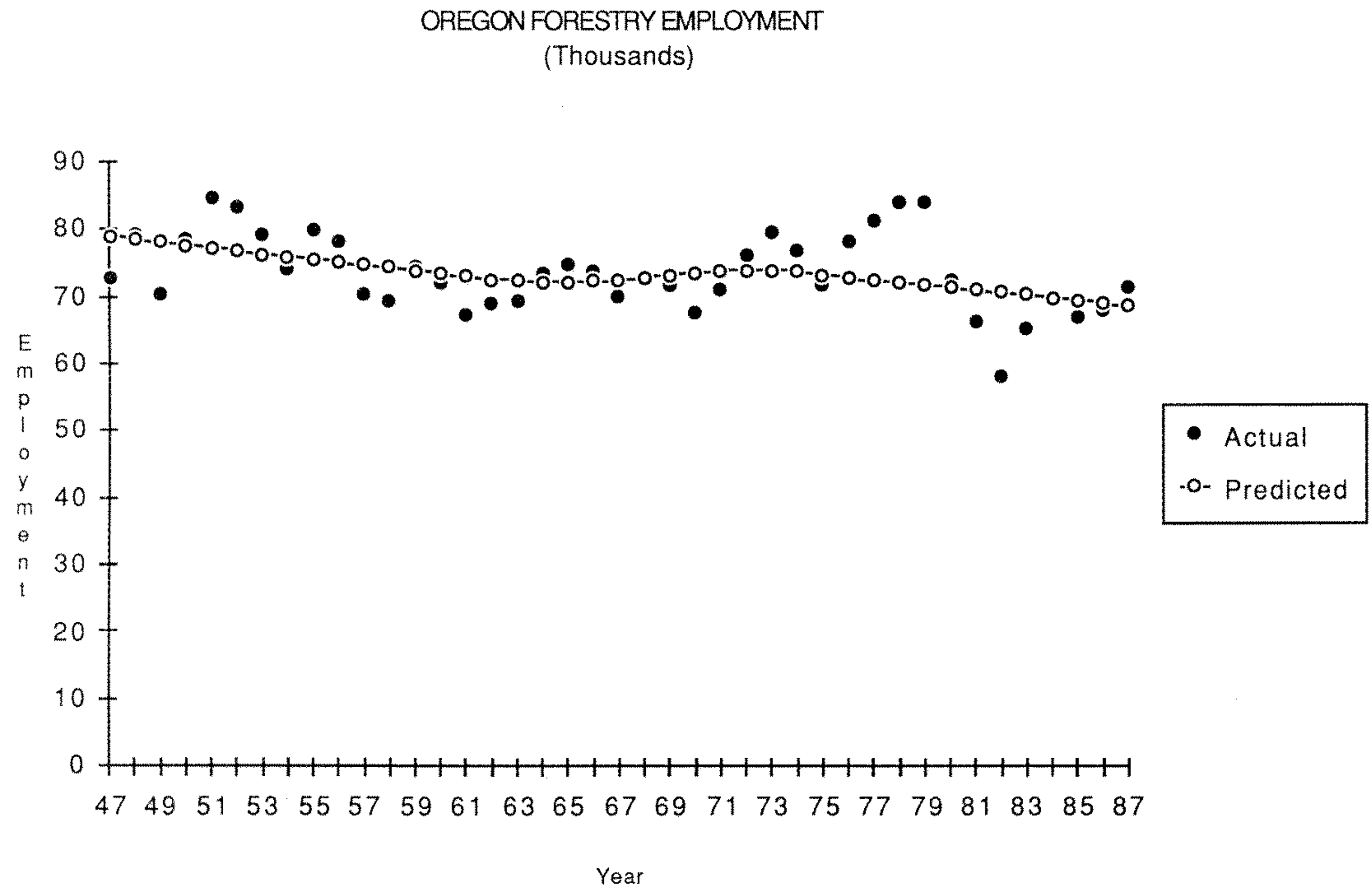
In this study we used both simple regression on time and time squared and Lowess (Cleveland, 1979)(a consistent form of nonparametric regression) for estimating the trend. The more flexible the regression surface, the smaller the apparent transitory elements, which is to say the smaller the instability.

