A Measure of Economic Diversity: An Input-Output Approach

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Abstract

Economic diversity has often been promoted as a means to achieve the economic goal of stability. Few empirical studies have been able to relate higher levels of diversity to both economic stability and overall levels of economic activity. Diversity measures, as used in these studies, have tended to be narrowly defined, usually emphasizing the distribution of employment across industries. These measures are lacking because they do not capture any elements of endogenous interindustrial linkages. We suggest the conceptual and empirical measures of diversification are at the root of the poor performance of this literature. An alternative approach to measuring diversity based on the technical coefficients matrix of an input-output model is outlined and computed for the 50 US states. Empirical results suggest that higher levels of diversification within the theoretical construct of input-output are associated with higher levels of stability.

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Introduction

The relationship between regional economic diversity and regional economic performance has been a topic of debate for nearly 50 years. While the logic of the policy, diversifying the economic base to achieve economic stability, is clear and straightforward, the empirical literature has been inconsistent. As argued by Kort (1981), the principal causes of this empirical inconsistency are the use of small sample sizes, highly aggregated data sets, theoretically or empirically poor measures of diversity and regional economic stability, and overly simplistic statistical methods. More recent studies, however, have attempted to rectify the shortcomings of those earlier studies and limited success has been seen.

The hypothesis extended in this paper is that a portion of the empirical inconsistencies in both earlier and latter studies is related directly to the method of thinking about and measuring economic diversity. Specifically, most diversity measures focus on employment distributions across industries and do not account for interindustry linkages and the relative size of the regional economy. The approach suggested here takes advantage of the widespread use of MicroIMPLAN, a regional economic modeling software package which uses secondary data to create detailed regional input-output models (Alward et al. 1989). Indeed, the data-base is sufficiently detailed to create custom input-output models for every county or multi-county region in the US.

We hypothesis that a combination of a set of measures describing the (I - A) matrix from a regional input-output model, relative to some base economy, provides a much more detailed and complete measure of diversity.[1] As describe latter in the paper, we combine measures of the (I - A) matrix size (i.e., number of endogenous industries relative to a base economy), the matrix density, and the condition number of the matrix. Explicit to our approach is the assumption that the chosen base economy is diversified and serves as a reasonable reference economy. We suggest that by accounting explicitly for interindustry linkages (i.e., by

[1] The (I - A) matrix is defined as the identity matrix, I, minus the technical coefficients matrix, A.

using the condition number of the (I - A) matrix), our measure more fully captures the characteristics of the regional economy.

The paper is composed of five sections. First, we review the alternative methods suggested for measuring regional economic diversity. Second, we discussion in detail our alternative approach to conceptualizing and measuring economic diversity followed by an outline of our measures of economic growth and stability. Next, we empirical estimate our diversity index for the US and the 50 states and its relationship to our measures of growth and stability. Finally, the paper closes with a brief summary section.

A Review of Diversity Measures

Within the academic literature the systematic analysis of the relationship between diversity and regional economic stability has been hindered by the problem of defining diversity in a theoretically meaningful manner and then deriving consistent empirical measures. As noted by Attaran (1987), diversity has been defined as "the presence in an area of a great number of different types of industries" (Rodgers 1957, p16), as "the extent to which the economic activity of a region is distributed among a number of categories" (Parr 1965, p22), or "in terms of balanced employment across industry classes" (Attaran 1987, p45). An implicit premise consistent with previous diversity studies is that a larger economy is better. We assert that regional economic diversity relates not only to the size of the regional economy and, more importantly, to the interindustrial linkages (i.e., the direct and indirect interactions between industries).

Measures used to capture the level of regional economic diversity have ranged from the simplistic, almost naive, to the complex using portfolio variance analysis. One example of the naively simple is that of Williams (1950) who measured diversity as the percent of manufacturing activity accounted for by nondurable goods, clearly an unacceptable measure. The majority of diversity measures, however, tend to fall into one of two groups: entropy and portfolio variance measures.

