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# **Regional Economic Diversity: Action, Concept, or State of Confusion**

**John E. Wagner\***

**Abstract.** Economic diversity has been promoted as a means to achieve the goals of stability and growth. However, the link between diversity, diversification and economic performance depends on the differences, both conceptually and empirically, between diversity and diversification. Unfortunately, the literature contains varying definitions of diversity and diversification. I propose two key points in defining diversity. First, it is a static concept. Second, it examines the size, the presence of multiple specializations, and the linkages present among industries within a region's economy. A brief review of diversity measures is used to discuss measuring diversity relative to some standard, as an explanatory variable in examining growth and stability, and other issues. No one diversity measure is critique free; care should be taken when using a diversity measure as the only factor in a policy designed to change the structure of a region's economy, given the goals of growth and stability.

## **1. Introduction**

### ***Background***

Regional economic stability has been a topic discussed in the literature of various disciplines dealing with regional economics and development for at least sixty years. Economic stability is important to regional policy makers because it promotes potential economic growth, stable incomes, and low unemployment levels (Akpadock 1996, Malizia and Kee 1993, and Conroy 1974). Included in these discussions are the

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\* Associate Professor of Forest Resource Economics, Faculty of Forestry, SUNY - College of Environmental Science and Forestry, 320 Bray Hall; 1 Forestry Drive, Syracuse, NY 13210 (315) 470-6971, jewagner@esf.edu.

concepts of diversity and diversification as they relate to stability and often growth. These discussions have led to varying definitions of diversity and diversification. More often than not, these definitions have also led to a proposed diversity measure. In some cases, these diversity measures have been related statistically to growth and stability. These academic discussions have been important in developing the concept of diversity (and diversification) as it relates to growth and stability. I feel that re-visiting this issue now is important to start a consensus building process.

The purpose of this paper is twofold. First, after reviewing the literature and a short discussion of how diversity is related to growth and stability, I will propose two key concepts that should be part of defining diversity. Second, after presenting a brief review of some diversity measures, I will focus my discussion on five topics that should be re-examined in the discussion of diversity. The first is measuring diversity relative to some standard. The second is using a static versus dynamic measure. The third is using diversity indices as an explanatory variable in examining growth and stability. The fourth is measuring diversity using a single number, or a scalar, versus a matrix in which the intersections of the rows and columns describe economic activity. The final is the computational ease for calculating each measurement versus the information received.

### *Diversity and Diversification*

Diversity has often been promoted as a means to achieve the economic goals of stability and growth (Kort 1979 and 1991 and Siegel et al. 1993a, 1994, and 1995a). Specifically, as a region's economy becomes more diversified, it becomes less sensitive to fluctuations caused by factors outside the region (Nourse 1968 and Richardson 1969). However, a recent article by Akpadock (1996) illustrates the concern of community development practitioners that the "conventional wisdom" - which states economic diversity not only promotes stability, but also broadens goals such as economic growth and low unemployment levels - does not seem to hold true.

Recently, this conventional wisdom has been challenged both on the theoretical and empirical fronts. On the theoretical front, elementary economic theory suggests that growth should be derived from economic specialization based on competitive advantage. Theory also suggests that stability is achieved through diversity. Therefore, theory seems to suggest that regional policy makers are forced to choose between two polar goals of growth and stability, and the corresponding set of policy options. This tradeoff is one that most, if not all, policy makers are unwilling to accept or act upon when designing policy. When policy mak-

ers attempt to pursue both goals simultaneously, contradictions seem to appear.

The economic development policy of diversification follows from the theory that stability is achieved through diversity. Killian and Hady (1988) state that “diversity is expected to increase the stability of local economies and enhance their potential for growth.” More recently, Akpadock (1996) reiterated the same policy that communities “diversify their economic base so that they could survive any future structural changes in the national economy.” The resulting economic development policy implications of diversity are then the strategies communities use to recruit -- and retain -- businesses (Akpadock 1996).