The last method is that of Beveridge and Nelson(1981) which has the advantage of a firm logical base, if not uniqueness. These authors reason that the level of activity can be decomposed into a permanent and transitory component. The permanent component consists of the current level of the variable, z(t), plus a cyclic component c(t). Assume the process z naturally grows at a deterministic rate, m, plus some stochastic rate. Define c as the k period ahead forecast, z(t+k | t) less z(t) less the deterministic growth, k m, for suitably large k. The cycle is how much the series will rise or fall because of past stochastic events; it is how much the series would change if there were no further growth of either the stochastic or deterministic kind. While this is an appealing definition of cycle devoid of the rank empiricism of regression on time, it depends upon a particular decomposition of the underlying time series. Since there are many such decompositions, it is not the only way to get a stochastic trend model.

To examine the stability of the forestry sector, we will take recent employment data for the state of Oregon. We have used total annual forestry employment for the state of Oregon for 1947 to 1987 to estimate the cyclical component. Actual employment was on the order of 70-90 thousand employees. Figure 1 is both the actual and Lowess predicted plot of employment on time.

The residuals of this regression are the solid dots in Figure 2. On this basis, the difference between the top and bottom of the cycle can be close to 20% of employment. These are not trivial fluctuations. For comparison, the residual standard error from

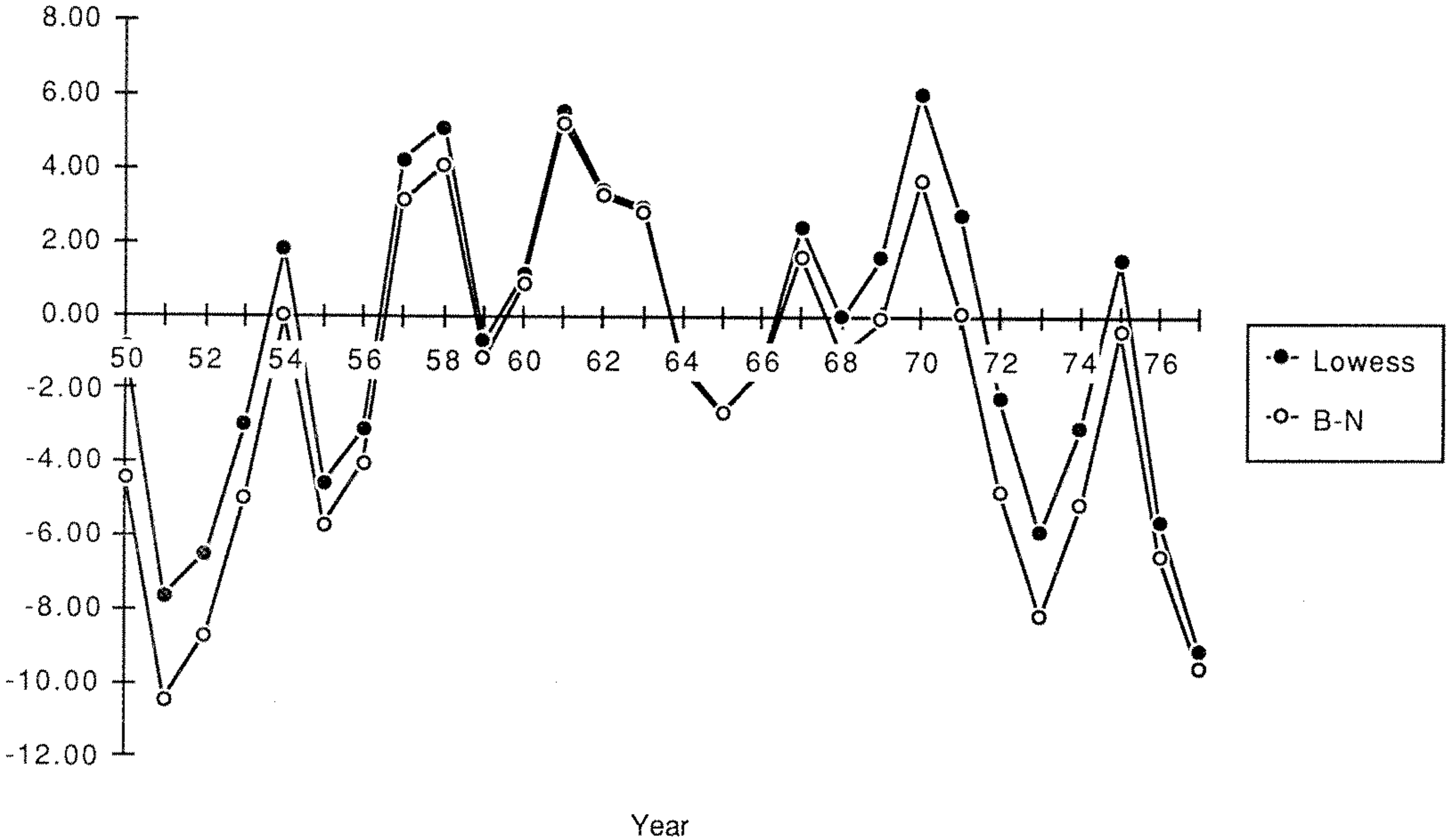
Fig. 1



OREGON FORESTRY EMPLOYMENT
(Thousands)
Employment
90
80
70
60
50
40
30
20
10
0
47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83 85 87
Year
Actual
Predicted

Fig. 2

CYCLICAL PORTION OF
FORESTRY EMPLOYMENT
(Thousands)



regression on a constant was 5.8, on a time trend was 5.6, and the residual standard error from Lowess was 5.3. Using the more complicated technique reduces the estimate of instability by 10%.

The Beveridge and Nelson method is much more difficult to accomplish. The series is first fit to an ARIMA model. A single differencing reduced the log of series to stationarity. ARIMA (2,1,2) with a constant was selected based upon the auto correlations and partial autocorrelations. None of the residual autocorrelations approached two standard errors in size, and the Box-Pierce-Ljung portmanteau test statistics at 12 and 24 lags were satisfactory. (P= .7 and .9). The additional coefficients were not significant in either a (3,1,2) or (2,1,3) model. Thus the model seemed adequate. The coefficient estimates and their standard errors are in Table 1.