Entropy indices are the most common measures used in empirical studies due, primarily, to their computation ease and limited demands for data. Entropy as a measure of disorder, uncertainty, or homogeneity has been used to study many different phenomena. For example, in biological and behavioral

studies, entropy has been used as a measure of organization and in communication theory, it quantifies the degree of uncertainty. Within economics, entropy measures attempt to capture the distribution of activity, usually employment, across a given set of industry sectors. In some cases, this distribution is then compared to some larger region, usually the U.S., which is viewed as diversified. These measures were applied originally to economies within the industrial organization literature and were intended to provide a single measure of industrial concentration (Stigler 1968). Yet, the application of these measures have been adopted in several studies of regional economic diversity (Kort 1981, Attaran 1987, Smith and Gibson 1987, and Deller and Chicoine 1989).

Entropy measures, as used within the regional economic diversity literature, explicitly structures diversity as a level of distribution of economic activity across a range of sectors. Within this framework, an ideally diversified economy would have equal levels of activity across industries. The greater the concentration of activity in a few industries, the less diversified, or more specialized, the economy. Several specific mathematical formulas have been suggested within the literature, ranging from the percent durable ($PDIV_i$), Herfidahl ($HDIV_i$), ogive ($ODIV_i$), national average ($NDIV_i$), to the log share ($LDIV_i$):

$$PDIV_i = \frac{e_{id}}{e_i} \cdot 100 \tag{1}$$

$$ODIV_i = \sum_{s=1}^{S} \frac{\left[\left(\frac{e_{is}}{e_i}\right) - \frac{1}{S}\right]^{\rho}}{1/S} \tag{2}$$

$$HDIV_i = \sum \left(\frac{e_{is}}{e_i}\right)^2 \tag{3}$$

$$NDIV_i = \sum_{s=1}^{S} \frac{\left[\left(\frac{e_{is}}{e_i}\right) - \left(\frac{e_s}{e}\right)\right]^{\rho}}{e_s/e} \tag{4}$$

$$\mathrm{LDIV}_i = -\sum_{s=1}^{S}\left(\frac{e_{is}}{e_i}\right)\ln\left(\frac{e_{is}}{e_i}\right) \tag{5}$$

where e_{is} is activity (usually employment) in region *i* in industry *s*, e_i is total activity in region *i*, *e* is total activity within the reference economy (usually the nation), e_{id} is activity in durable manufacturing within region *i*, ρ is a positive constant, usually assigned a value of one or two, and *ln* is the natural logarithm operator. Note that in all formulations of the entropy measure, greater values of the measure suggests greater levels of diversity, whereas lower levels hint at a more specialized economy.

These entropy diversity measures have been question on both the theoretical and empirical front. On the theoretical front, Conroy (1972, 1974 and 1975), and latter Brown and Pheasant (1985), have pointed out that the selection of an equal distribution of activities across sectors as the reference point for diversity is not based on any *a priori* rationale, and is indeed, quite arbitrary. Two additional theoretical concerns include the fact that these measures do not account for any form of interindustry linkages and the number of industry sectors is usually fixed and not allowed to vary by region. Bahl, Firestine and Phares (1971) and Conroy suggest that perhaps equality in the distribution of activities is not the key, but rather the specialization in specific industries that tend to be "inherently" stable.

Empirical concerns have been raised by Wasylenko and Erickson (1978), Kort (1981), and Attaran (1987). Wasylenko and Erickson, for example, found that regions defined as highly specialize by the entropy approach, were, in fact, characterized by relative economic stability. Kort found that policy results were sensitive to the specific entropy measure used, and Attaran found, for example, that more specialized regions experienced greater economic growth and there was little relationship between levels of diversity and unemployment. Smith and Gibson (1987) and Kort suggest that part of the empirical shortfall may be due to factors, other than diversity, that influence stability have tended to be ignored in empirical estimation.