Nonetheless, Wagner and Deller (1998) suggest that the simultaneous pursuit of growth and stability is not contradictory when viewed in terms of the short- and long-run. Short-run policy can be viewed as more growth oriented where policy makers’ develop strategies that target growth industries. These strategies capitalize on a region’s comparative advantage by specializing in a few select industries. However, targeting growth industries is only part of the picture. Relying only on short-run plans may create a trap where policy makers fall into a “job is done” syndrome. This can be dangerous because as the industry matures, a dampening pressure on growth levels will develop. Furthermore, if the targeted growth industries fail, the region may be worse off than before the policies are implemented. Diversification policies should be viewed as the long-run envelope of the region’s short-run efforts in promoting growth. Therefore, within this framework, it is vitally important to remember that short-run policies are aimed at promoting growth and long-run policies are aimed at promoting stability with growth. As stability and diversity increase, so should the potential for growth. The apparent contradictory goals and policies can be pursued simultaneously and consistently.

On the empirical front, the literature is inconclusive in analyzing and testing hypotheses concerning diversity and its relationship to growth and stability. Wagner and Deller (1998) concur with Kort (1979 and 1991) and Siegel et al. (1993a, 1994, and 1995a) that a major shortcoming of the empirical literature is methodological. In addition, Wagner and Deller (1998) propose that the empirical literature has discounted the role of diversity incorrectly due to the confusion over short- versus long-run hypotheses. Higher levels of diversity should be related to stability and levels of growth within this broader framework.

Examining and testing the link between diversity and growth and stability, and diversification and growth and stability depend on the definitions of diversity and diversification. Siegel et al. (1995b) provide a discussion of how the term diversity and diversification are used in in-

dustrial organization theory, economic base theory, regional business cycle theory, trade theory, portfolio theory, location and regional economic theories, and economic development theory. My purpose is not to repeat Siegel et al.'s discussion but draw out what I feel are two key points in defining diversity. First, Malizia and Ke (1993), Siegel et al. (1993a, 1993b, and 1995b), and Wagner and Deller (1998) define the difference between diversity and diversification as a static versus a dynamic concept. Malizia and Ke (1993) define diversity as "the variety of economic activity which reflects differences in economic structure ... diversity is measured at a specific time." Siegel et al. (1993a, 1993b and 1995b) state that "economic diversification is a *process* that increases the *state* of diversity over time." Second, 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 and definitions is that a larger economy is better. Malizia and Ke (1993) define diversity as not the absence of specialization, but reflects the presence of multiple specializations and "industrial complexes with strong interindustry linkages." Wagner and Deller (1998) and Siegel et al. (1993a and 1995b) agree that regional economic diversity relates not only to the size of the regional economy and the presence of multiple specializations but also to the interactions or linkages present among industries. In my humble opinion, the two key points in defining diversity are that, first, it is a static concept and that, second, it examines the size, the presence of multiple specializations, and the linkages present among industries within a region's economy.

## **2. A Brief Review of Common (and not so common) Diversity Measures**

The resulting different definitions of diversity have led to a variety of diversity measures. The purpose of this section is to review the assumptions various diversity measures use. To this end, I will group the diversity measures into four broad categories: equiproportional, type of industries, portfolio, and input-output measures.<sup>1</sup>

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<sup>1</sup> This review is not meant to be all encompassing.

### **Equiproportional Measures**

The principle assumption of this category is that ideal diversity implies equiproportional levels of economic activity in all industries. This notion of diversity is derived from the second law of thermodynamics or the entropy law. Entropy as a measure of disorder, uncertainty, or homogeneity has been used to study many different phenomena. Within economics, entropy measures attempt to capture the distribution of activity, usually employment, across a given set of industry sectors. Consequently, the greater the concentration of activity in a few industries, the less diversified, or more specialized, the economy. For these diversity measurements, the variety of industries is the focus rather than the type of industries (Siegel et al. 1993a and 1995b). These measures are applied originally to economies within the industrial organization literature and are intended to provide a single measure of industrial concentration (Stigler 1968).