The open dots in Figure 2 are the Beveridge and Nelson method estimates of the cyclical component of employment. They are remarkably similar to the Lowess residuals.

In summary, both the Beveridge and Nelson and the deterministic trend models provide plausible models of cyclic behavior. In both definitions, stability refers to only part of the variation in the series; the other part is attributed to trend. In the case examined, the answers from these two models are not much different. For the remainder of the paper we will stick with the simpler definition of transitory—the residuals from a regression and quantify instability as the CV of these residuals.

Comparing the Stability of Sectors: The Oregon Case

Oregon is generally regarded as a state in which forestry and forest products constitute a relatively large and important part of the economy. In addition to government employment in the national forests, roughly 38 % of private employment in Oregon is in the lumber, wood products, and paper sectors with several counties more than 70% dependent on lumber (Lettman, 1988). The national forests cover 47% of the commercial

Table 1

ARIMA ESTIMATES

	PARAMETER ESTIMATES	STD ERROR	T-STATISTIC
AR(1)	-0.134	0.164	-0.82
AR(2)	0.316	0.164	1.925
MA(1)	-0.019	0.05	-0.377
MA(2)	0.95	0.044	21.39
CONSTANT	-0.002	0.002	-0.93

timberland in Oregon (Brodie, McMahon, and Gavelis, 1978), and the users of timber got about 43% of their logs from national forests in 1987 (Nokes, 1987).

Monthly and annual data on those nonpublic sector jobs covered by state unemployment insurance were analyzed for the years 1947 through 1987. The data were detailed at the two digit Standard Industrial Classification (SIC) code level, allowing the forestry and wood products industries to be analyzed separately. The database covers all but a small number of those employed in Oregon; the notable exclusions from these counts are government employment and self-employed entrepreneurs.

Statistics on the raw monthly data for selected groups of SIC codes are presented in Table 2. The third column of Table 2 displays the coefficient of variation for each employment category which measures the amount of variation, or stability, in the series. The highest coefficient by far is for agriculture and fisheries, where the standard deviation of the series about 1.5 times the mean. The smallest variation is in textiles and apparel manufacturing, suggesting relatively stable employment over the period of study. Overall forestry has a surprisingly low coefficient of variation for an industry which is generally thought to have large variations in employment.