An alternative approach advanced by Conroy and Brown and Pheasant, which adapts portfolio theory from the finance literature, has received less attention within the empirical literature. Conroy suggested a direct appeal to portfolio analysis, in particular the work of Markowitz (1957) and Sharpe (1970). Conroy

viewed regional and local policy designed to promote economic growth and diversity analogous to an investor selecting a set of financial instruments in creating an investment portfolio. Local policy-makers are in essence selecting a set of industries in which to invest which "seems appropriate here to refer to the industrial structure of a regional economy, when viewed stochastically, as the community industrial portfolio" (Conroy 1974, p32).

Using the entropy method of measuring diversity, the explicit assumption detailing the ideal portfolio is that of an even distribution of investments over many stocks, or in our case, industries. These measures ignore "the inherent interdependence among elements of the portfolio which is possibly a key element in the analysis of the diversification of that portfolio" (Conroy 1974, p32). This framework focuses not only on the net return and the stability of individual industry's net return, but with the quantified interdependence with other industries within the portfolio.[2]

As outlined by Markowitz (1957), and latter by Conroy and Brown and Pheasant, the problem is to determine the set of mean-variance efficient portfolios. A portfolio is mean-variance efficient if no other portfolio gives either a higher expected return for the same amount of variance, or a lower variance for the same expected return. Formally, the analyst wants to choose form N stocks (or industries) so as to maximize:

$$M_P = f \sum_{i=1}^{N} w_i E_i - \sum_{i=1}^{N} \sum_{j=1}^{N} w_i w_j \, COV\,(E_i, E_j) \tag{6}$$

subject to:

$$\sum w_i = 1 \quad ; \quad \forall\, i \qquad w_i \geq 0 \tag{7}$$

for all i, where w_i is the proportion of the portfolio invested in security (or industry) i; E_i is the expected return from security (or industry) i; cov(E_i,E_j) is the covariance between the expected return of security (or industry) i and j; and f is a positive constant which indicates a preference between growth and stability.[3] The first term

[2] Net return here is viewed as economic growth rates.

[3] A more direct interpretation of w is the proportion of the region's employment (or income) from the particular industry and E is the expected rate of growth in employment (or income) in the industry.

of eq(6) is a simple proportions share entropy measure. Therefore, the more compete portfolio approach is still subject to some of the criticizes of the entropy approach.

In this formulation of the regional economic diversity problem, the interdependence between industries are based on how their returns (i.e., expected rate of growth in either employment or income) are correlated linearly. Basically, the cov(E_i,E_j) matrix shows the growth of employment or income moves in the same or in the opposite direction between the endogenous industries. Using either employment or income in this manner (be it in the entropy or portfolio technique) is limiting the interdependence to these direct measurements. There are no allowances for any indirect interrelationships or linkages between the endogenous industries.[4]

An Alternative Measure of Diversity

We feel the strategy suggested by Conroy of measuring "the inherent interdependence" between industries is correct. However, we suggest a complete break from the existing entropy or portfolio measures, or any extended variations. We posit that the complexity of regional diversity can be best captured by using input-output (I-O) models. Here we can capture not only the overall size of the regional economy, but also the level of interindustry linkages (both the direct and indirect influences). The manner in which we construct our alternative measure also allows for direct policy interpretation, such as minimizing leakages due to imports.

As stated earlier, a problem with measuring diversity is first defining diversity in a precise manner that will lead to an easily measurable index. We define diversity in terms of both industries' direct and indirect influences on the regional economy. In mathematical terms, the direct effects of industries are the diagonal

[4] In studies of diversification which use entropy measures, separate measure of regional stability is required. Often, deviations in income, employment or unemployment rates around a trend-line or average is assumed to capture stability. Within the Conroy approach, the covariance matrix itself is the stability measure. Thus, within this framework, diversity and stability are treated simultaneously.

elements of a matrix and the indirect effects are the off-diagonal elements.[5] Therefore, greater diversity implies more off-diagonal elements being non-zero.

I-O analysis was designed principally to analyze the transactions among the producers and consumers of goods and services within an economy. As such, I-O provides a detailed picture of interindustry linkages through industrial expenditure patterns. We propose to use this representation of interindustry linkages to construct a unique measure of regional economic diversity.