These indices are the most common measures used in empirical studies due, primarily, to their computation ease and limited demands for data (Kort 1981, Attaran 1987, Smith and Gibson 1987, Deller and Chicoine 1989, Malizia and Ke 1993, and Akpadock 1996). Several specific mathematical formulas have been suggested within the literature ranging from Ogive ( $O_i$ ), Herfindalh ( $H_i$ ), national average ( $N_i$ ), to the log share ( $L_i$ ):

$$O_i = \sum_{s=1}^{S_i} \frac{\left[ \left( \frac{e_{si}}{e_i} \right) - \frac{1}{S_i} \right]^r}{\frac{1}{S_i}} \quad (1)$$

$$H_i = \sum_{s=1}^{S_i} \left( \frac{e_{si}}{e_i} \right)^2 \quad (2)$$

$$N_i = \sum_{s=1}^{S_i} \frac{\left[ \left( \frac{e_{si}}{e_i} \right) - \left( \frac{e_s}{e} \right) \right]^r}{\frac{e_s}{e}} \quad (3)$$

$$L_i = - \sum_{s=1}^{S_i} \left( \frac{e_{si}}{e_i} \right) \ln \left( \frac{e_{si}}{e_i} \right) \quad (4)$$

where  $S_i$  is the total number of industries in the  $i^{\text{th}}$  region,  $e_{si}$  is activity (usually employment) in the  $i^{\text{th}}$  region in industry  $s$ ,  $e_i$  is total activity in the  $i^{\text{th}}$  region,  $e$  is total activity within the reference economy (usually the nation),  $p$  is a positive constant, usually assigned a value of one or two,

and  $\ln$  is the natural logarithm operator. If  $\rho = 2$  in equations (1) and (3), then more weight is placed on larger deviations than smaller, regardless of the type of industry. In equations (1), (3), and (4), the ideal equiproportional distribution of economic activity is defined by  $1/S_i$ ,  $e_s/e$ , and  $\ln[e_{si}/e_i]$ , respectively. For equations (1), (2) and (3), smaller values of the measure suggests greater levels of diversity, whereas larger values hint at a more specialized economy. While for equation (4), larger values of the measure suggests greater levels of diversity, where as lower levels hint at a more specialized economy.<sup>2</sup>

These equiproportional diversity measures have been questioned both theoretically and empirically. On the theoretical front, Conroy (1972, 1974 and 1975), and later 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 (Wagner and Deller 1998). Bahl et al. (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.

Wasylenko and Erickson (1978), Kort (1981), Attaran (1987), Smith and Gibson (1987), and Malizia and Ke (1993) have raised empirical concerns. Wasylenko and Erickson found that regions defined as highly specialized 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 that more specialized regions experienced greater economic growth and there was little relationship between these levels of diversity and unemployment. Smith and Gibson and Kort suggested that part of the empirical shortfall might be due to factors, other than diversity, that influence stability and have tended to be ignored in empirical estimation. Malizia and Ke suggested that the empirical literature has been lax regarding modeling the relevant economic regions.

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<sup>2</sup> Cowell (1987) provides an equation describing a “generalized entropy family”:

$$I(e) = \frac{1}{a^2 - a} \left[ \frac{1}{n} \sum_{i=1}^n \left( \frac{e_i}{e} \right)^a - 1 \right]$$

where  $-8 = \alpha = +8$ ,  $n$  is the number of regions in the study area,  $e$  is the activity (e.g., income or employment) in region  $i$ , and  $e$  is the activity's average. The Atkinson or Theil diversity indices can be generated from this equation.