The consideration of the employment stability of an industry, over such a long time, should take into account long-term trends which may affect employment due to long-term changes in demand, technology, or resource availability. Therefore, each series was detrended and deseasonalized using a regression on a constant, eleven monthly dummys, a time trend, and a squared time trend. The R-squared indicates the amount of variability in each series explained by the constant, dummys, and trends. The regression results, for some main aggregates, are presented in Table 3. For all of the main aggregates except forestry, most of the variation is explained by these variables. The Durbin Watson statistics show that all of these regressions have highly autocorrelated residuals. It is the autocorrelation of these residuals that give the residual series its cyclic shape. From the regression coefficients and t-statistics, one can see that the dummy variables for month are

Table 2
Summary Statistics for Oregon Employment

Industry	Mean	Standard Deviation	Std. Deviation /Mean
	(000)	(000)	
Forestry	73.7	7.8	0.106
Forests	1.3	1.1	0.897
Lumber	72.4	8.0	0.110
Manufacturing	95.8	31.8	0.332
Equip., Instrs.	28.5	17.2	0.604
Food	21.6	5.3	0.243
Metals	14.1	5.5	0.387
Paper	8.1	1.6	0.203
Printing	7.1	2.4	0.333
Petroleum, Chemicals	2.3	0.5	0.201
Textiles, Apparel	5.1	0.5	0.099
Other	6.0	2.4	0.393
Nonmanufacturing	360.1	165.7	0.460
Services	89.9	63.1	0.702
Finance	32.2	16.4	0.511
Retail	118.8	48.8	0.410
Wholesale	42.5	16.0	0.376
Transportation and Utilities	39.2	8.6	0.220
Construction	30.4	8.8	0.290
Mining	1.5	0.4	0.241
Agriculture and Fisheries	5.6	8.3	1.469
NonForestry (Manufacturing plus Nonmanufacturing)	455.9	196.4	0.431
Total Covered Employment	529.5	195.7	0.369

Table 3

Regression of Employment. Monthly Data

Variable	Coef. Forestry	t-stat	Coef. Manufacturing	t-stat	Coef. Nonmanufacturing	t-stat
CONSTANT	70.33	51.87	37.01	21.52	147.44	25.54
TREND	-0.01	-1.09	0.20	18.13	0.11	3.08
TRENDSQ	-8.38E-06	-0.52	3.04E-05	1.49	1.95E-03	28.47
DEC	3.29	2.32	1.97	1.09	13.71	2.27
NOV	6.03	4.24	5.04	2.79	14.23	2.35
OCT	8.40	5.91	9.30	5.16	18.40	3.04
SEP	11.28	7.94	14.06	7.80	25.97	4.29
AUG	11.93	8.40	14.42	8.00	26.27	4.34
JUL	10.90	7.67	8.89	4.93	25.16	4.16
JUN	10.55	7.42	6.98	3.88	23.03	3.81
MAY	7.56	5.32	1.47	0.82	12.46	2.06
APR	5.07	3.57	0.69	0.38	8.19	1.35
MAR	2.32	1.64	0.37	0.21	3.07	0.51
FEB	0.71	0.50	0.00	0.00	-1.48	-0.24
R-square		0.33	0.94			0.97
Durbin Watson		0.13	0.04			0.02

important and for all but forestry, so are the time variables, either time or time squared or both. Forestry is the exceptional case, most particularly the lumber sector.

Overall, variation in forestry employment is explained very little by a constant and trends. However, the two components of this category have very different results for this regression. Covered private employment of foresters is largely explained by a constant, a negative trend, and a positive trend-squared. These coefficients are all highly significant. A negative trend for the overall forestry category was expected in view of technology changes and the depletion of private forestlands over the years. On the other hand, lumber employment is explained relatively little by the trends, though the constant is highly significant.

The detrending process has decreased the variation in all of the series, but a good amount of variation still remains in construction, mining, and agriculture and fisheries, which are typically seasonal industries. Compared to other categories, forestry is not markedly more variable.

The residuals of the data series are then composed of detrended, deseasonalized values which represent the remaining variability of the employment. It is the stability of these numbers that can be appropriately discussed in terms of the stability which can be addressed by relatively short-term public policy. The statistics for these data are presented in Table 4. The means of the detrended, deseasonalized series are zero, and a residual variation coefficient—standard deviation of the residuals divided by the original mean—is employed.