Prior to just a few years ago, the use of I-O to construct any type of diversity measure would have been difficult if not impossible. To empirically test hypotheses relating diversity to stability requires a reasonable sample size upon which to base the required statistical analysis. Using I-O would require constructing specific I-O models for several regions. Prior to just a few years ago, this monumental task would have effectively preempted our approach. However, with the advent of state-of-the-art regional modeling systems, such as MicroIMPLAN (Alward et al. 1989), this computational barrier has been overcome. For this analysis we employ MicroIMPLAN to construct 51 separate I-O models for each of the fifty states, plus the US. Because of the flexibility of the regional databases contained within the MicroIMPLAN system, the analysis presented here for the fifty states and the US, could be repeated for every county, or multi-county combination, in the US. We posit that a measure of regional economic diversity can be constructed from scalers which describe the interindustry linkages within the (I - A) matrix (i.e., the identity matrix, I, minus the technical coefficients matrix, A). These scalers, once combined, are then compared to a reference base economy.

Our diversity index is composed of three parts: 1) the relative size of the (I - A) matrix (i.e., number of endogenous industries), 2) the density of the (I - A) matrix, and 3) a scaler measuring the degree of interindustry linkages. Our Primary Diversity Measure (PDM) is defined as the simple multiplicative combination of these three characteristics

$$PDM_i = SI_i * DEN_i * CN_i \tag{8}$$

[5] In previous studies, diversity was estimated measuring only the direct effect of each industry and implied generally that more industries were better than fewer. In mathematical terms, this translates into an diagonal matrix whose size denotes the number of endogenous industries and the diagonal elements are scaled to represent either employment or income.

where SI_i is the relative size of the (I - A) matrix for region *i*, DEN_i is the density of the matrix, and CN_i is a scaler measure of the degree of linkage within the regional economy as captured by the (I - A) matrix.

We define the relative size (SI) of a region's economy as

$$SI_i = N_i \ / \ N_{be} \tag{9}$$

where N_i is the number of endogenous industries identified by MicroIMPLAN to be within region *i* and N_{be} is the number of endogenous industries in the base economy. This measure implies the larger the regional economy as compared to the base economy the better. The larger the regional economy, in terms of the number of industries contained within the economy, the greater the ability of the economy to absorb shocks. An economy composed of only a small handful of industries is less likely to absorb a shock than an economy composed of many industries. This is a measure of relative size but does not contain any information on interindustry linkages.

The density (DEN_i) of the (I - A) matrix is defined as

$$DEN_i = NON\text{-}ZERO_i \ / \ N_i{*}N_i \tag{10}$$

where $NON\text{-}ZERO_i$ is the number of non-zero elements in the (I - A) matrix for region *i*, an N_i is the same as above. The greater the number of non-zero elements contained in the table, the greater the degree of possible interindustry linkages. Economies described by a relatively high number of zero elements, is a more open, or "loose" economy in our view of diversity. This measure does not capture the relative magnitudes of the elements nor does it capture the positions of these elements within the (I - A) matrix.

The final component measures the degree of interindustry linkages. The condition number of the (I - A) matrix defines a scaler denoting the interindustry linkages. The condition number is defined as

$$CN_i = \| (I - A) \| \| (I - A)^{-1} \| = \delta_1(I - A) \ / \ \delta_n(I - A) \tag{11}$$

where $\| I - A \|$ is the 2-norm of the (I - A) matrix, $\| (I - A)^{-1} \|$ is the 2-norm of the $(I - A)^1$ (the Leontief inverse matrix), and $\delta_1(I - A)$ is the largest singular value and $\delta_n(I - A)$ is the smallest singular value of the (I - A) matrix, respectively.

The condition number is a measure of linear independence. Most commonly it is used to test for the uniqueness of a solution to a set of linear equation. By definition, an identity matrix, of any size, has a

condition number equal to one. Any divergence from an identity matrix will cause the condition number to increase. In terms of regional economics, divergence from the identity matrix in terms of the (I - A) matrix implies more purchases from endogenous industries or a greater degree of interindustry linkages. Thus, the condition number should increase the more diverse the economy.