### **Type of Industries Measures**

The next three measures focus on the type of industries present in the region rather than the variety of industries. These measures are the percent durable good ( $P_i$ ), location quotient ( $LQ_s$ ), and shift-share ( $SS_i$ ):

$$P_i = \frac{e_{id}}{e_i} \cdot 100 \quad (5)$$

$$LQ_s = \frac{\frac{e_{si}}{e_i}}{\frac{e_s}{e}} \quad (6)$$

$$SS_i = G_i - R_i \quad (7)$$

$$G_i = e_{it} - e_{i0}$$

$$R_i = \left( \frac{e_t}{e_0} \right) \cdot e_{i0} - e_{i0}$$

where  $e_{id}$  is activity in durable manufacturing within the  $i^{\text{th}}$  region,  $e_{it}$  and  $e_{i0}$  denote the activity in the  $i^{\text{th}}$  region in time  $t$  and time  $0$ , and  $e_t$  and  $e_0$  denote the activity at the national level in time  $t$  and time  $0$ .

The quantity demanded of a durable good is sensitive to changes in income; a small percentage increase (decrease) in income results in a larger percentage increase (decrease) in the quantity demand of durable good. An assumption of a region's stability is related to the demand for its exports. Given this assumption and the relationship between changes in income and demand for durable goods, the percent of durable goods in a region's export mix are used as a measure of diversity (Siegel et al. 1995b).

If a region's economic growth is driven by export demand, then identifying those industries is important. Industries whose  $LQ$  are greater than one are defined to be basic. That is, they have either employment or income in a greater proportion than the nation. The excess employment or income is assumed to generate exports. An assumption of using location quotients is that local and national demand and supply functions are identical. However, if there are differences between local and national demand, then the excess employment might be used to satisfy local needs and not for export. In addition, if production technology is different between the local and national level, then this would account for the excess employment. Furthermore,  $LQ$  are sensitive to the level of aggregation used. An industry defined using a 2-digit Standard Industrial Classification (SIC) Code may have a  $LQ$  less than one; however, using a 4-digit SIC code, the  $LQ$  is greater than one. Finally, the level of cross-hauling can impact the  $LQ$ . Cross-hauling occurs when a commu-



nity produces a good for export at the same time as it imports the same good for local consumption (Shaffer 1989).

Shift-share analysis is used to examine the growth rate of a given region relative to some base economy, usually the nation. If the shift-share of the  $i^{\text{th}}$  region is positive (negative) then the region grew at a rate faster (slower) than nation. Shift-share disaggregates growth into two major components. The first is the actual total regional growth ( $G_i$ ), see equation (7). The second is the regional share ( $R_i$ ), see equation (7). This component measures the region's growth if the region had grown at the national average. It is this component of shift-share analysis that can be used to examine diversity.

The regional share can be further disaggregated into two components. The first is the proportional shift and the second is the differential shift. The proportional shift examines the growth from the mix of industries present in the region. The differential shift examines the growth rate of the region's individual industries to the national growth rate of the same industries. If the proportional shift is positive, then this may be interpreted as an indicator of a diverse set of industries. Conversely, if the proportional shift is negative, then this may be interpreted as an indicator of a specialized economy.

There are several limitations associated with shift-share analysis. I will discuss only two. First, shift-share analysis is a descriptive tool based on historical data. This method does not provide any insight into the reasons for the growth changes; therefore, one should not forecast regional growth using shift-share. Second, the arbitrary selection of the beginning and ending years for estimating  $G_i$  and  $R_i$  in equation (7), peak versus trough years, may alter the results.

A more recent approach by Akpadock (1996) uses three models to derive the multiple-model replicants (MMR) technique. Akpadock (1996) defines the MMR as consisting "of the shift-share, Lorenz curve, and the Gini coefficient models. Each sub-model of MMR has its unique statistical interpretations capable of replicating the results of the others by which an analyst can verify the existence or lack of diversification trends." The MMR technique can be critiqued in two fronts. First, the MMR technique uses a shift-share model; a review of shift-share models is provided in the preceding paragraph. Second, the Lorenz Curve measures the inequality in the distribution of employment or income (Nicholson 1978). Inequality is measured with respect to the ideal of an equal number of employees in each industry or an equal distribution of income. The Gini coefficient is a scalar summary of the Lorenz Curve and is also a measure of inequality (Nicholson 1978). The Lorenz Curve and the Gini coefficient suffer the same criticisms as the entropy measures discussed in previous section.