Table 4 shows that there is nothing very special about employment in forestry. The CV for forestry is not meaningfully above that of manufacturing as a whole. The extractive sector (forests), which is small compared to the lumber sector, has a CV half of agriculture and fisheries but higher than any other sector in our study. The combined CV of the lumber and forests sectors, however, ranks in the middle of the sectors studied. Construction, mining, agriculture, metals, and equipment all have a much higher CV. The

Table 4

Industry	Coefficient of Variation	R-Sqaured	Residual Coefficient of Variation
Forestry	0.106	0.334	0.086
Forests	0.897	0.885	0.304
Lumber	0.110	0.389	0.086
Manufacturing	0.332	0.936	0.084
Equip., Instrs	0.604	0.939	0.149
Food	0.243	0.921	0.068
Metals	0.387	0.877	0.136
Paper	0.203	0.887	0.068
Printing	0.333	0.989	0.036
Petroleum, Chemicals	0.201	0.720	0.106
Textiles,Apparel	0.099	0.365	0.079
Other	0.393	0.951	0.087
Nonmanufacturing	0.460	0.973	0.075
Services	0.702	0.984	0.090
Finance	0.511	0.973	0.084
Retail	0.410	0.974	0.066
Wholesale	0.376	0.966	0.070
Transportation, Utilities	0.220	0.960	0.044
Construction	0.290	0.635	0.175
Mining	0.241	0.558	0.160
Agriculture, Fisheries	1.469	0.806	0.647
Total NonForestry (Manufacturing plus Nonmanufacturing)	0.431	0.970	0.074
Total Covered Employment	0.369	0.963	0.071

proper conclusion is that there is nothing very different about the occupation of forestry. It is not more plagued by economic fluctuations than other sectors in the economy. What is different about forestry is the extreme reliance of communities upon the forest industry (Belzer and Kroll, 1984). The next section uses a SAM to examine that reliance.

Community Instability: A Social Accounting Matrix Analysis

To compare forestry with other (hypothetical) dominant sectors in a "one industry" area, we examine the case of Humboldt county. We have taken an extended input-output (I-O) model for Humboldt County (Dean *et. al.*, 1973) and recast it in the SAM framework. This SAM expresses the economic activity of 1969 as a function of exogenous demand for the county products. We use the model to find the implied instability in the county's value added and production as a function of the instability in the demand for its products. Also, we compare the existing instability with the instability that would result from several hypothetical alternatives.

A SAM (Pyatt and Round, 1985, or Pyatt and Thorbecke, 1976) has all the elements for a small, linear, fixed price, general equilibrium model of a very open economy. The entries in Table 5 are all the production, transfer, and consumption flows, in thousands of dollars, for Humboldt County in 1969 The entry in the i^{th} row and j^{th} column is a sale or transfer from sector (or institution) i to sector (or institution) j. Equally well it is a purchase by j from i. The upper left hand corner (28 columns by 28 rows) of the SAM is the transactions table, an unnormalized Leontief I-O model. For sector purchases, read down each column, and for sector sales read across each row. For instance, forestry (the first column) purchases $23,000 from the logging sector and sells $31,357,000 to the sawmill sector. Below the I-O are rows representing the factors of production, labor and capital, institutions, households, government, and corporations so that numbers in these rows represent payments to these agents. For instance, forestry pays $5,377,000 to labor. To the right of the I-O matrix are the added columns representing