In our construction of the Primary Diversity Measure (PDM), three testable hypotheses come to light. First, if more diverse economies are characterized by higher condition numbers, then the US should have the largest condition number. Second, if this is the case, does this mean, in general, that a larger (smaller) economy will have a larger (smaller) condition number? Finally, a larger economy will probably have a more dense matrix. Therefore, if the density of a matrix increases (decreases) then the condition number should also increase (decrease).

Hypothesis #1:	The condition number for the U.S. is the largest.
Hypothesis #2:	There is a positive relationship between the size of the economy (or the number of endogenous industries) and the condition number.
Hypothesis #3:	There is a positive relationship between the density of the direct requirements tables and the condition number.

Consistency of these hypotheses, and the data's support of these hypotheses, lends credence to our measure of regional economic diversity.

To complete the diversity index, we scaled the Primary Diversity Measure (PDM) relative to some reference base economy. The final diversity index is defined as

$$INDEX_i = PDM_i \ / \ PDM_{be}. \tag{12}$$

If the base economy's PDM is the largest, then the Index will range between zero and one ($0 < INDEX \leq 1$), with a value of one defined as the most diversified. A value of zero can only occur if there is no economic activity within the region, clearly impossible given our construction of the problem.

Measures of Growth and Stability

In order to test the over-riding hypothesis that higher levels of economic diversification yields higher levels of economic growth and stability, we need to define measures of both. First, we proxy economic

performance using three characteristics of the regional (state) economy: population, total personal income, and employment. We examine annual data over a twenty-two year period starting with 1969 and ending with 1990.

Our measure of economic growth is straightforward and is defined for the ith region as the average annual growth rate over the period examined:

$$AYGR_i = \frac{\sum_{t=1}^{T} \left((Y_{it} - Y_{it-1}) / Y_{it-1} \right) \times 100}{T} \tag{13}$$

where T in the number of time periods examined (twenty-two) and Y is the proxy characterizing the economy (population, income, and employment). Higher values of $AYGR_i$ indicate a faster growing region over the twenty-two period we examine. Our measure of stability is equally straightforward and is defined as the variance in the annual growth over the same period. A higher variance describing the distribution of $AYGR_i$ is interpreted as a more unstable regional economy. Ideally, regional policy makers should peruse policies which promote high, but stable rates of growth.

Given these measures of economic performance, there are six additional hypotheses to be tested:

Hypothesis #4: Diversity and the average annual growth rate in regional population is positively correlated.

Hypothesis #5: Diversity and the average annual growth rate in regional total personal income is positively correlated.

Hypothesis #6: Diversity and the average annual growth rate in regional employment is positively correlated.

Hypothesis #7: Diversity and stability in the average annual growth rate in regional population are negatively correlated.

Hypothesis #8: Diversity and stability in the average annual growth rate in regional total personal income are negatively correlated.

Hypothesis #9: Diversity and stability in the average annual growth rate in regional employment are negatively correlated.

Empirical Results

The state level data files from MicroIMPLAN were used to calculate our diversity index and test the three hypotheses. The state level data were from 1990.

Diversity Index

The results of calculating our diversity index are reported in Table 1, defining the US as the base economy. The value of the Diversity Index, save for the reference base economy of the US, ranges from a high of 0.6149 for the State of Alabama to a low of 0.12777 for the State of Alaska with an average value of 0.34001 and a standard deviation of 0.08759. The top three diversified states, by our measure are Alabama, Tennessee, and Georgia, and the three least diversified are Hawaii, Wyoming, and Alaska. States which one would view as more diversified, such as New York, Illinois and Texas to name a few, tend to fall more in the middle of the range. New York, for example is ranked 40th, Illinois is ranked 29th, and Texas is 18th.