Finally, the type of industries measures also suffer from some of the same criticism as those in the previous section (e.g., the criticism of Kort

1981, Smith and Gibson 1987, Malizia and Ke 1993, and Wagner and Del-ler 1998).

### **Portfolio Measure**

An approach advanced by Conroy (1972 and 1974), Brown and Pheasant (1985), and Hunt and Sheesley (1994) 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 (1959) and Sharpe (1970). Conroy viewed regional and local policies designed to promote economic growth and diversity as 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, in creating a “community industrial portfolio” (Conroy 1974, p32). This framework focuses on the individual industry’s net returns, the stability of these net returns, and the covariance of these net returns between industries within the portfolio.<sup>3</sup> This combination provides a measure of the relationships “among elements of the portfolio which is possibly a key element in the analysis of the diversification of that portfolio” (Conroy 1974, p32).

As outlined by Markowitz (1959), and later by Conroy (1972 and 1974) and Brown and Pheasant (1985), 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 from  $N$  industries to maximize:

$$MP = \beta \sum_{i=1}^N w_i E_i - \sum_{i=1}^N \sum_{j=1}^N w_i w_j \text{cov}(E_i, E_j) \quad (8)$$

subject to

$$\begin{aligned} \sum w_i &= 1; \forall i \\ w_i &\geq 0 \end{aligned} \quad (9)$$

where  $w_i$  is the proportion of the portfolio invested in industry  $i$ ;  $E_i$  is the expected return from industry  $i$ ;  $\text{cov}(E_i, E_j)$  is the covariance between the expected return of industry  $i$  and  $j$ ; and  $\beta$  is a positive constant that indicates a preference between growth and stability.<sup>4</sup>

<sup>3</sup> Net returns are viewed as economic growth rates of either employment or income.

<sup>4</sup> 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.

A scalar measure of portfolio variance is given by:

$$V = \sum_{i=1}^N \sum_{j=1}^N w_i w_j \text{cov}(E_i, E_j) \quad (10)$$

This has been used as a measure of economic diversity; the lower the variance the more diversified the regional economy (Siegel et al. 1993a and 1995b). The relationship between industries is based on a linear association between their net returns; namely, the  $\text{cov}(E_i, E_j)$ . The  $\text{cov}(E_i, E_j)$  shows the degree to which the growth of employment or income move, in the same or opposite directions, between endogenous industries. The  $\text{cov}(E_i, E_j)$  term of equations (8) or (10) does not account for the flow of locally produced inputs between the two endogenous industries either directly or through intermediate industries. Two industries in a region whose economy is growing may have a  $\text{cov}(E_i, E_j) > 0$  and may not be linked through the flow of locally produced inputs. Therefore, this measure would make no allowances for the economic effects of these indirect interrelationships or linkages between the endogenous industries.<sup>5</sup> In addition, Siegel et al. (1995b) state that regions may not have the same degree of control over a regional economy as an investor has over his or her portfolio of investments. Finally, the expected value,  $E_j$ , and variance covariance matrix,  $\text{cov}(E_i, E_j)$ , are calculated using time series data (Brown and Pheasant 1985). This implies the portfolio measure is dynamic not static like the previous measures.

### ***Input-Output Measures***

Siegel et al. (1993a, 1994, 1995a, and 1995b) and Wagner and Deller (1998) describe diversity using an alternate approach. They assert that the complexity of regional diversity can be best captured by using input-output (I-O) models. More specifically, these authors concentrate on the  $(I-A)^{-1}$  and  $(I-A)$  matrices of the I-O model, respectively.<sup>6</sup> They suggest that by accounting for the interindustry linkages, as described by the regional input coefficient matrix, explicitly, they capture more fully the structure and performance of the regional economy.