Table 5. Social Accounting Matrix

Receipts	Expenditures	Forest Products						Agriculture				
		Forestry	Logging	Sawmills	Veneer-Plywood	Pulp Mills	Other Wood	Field Crops	Dairies	Other Ag. Stuff	Meat Processing	Dairy Process.
Forest Products	Forestry	770	33	31357	6564		275					
	Logging	23		16644	3375		141					
	Sawmills			186		13034	1155			39		
	Veneer-Plywood				594		409					
	Pulp Mills											
	Other Wood Prod.						242					
Agriculture	Field Crops							28	267	44		
	Dairies											7000
	Other Ag. Stuff	516								99	19	
	Meat Processing											
	Dairy Processing											
	Other Food Proc.											
Fishing and Mining	Seafood Process.											
	Mining						6					
	Fisheries											
Other Industry	Construction						17	14				
	Boat Building											
	Other Local Manf.		550	397			192	57	98	78		
Transportation	Water						30					
	Other	426	900	1528		9122	323		104		25	
Trade	Comm. & Util.	76	57	1386	126	3047	145	23	93	113	10	136
	Wholesale&Retail	86	263	5659	677	2454	297	26	463	134	4	
	Finance&Insur.	34	198	1327	16	149	42	9	95	235	2	107
	Real Estate						131					
Services	Lodging											
	Select. Services	63	356	556	92	707	24	12	43	26	2	19
	Entertainment											
	Med., Legal, etc.	23	116	522		142	36	3	143	79	1	
Factors of Production	Labor	5377	14964	39587	12805	14807	2965	794	3500	2194	202	1508
	Capital	27548	630	6334	1440	3027	463	4	118	47	18	92
Institutions	Corporations											
	Households											
	Local Gov't	2039	58	1784	406	3629	242	86	435	480	5	83
	Rest of the World	2115	2210	16922	2153	9243	2405	178	2712	463	493	5398
	Totals	39096	20335	124189	28248	59361	9540	1234	8071	4031	781	14343

	Fishing and Mining				Other Industry			Transportation		Trade		
ther Food Proc.	Seafood Procc.	Mining	Fisheries	Construction	Boat Building	Other Local Manf.	Water	Other	Comm.&Utils.	Whole&Retail	Finance&Isur.	Real Estate
3				539 333 192		967 213 195			3 67	50 6 39		
71 27 7 73 117				8		2 36		7 2	2	2 58 35		
	7316			157				8		8		
15 42	139 99	5	481 44		1	18	28 3 4	432 22	256 2 26	135 154	62 134	83 18
12 171		9	105	343	2	12	409 37	11 908	92	13 308	25	18
70 179 23 46	107 57 68	17 7 29	68 397	131 1341 94	3 1 2	235 226 109	33 22 47 36	166 265 124 281	1450 34 133 33	1030 56 452 591	701 171 2345 906	32 31 33 62
34 29	15 34	9 135	33	67 22	1 1	70 191	8 20	26 97	98 256	311 26 630	189 87 746	25 40
1663 238	3053 438	1420 372	5288 61	4987 927	320 4	10862 177	2448 0	11194 800	12020 6887	50264 1605	10920 1903	2744 72
148	133	72	56	404	12	506	90	440	650	1101	566	91
2837	623	763	805	8252	140	6110	333	2823	3850	7371	3471	317
5805	12082	2838	7338	17797	487	19929	3518	17606	25859	64245	22226	3566

Services				Factors of Production		Institutions			Rest of World	Totals
Lodging	Select. Service	Entertainment	Med., Leg., etc.	Labor	Capital	Corps.	Households	Goverment		
									47	39096
									152	20335
				0	0	0			108260	124189
									26699	28248
									59361	59361
							2916		5886	9540
							817			1234
									1071	8071
		7		0	0	0	3353			4031
			2				768			781
			28				5715		8433	14343
			14				5637			5805
							1361		10721	12082
				0	0	0			2667	2838
	3								11	7338
	5	25	106				5745	2732	7980	17797
				0	0	0				487
	22	43	149				1322		16478	19929
									3043	3518
	12	10	28	0	0	0		347	2751	17606
241	1229	99	471				13303	738	591	25859
11	72	87	205	0	0	0	47635	1044	2670	64245
4	59	39	142				10860	470	4582	22226
	61	494	225					14	686	3566
								344	4100	4444
56	257	25	78	0	0	0	2496	84	7182	12964
		106					3499		1235	4953
11	172	236	748				21034	1878	1161	28506
3463	5603	1163	21636						28607	276358
8	235	1791	0	0	0	0	0	0		55239
				28607	55179	0	0	0	0	83786
				247751	0	0	46731	29503	36206	360191
328	330	124	725	0	0	0	14981	0	12793	42797
322	4904	704	3949	0	60	83786	172018	5643	0	353373
4444	12964	4953	28506	276358	55239	83786	360191	42797	353373	1735136

factors of production and institutions, so that numbers in these columns represent the flow of goods and services to these sectors. For instance, labor pays households \$247,751,000. In turn, households purchase goods from most other sectors (including \$2,916,000 of other wood products). The penultimate column of the SAM is sales to the rest of the world, the county's net exports. These exports, also called final demand (FD), are taken as exogenous to the county and determined mostly by macro-economic conditions. In the experiments below we simply replace FD with the value exports would have in various years and under various circumstances, and we recalculate the table.