Turning to our testable hypotheses, we see that the data tends to support our logic. As can be seen in Table 1, the condition number for the US is the largest. Therefore, we fail to reject the first hypothesis. This result also makes intuitive sense. The second and third hypotheses are tested using the Pearson Correlation Coefficient, which are given in Table 2. Table 2 shows that there is a statistically significant positive correlation between the size variable (SI_i) and the condition number (CN_i). Therefore, we failed to reject the second hypothesis. Table 2 also shows that there is a statistically significant positive correlation between density of the (I - A) matrix (DEN_i) and the condition number (CN_i).[6] These data suggest that the logic of focusing on the condition number as a locus for the analysis is reasonable. In light of the empirical results around our three testable hypotheses, the resulting pattern in the Diversity Index ($INDEX_i$), becomes clearer; the condition

[6] The negative correlation between density and the number of industries (or size measure) is due to the definition of density. That is, as the number of endogenous industries increases, the denominator of the density measure increases at a rapidly increasing rate while the number of non-zero elements does not grow as rapidly.

Also not that the number of industries is a perfect proxy for our size measure. We have elected to stay with the size measure as we have defined it to maintain consistency in the scaling of the measure.

number, or some homothetic transformation of the condition number, most directly influences the Diversity Index.

Growth and Stability Results

In order to test for the level of association between diversity within the framework of input-output and economic growth and stability, a set of simple Pearson correlation coefficients have been computed. The results of these experiences are reported in Table 3. Turning attention first to our three measures of economic growth, the results are consistent; there appears to be no statistical relationship between levels of growth and diversity. We find ourselves rejecting each of the three hypotheses relating diversity to growth. While this result is disappointing, it is not completely unexpected. The rationale for diversifying a regional economy, as with diversifying an investment portfolio, is to minimize instability, not maximize growth rates.

Our results concerning stability levels, however, lends greater conviction to our alternative measure of diversity. As the theory suggests, diversity lends itself to greater stability in growth rates. The results reported in Table 3 reveal that a higher level of diversity within an input-output framework results in higher levels of stability (i.e., lower variances in growth rates) in all three measures of economic performance; population, personal income and employment. Indeed, the level of association is significant at or above the 99 percent level of confidence is each of the three cases. These results support the overall conclusion of the conceptual discussion relating levels of economic diversity to economic stability. We view these results as evidence supporting our alternative view of conceptualizing and measuring economic diversity.

Conclusions

A commonly pursued regional economic development strategy is that of economic diversity in order to achieve the goal of economic stability. While logic, and common sense, suggests that this is a reasonable approach, the empirical literature has not been able to affirm this strategy. Part of the shortcomings of the empirical literature is the consistent use of entropy diversity measures. While intuitive, these measures fail to capture vitally important interindustry linkages within the region.

We suggest that one approach to develop a family of more comprehensive measures of economic diversity builds upon input-output representations of the regional economies. We suggest that the (I - A) matrix, supplied by input-output analysis, provides a detailed data set upon which diversity measures can be based. The dimension of the matrix gives insight into the relative size of the economy in terms of the number of endogenous industries. The density of the matrix gives a simple measure of the degree of interindustry linkages. Finally, the condition number, which describes the level of linear independence across a matrix, is related directly to the level of economic diversity. We combined all three of these summary scaler measures characterizing the (I - A) matrix in a multiplicative manner to calculate a primary diversity measure. Comparing this measure to a base economy (e.g., the US) allowed us to construct a relative diversity index.

Using data available through the MicroIMPLAN, we construct the (I - A) matrices for the US and all 50 states for the year 1990. After computing the three summary scalers for each of the 51 tables, we were then able to construct our suggested regional economic diversity index.

Our empirical results focusing on economic growth and stability are consistent with economic theory; higher levels of diversity, as measured within the framework of input-output analysis, are not necessarily associated with levels of growth, as measured by population, total personal income and employment, but are associated with stability in the average annual growth rates in the same proxies.