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<sup>5</sup> 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, growth and stability are treated simultaneously.

<sup>6</sup> The  $(I - A)^{-1}$  matrix is defined as the Leontief inverse matrix where I denotes the identity matrix and A denotes the regional input coefficients matrix. The regional input coefficients matrix reflects the way in which local firms use local inputs (Miller and Blair 1985).

Siegel et al. (1993a) describe a conceptual model using the following equations:

$$E(\cdot) = (I - A)^{-1} E(f_{t+1} - f_t) \quad (11)$$

and

$$V(\cdot) = [(I - A)^{-1}] V(f) [(I - A)^{-1}]^T \quad (12)$$

where  $E(\cdot)$  measures expected growth (e.g., output),  $(I - A)^{-1}$  is the Leontief inverse,  $f$  is a vector of sectoral final demands at times  $t+1$  and  $t$ ,  $V(\cdot)$  is a variance-covariance matrix that measures economic stability, and  $V(f)$  is a variance-covariance matrix of sectoral final demands. In a latter version, Siegel et al. (1994 and 1995a) describe a model that allows both the vector of final demand,  $f$ , and the  $(I - A)^{-1}$  matrix to be stochastic. While variance may be due to the cross-sectional nature of the data (e.g., firms are not necessarily homogenous for a given SIC category), measurement error in gathering the data (e.g., firms providing incorrect information), or time-series nature of the data (e.g., firms change production technology over time), the variances in both models are functions of time (Siegel et al. 1993a and 1995a).

While equations (11) and (12) do not provide a direct diversity measure, Siegel et al. feel that their model provides an analytical “framework to analyze the relationship between changing economic structure and performance, which is ostensibly the issue addressed by the previous studies on economic diversity and diversification.” Unfortunately, methods that rely on some aspect of the variance-covariance matrix to capture economic performance are not independent of stability itself thus not lending themselves to subsequent statistical tests of the hypothesis linking diversity with growth and stability (Wagner and Deller 1998). In addition, defining variance as a function of time implies this measure is also dynamic not static.

Wagner and Deller (1998) define a diversity index as a function of three components that describe the  $(I - A)$  matrix. Each of these three components is measured relative to some base economy. The first is a measure of the types of industries present in the economy (i.e., the number of industries present in the region). An economy with only a handful of similar industries is less likely to absorb a shock than an economy composed of many different types of industries.<sup>7</sup> The first component,  $SI_i$ , is the total number of industries in the  $i^{\text{th}}$  region divided by the total

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<sup>7</sup> This component counts the number of industries (not firms) with different SIC codes. An assumption of this scalar is that firms within a given SIC code level are homogenous. Empirically, this may not be the case. The intent of this component is to identify the number of heterogeneous industries within the regional coefficients matrix.

number of industries in the base economy. If the base economy has more industries, then  $0 < SI_i < 1$ .

The size of an economy does not provide a measure of the degree that a regional economy imports its inputs. This is captured by the second component; a measure of the density of the (I-A) matrix. A nonzero element in the (I-A) matrix denotes a purchase of a locally produced input by a local industry; a zero element implies the opposite. Economies described by a relatively high number of zero elements in the (I-A) matrix are more open and have fewer interindustry linkages. The second component,  $DEN_i$ , is defined as the sum of the absolute values of the (I-A) of the  $i^{\text{th}}$  region divided by the sum of the absolute values of the (I-A) of the base economy. If the base economy imports fewer inputs, then  $0 < DEN_i < 1$ .