These experiments were carried out on a multiplier version of the SAM which is explicitly written as an equilibrium system. To get this representation of our model there were several steps. First consider the first 33 columns and rows of Table 5 which are the whole of the SAM excluding the rest of the world and row and column totals. Divide each of these elements by its respective column total and call the result A. It is a matrix whose i, j^{th} element gives the percent of the j^{th} sectors payments made to the i^{th} sector. Let TP be the (33) vector of the total payments, TS be the (33) vector of total sales and FD be the (33) vector of the final demands (labeled rest of world). Then

$$A \bullet TP + FD = TS.$$

Since total sales and payments are the same,

$$A \bullet TP + FD = TP$$

which can be solved in terms of the multiplier matrix, $(I-A)^{-1}$, for the multiplier equation:

$$TP = (I-A)^{-1} \bullet FD.$$

This equation gives the total payments vector as a function of the final demands. Our concern is with the payments to institutions within the county, most particularly to households. We have made the assumption that corporate profits all are taken out of the county, which is equivalent to saying that ownership of the timber companies is mostly from outside the county, which is true. Thus, we are interested in the 32nd element of TP, payments to households. Let e be a vector with zeros everywhere except the 32nd element, which is one. Local income in year t, L_t, is then a function of demand in year t given by

$$L_t = e' \cdot TP = e' \cdot (I-A)^{-1} \cdot FD_t$$

By collecting a series of observations on FD_t, it is a simple matter to construct a series of local payments L_t and calculate their CV or display their histograms. The major sectors in this economy are the forestry sectors, and we constructed FD_t for these sectors as follows. We collected time series data (1959-1985) on county forestry employment and assumed that the variance in demand and employment were nearly the same. Sullivan (1988, p. 43) shows, for the state of California, that the relation between sales and employment is more like .9, which seems close enough for our purposes. We scaled the employment series so that its mean was the same as forestry sales in 1969. Then we smoothed the series and saved the residuals from the smooth. These residuals, our estimate of the variation in (the six) forestry demands, were added to the 1969 value of forestry demand to produce the section of the time series FD_t relating to the forestry sectors. Manufacturing was treated similarly. For agriculture and fisheries, actual output figures were used and the same procedure was followed. This procedure yields L_t, and from there it was a simple matter to compute its CV, which by construction, its mean was exactly its 1969 value. Another way to reach the same result is to take the variance of the expression for household income. Let V be the variance operator, so V(FD) is the variance covariance matrix of final demands, then

$$V(L_t) = e' \cdot (I-A)^{-1} \cdot V(FD_t) \cdot (I-A)^{-1'} \cdot e.$$

The formula shows that the variance in household incomes depends upon the covariances of the various final demands. Thus, adding an activity to Humboldt County that is well correlated with forestry will do little to reduce the CV of activity. This way of thinking about the problem is akin to portfolio theory, although previous practitioners do not recognize the role of the SAM multiplier. We shall not follow this approach further here.

We compare the instability in household payments caused by the actual instability, mostly caused in the forestry sectors, to several hypothetical cases. Our first counterfactual is that Humboldt County is dependent upon a (properly scaled) automobile sector rather than forestry. That is, we replace the stochastic elements in FD_t with elements that mirror the smoothed residuals of automobile production in the United States, rather than forestry in Humboldt County. For the second case, we examine a dominant industry with the same stochastic element as one-half of forestry and one-half automobile. It gives an example of the power of diversification. Finally, we consider the maximum diversification possible—an export sector which mirrors the national GNP in stability characteristics. To preserve the covariance structure of V(FD), twenty-seven years worth of data from Humboldt County of the three sectors: fish, dairy, and "other industries" are contained in all the counterfactuals.