While our results may appear as suggestive in nature, we think that our alternative view of conceptualizing economic diversity warrants consideration. Our suggested approach not only allows for variation in the relative size of the regional economy, but more importantly the level of interaction within the economy beyond the direct effects. In addition, the availability of county, multi-county and state level MicroIMPLAN input-output models over a period of years allows for a rich and detailed analysis of the diversity-stability hypothesis.

In addition to the robustness of our measure with respect to dynamics and cross sectional analysis, employing an input-output framework to view the problem opens a door to policy prescriptions. For example, a direct result of our approach is the expansion of the number of industrial sections within the economy. A simple concept that is easily incorporated into our approach. Perhaps the more direct approach in terms of

policy design is that of industry integration. The input-output approach lends itself to immediate policy interpretations such as expanding interregional linkages to minimize export leakages to industrial expansion. The key to our conceptual and empirical approach is that regional economies that are highly integrated are, by definition, highly diversified and inherently stably.

Table 1. Empirical Estimates of Input-Output Based Diversity Measures

STATE	NUMBER OF INDUSTRIES	DENSITY	SIZE	CONDITION NUMBER	DIVERSITY INDEX
AK	229	0.31769	0.43870	2.23404	0.12777
AL	447	0.33823	0.85632	5.17354	0.61490
AR	435	0.34375	0.83333	3.41083	0.40095
AZ	436	0.30559	0.83525	3.08772	0.32341
CA	513	0.31401	0.98276	3.43309	0.43475
CO	468	0.31020	0.89655	2.94302	0.33587
CT	435	0.28955	0.83333	2.96760	0.29384
DE	304	0.35641	0.58238	3.05008	0.25980
FL	489	0.30066	0.93678	2.92209	0.33773
GA	477	0.33003	0.91379	3.75344	0.46451
HI	277	0.28229	0.53065	2.94919	0.18129
IA	445	0.33217	0.85249	3.25291	0.37800
ID	351	0.31658	0.67241	2.99929	0.26200
IL	501	0.31441	0.95977	2.53418	0.31381
IN	458	0.34857	0.87739	3.00558	0.37720
KS	430	0.34171	0.82375	3.52968	0.40771
KY	438	0.34685	0.83908	3.51450	0.41973
LA	419	0.31588	0.80268	3.65872	0.38068
MA	469	0.32730	0.89847	3.02761	0.36536
MD	437	0.31747	0.83716	3.70410	0.40398
ME	358	0.34077	0.68582	3.04290	0.29183
MI	485	0.26791	0.92912	2.58441	0.26399
MN	466	0.32972	0.89272	3.44670	0.41632
MO	469	0.33616	0.89847	3.59304	0.44533
MS	418	0.30359	0.80077	3.44301	0.34348
MT	330	0.32658	0.63218	3.38070	0.28642
NC	480	0.28875	0.91954	4.08701	0.44531
ND	298	0.35210	0.57088	3.44041	0.28378
NE	368	0.30105	0.70498	2.85191	0.24838
NH	388	0.34969	0.74330	2.92171	0.31164
NJ	477	0.29794	0.91379	2.91737	0.32594
NM	376	0.32058	0.72031	3.13159	0.29675
NV	369	0.31475	0.70690	3.04073	0.27763
NY	495	0.30895	0.94828	2.26764	0.27262
OH	486	0.33201	0.93103	2.98811	0.37903
OK	442	0.33210	0.84674	3.44040	0.39700
OR	457	0.29136	0.87548	2.94069	0.30782
PA	491	0.31546	0.94061	2.82253	0.34368
RI	365	0.35801	0.69923	2.89953	0.29786
SC	452	0.32616	0.86590	3.20901	0.37191
SD	305	0.36096	0.58429	3.01419	0.26087
TN	481	0.34103	0.92146	4.23203	0.54574
TX	496	0.31231	0.95019	3.09836	0.37731
UT	415	0.33743	0.79502	2.78051	0.30609
VA	458	0.32241	0.87739	3.40859	0.39568
VT	336	0.34501	0.64368	2.78372	0.25368
WA	465	0.30697	0.89080	3.16102	0.35471
WI	467	0.33833	0.89464	3.04413	0.37811
WV	353	0.33729	0.67625	2.75988	0.25833
WY	276	0.26924	0.52874	3.07898	0.17987
US	522	0.41928	1.00000	5.81206	1.00000

Data Source: MicroIMPLAN, 91-F.