However, the density measure does not provide an estimate of the linkages among industries. The third component captures the flow of locally produced inputs between local industries. The condition number of a matrix is a measure of linear independence between the rows and columns (Golub and Van Loan 1983). For example, an identity matrix of any size has a condition number equal to one identically. A matrix with nonzero off diagonal elements will cause the condition number to be greater than one. The nonzero off diagonal elements of the (I-A) matrix implies purchases of locally produced inputs or interindustry linkages. Therefore, the condition number of the (I-A) matrix should increase as the interindustry linkages of the economy increase. The third component,  $C_i$ , is defined as the condition number of the (I-A) matrix of the  $i^{\text{th}}$  region divided by the condition number of the (I-A) of the base economy. If the base economy has more interindustry linkages than the  $i^{\text{th}}$  region, then  $0 < C_i < 1$ .

Wagner and Deller (1998) combine these three components in a multiplicative diversity index ( $MDI_i$ ) and an additive diversity index ( $ADI_i$ ) of the  $i^{\text{th}}$  region:

$$MDI_i = SI_i \cdot DEN_i \cdot C_i \quad (13)$$

$$ADI_i = (w_1 \cdot SI_i) + (w_2 \cdot DEN_i) + (w_3 \cdot C_i) \quad (14)$$

$$\sum_{j=1}^3 w_j = 1$$

where the  $MDI$  and the  $ADI$  of the base economy equals one. If the base economy is defined as more diverse than the  $i^{\text{th}}$  region, then  $0 < MDI_i \leq 1$  and  $0 < ADI_i \leq 1$ . The  $MDI$  and  $ADI$  are static measures of diversity.

Wagner and Deller (1998) also provide a critique of their index. The first is that by using the (I-A) matrix, their index is insensitive to industry output levels. If two regions appear identical in all aspects of the (I-A)

matrix, but the first has a high percentage of total output in risky industries, then the relatively specialized region may be less stable in the economically important sense. The second is that I-O models are by definition static, while the policy question of diversification is dynamic. However, Wagner and Deller (1998) argue that the intent of this type of analysis is to address the association between a given level of diversity with growth and stability, or whether a given level of diversity at time  $t$  affects growth and stability in time  $t + i$ .

The last model is a combination of a portfolio measure and an I-O model. Wundt and Martin (1993) describe the model as a constrained optimization problem:

$$\text{Min } s^2 = x(V)x' \quad (15)$$

subject to

$$\begin{aligned} TE &= \sum_{i=1}^n x_i \\ (I - A)x &\geq f \end{aligned} \quad (16)$$

where  $\sigma^2$  is a scalar measure of the portfolio variance or the variance of industry employment,  $x$  is a vector of industry employment,  $V$  is a variance-covariance matrix,  $TE$  is total employment, the  $(I - A)$  matrix is converted to represent employment rather than input requirements, and  $f$  is a vector of final demands converted to employment. The objective of the model is to minimize the variation in overall state employment and to provide policy makers with a slate of candidate industries to expand that would promote employment stability. The variance of industry employment,  $\sigma^2$ , is the measure of instability that is minimized (Wundt and Martin 1993).

The variance-covariance matrix, as with the portfolio measure, is calculated using time series data; while the I-O component is static. Using the static I-O component implies that the structure of the economy and its production technology are constant for the given time series (Wundt and Martin 1993). For marginal contractions or expansions of the economy this implication seems tenable. However, diversification policies seem to imply changing the structure of a region's economy. The diversification policy would dictate whether or not this structural change is marginal.

Wundt and Martin's (1993) model provides a constrained dynamic or quasi-dynamic measure of diversification. Siegel et al. (1993a and 1995b) state that the portfolio variance, equation (10), has been used as a measure of economic diversity; the lower the variance the more diversified the regional economy. In this case  $\sigma^2$ , in equation (15), defines that

variance. On the other hand, Wundt and Martin (1993) define the same variance as a measure of instability to be minimized. These statements are compatible since economic development policy of diversification follows from the theory that stability is achieved through diversity. Consequently, minimizing instability implies a more diversified regional economy. As with the portfolio measure and the model described by Siegel et al. (1993a, 1994, 1995a, and 1995b), this measure is not conducive to statistical hypothesis testing because the diversity measure is not independent of stability by definition (Wagner and Deller 1998).