The coefficient of variation in the forestry case (.056) is less than the coefficient of variation in the auto case (.080) and less than the coefficient of variation in the one-half autos and one-half forestry case (.065) and slightly more than the coefficient of variation (.047) in the GNP-like industry case. Thus, the forestry case has less instability than the automobile case and the one-half auto and one-half forestry case and only slightly more instability than the GNP-like case.

Should a local industry which is one-half forestry and one-half autos reduce the variability of total payments of the local economy? If the two industries were counter cyclical, then this kind of diversification should produce a smoother economy with less instability. As it happens, we can see from the results that the one-half forestry and one-half auto economy lies in between the auto economy and the forestry economy, as might be expected if the correlation between them is small.

An economy based on forestry has the hazard of being based on one industry, but may be no worse off than other communities based on one industry, in terms of the stability in total payments based on the business cycle. Certainly, the forestry industry has been in decline since the 1960's, and this decline has had disastrous consequences for communities. However, as mentioned above, that is not the issue we are looking at here.

As might be expected, the GNP-like economy has the lowest instability of any of the experiments. This is not very surprising. The somewhat surprising result is that the forestry-based local economy is not that much worse off than the GNP-like economy, as far as the instability in total payments is concerned. Having demand follow the stochastic elements of GNP rather than forestry reduces CV by only 16%. This is partially because export sectors (such as forestry) with high leakage to the outside world are insulated from the full effects of the instability of the outside world by this leakage. This has very interesting and ironic implications as far as community development and local economic development strategy is concerned. For some time rural communities in decline have been told to look for import substitution and/or low leakage activities for economic development purposes. Our GNP-based experiment is an extreme example of such a policy. However, this experiment does not capture the full consequences of diversification. An import substitution policy necessarily has lower leakages to the rest of the economy. Lower leakages mean higher multipliers, and stability varies as the square of the multiplier. Thus, our estimate that CV can be reduced by 16% by full diversification is certainly an upper bound of what can be accomplished by full diversification.

The other strategy for rural development has been diversification (Belzer and Kroll). As we have seen with our one-half forestry and one-half auto economy experiment, this strategy does not necessarily lead to less instability than the forestry economy. If the "diversified" new activities respond to movements in the national GNP in the same way as the forestry sectors or are simply highly variable in and of themselves, this diversification may actually increase the instability problem.

Conclusion

Humboldt County has two and a half times the employment CV of the state of California, yet forestry is not to blame. Forestry does not have a much different CV from many other manufacturing industries. Under these circumstances, the case for special treatment from Washington is hard to make.

Diversification is often touted as the solution to the instability problem. Our experiments show that a small amount of diversification could easily exacerbate the instability problem. There are industries, such as Victor Welding, owned by Pacific Lamber, whose demand varies in a counter cyclical fashion; but the nature of their business precludes an isolated location. Tourism, and more generally services, are usually advocated and they are stabilizing, though we have not investigated these alternatives in detail. Again, remote location is a problem. Single manufacturing plants, like the Hewlett Packard plant in Corvallis or Roseville, are possible; but they look much like the auto experiment in effect. The full diversification experiment gives the limits of this sort of strategy, at best a 16% reduction in CV.

Footnotes

[1]Associate Professor, Graduate Student, Specialist-Cooperative Extension, and Graduate Student, all at the Department of Agricultural and Resource Economics, University of California at Berkeley. We would like to thank H. Alan Love and Vijay Pradhan for comments; all remaining errors are our responsibility. This is Department of Agricultural and Resource Economics Working Paper No. 512.

[2]Other relevant literature includes a study concluding that employment in a timber-dependent town is more unstable than a large diversified town relatively and in absolute numbers (Byron, 1979). Stevens (1979) claims that a better understanding of the nature of wood products employment is needed to account for those peripheral workers who also work in other industries. Rufolo, Strathman, and Bronfman (1988); Stere, Hopps, and Lettman (1980); Schallau, Olson, and Maki (1988); Olson and Schallau (1988) all have analyzed community stability with respect to timber-dependent regions and most recommend consideration of policy actions to alleviate the changes in employment which are observed or modeled.

[3]In macro-economics the same dichotomy is often made, but see James Stock and Mark Watson (1988) for a more modern view that emphasizes the interaction of trend and cycle.

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