Table 2. Correlation Matrix of Key Diversity Measurement Elements

VARIABLE	NUMBER OF INDUSTRIES	DENSITY	SIZE	CONDITION NUMBER	DIVERSITY INDEX
NUMBER OF INDUSTRIES	1.00000 (0.0)				
DENSITY	-0.01680 (0.9069)	1.00000 (0.0)			
SIZE	1.00000 (0.0)	-0.01680 (0.9069)	1.00000 (0.0)		
CONDITION NUMBER	0.29274 (0.0371)	0.45100 (0.0009)	0.29274 (0.0371)	1.00000 (0.0)	
DIVERSITY INDEX	0.60859 (0.0001)	0.54196 (0.0001)	0.60859 (0.0001)	0.88638 (0.0001)	1.00000 (0.0)

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N=51.

Table 3. Levels of Association between Diversity and Growth and Stability

	Average Annual Growth Rate		
	Population	Personal Income	Employment
Diversity Index	-.05593	-.16331	-.15678
	(.6997)	(.2571)	(.2769)

	Stability in Annual Growth Rate		
	Population	Personal Income	Employment
Diversity Index	-.39056	-.49393	-.40088
	(.0050)	(.0003)	(.0039)

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N=50.

References

Alward, G.S., L.E. Siverts, D. Olsen, J. Wagner, D. Senf, and S. Lindall, *MicroIMPLAN Software Manual.* Unpublished material developed in cooperation with the USDA Forest Service Timber and Land Management Group in Ft. Collins and the Department of Agricultural and Applied Economics at the University of Minnesota. 1989.

Attaran, M., "Industrial Diversity and Economic Performance in US Areas." *Annuals of Regional Science.* XX(1987):44-54.

Bahl, R.W., R. Firestine, and D. Phares, "Industrial Diversification in Urban Areas: Alternative Measures and Intermetropolitan Comparisons." *Economic Geography*. 47(1971):414-425.

Brown, D.J, and J. Pheasant, "A Sharpe Portfolio Approach to Regional Economic Analysis." *Journal of Regional Science.* 25:1(1985):51-63.

Conroy, M.E., "Optimal Regional Industrial Diversification; A Portfolio-Analytic Approach." unpublished Ph.D. dissertation, The University of Illinois at Urbana-Champaign. 1972.

Conroy, M.E., "Alternative Strategies for Regional Industrial Diversification." *Journal of Regional Science.* 14:1(1974):31-46.

Conroy, M.E., *Regional Economic Diversification.* New York: Praeger. 1975

Deller, S.C. and D.L. Chicoine, "Economic Diversification and the Rural Economy: Evidence from Consumer Behavior." *Regional Science Perspectives* 19(1989):41-55.

Kort, J.R., "Regional Economic Instability and Industrial Diversification in the US." *Land Economics*. 57:4(1981):596-608.

Markowitz, H.M., *Portfolio Selection: Efficient Diversification of Investments.* Chicago: Cowles Foundation for Economic Analysis. 1959.

Sharpe, W.F., *Portfolio Theory and Capital Markets.* New York: McGraw-Hill. 1970.

Smith, S.M., and C.M. Gibson, "Economic Diversification and Employment Stability in Nonmetropolitan Counties." Department of Agricultural Economics and Rural Sociology Staff Paper No. 137, Pennsylvania State University, University Park, PA. June, 1987.

Stigler, G.J., *The Organization of Industry*. Homewood, IL: Irwin. 1968.

Wasylenko, M.J. and R.A. Erickson, "On Measuring Economic Diversification: Comment." *Land Economics*. 54:1(1978):106-110.

Williams, R.M., "The Timing and Amplitude of Regional Business Cycles." *Papers and Proceedings of the Pacific Coast Economics Association.* 4(1950):47-51.