### 3. Discussion

While I have identified four broad categories for the purposes of discussing the various diversity measures, there are five other groupings of these diversity measures that are of interest. The first is measuring diversity relative to some standard. The second is using a static versus dynamic measure. The third is using diversity indices as an explanatory variable in examining growth and stability. The fourth is measuring diversity using a single number, or a scalar, versus a matrix in which the intersections of the rows and columns describe economic activity. The final is the computational ease for calculating each measurement versus the information received.

#### **Standard**

Diversity indices are generally calculated relative to some standard or benchmark. There are four issues that should be considered when using a standard. First, a standard is used to develop a diversity index that facilitates comparisons among the regions being examined. The yardstick that a standard provides allows statements like the  $i^{\text{th}}$  region's economy is more diverse than the  $j^{\text{th}}$  region's relative to the given standard. For example, national averages, location quotients, shift-share, and the diversity measurement proposed by Wagner and Deller (1998) all use a base economy as the standard. Often this base economy is defined as the national economy, which is identified as completely diversified.<sup>8</sup> In the case of the Ogive, Herfindalh, log-share, and any other entropy style diversity measures, the standard is an equiproportional level of economic activity in all industries. In the portfolio method and the combined portfolio I-O model, the standard is a mean-variance efficient set of industries. The approach taken by Siegel et al. (1993a, 1994, 1995a, and 1995b) does not generate a diversity measure directly. In spite of this, the standard is the policy maker's preference concerning the short-

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<sup>8</sup> In the case of the percent durable goods, the standard is the total economic activity within the region.

run goal of growth and the long-run goal of stability. However, comparing among the different diversity indices is difficult and often impossible. In some diversity indices the definition of the standard is not even the same, as is the case with a standard defined as a base economy versus equiproportional level of economic activity. For some diversity indices the definition of the standard is the same, but they are not monotonically increasing or decreasing transformations of each other; for example the Ogive index is not a monotonical transformation of the Herfindalh index.

Second, the definition of the standard must be constant for developing a given diversity index. For example, in developing the diversity measurement described by Wagner and Deller (1998), the definition of the base economy must not change during the calculations. If the standard changes, then comparisons between observations before and after the change are difficult if not impossible.

Third, the definition of the standard needs to make sense relative to the comparisons being made. For example, Malizia and Ke (1993) define diversity as “the variety of economic activity which reflects differences in economic structure” and the presence of multiple specializations; diversity implies economic structure. The structure of a regional economy is also a function of other variables; these include location, relative transportation costs and other input costs, and infrastructure, etc. (Kilkenny 1998, Nijkamp and Poot 1998, Henery et al. 1997, Barkley et al. 1996, Hughes and Holland 1994, and Waters et al. 1994). These combined variables define a region’s competitive advantage. Defining a base economy that is “diverse” implies comparing the base economy’s structure to the structure of other regional economies. For example, the structure of an urban economy will be different then that of a rural economy, in part, due to competitive advantage. Using the urban economy as the standard to define the diversity of a rural economy may be similar to using a tropical rainforest biotope as a standard for examining the ecological diversity of an alpine biotope. The standard may be too vastly different from the region being examined for the comparison to make any sense.

Finally, does the standard lead to a diversity index that satisfies the two key parts of diversity; namely, is it a static concept that examines the size, the presence of multiple specializations, and the linkages present among industries within a region’s economy? The equiproportional indices are static but only examine the size of a region’s economy. The type of industry measurements are also static but are concerned primarily with industries that satisfy export demand. The portfolio measure is a dynamic; the variance is estimated using a time series. The method proposed by Siegel et al. (1993a, 1994, 1995a, and 1995b) is also dynamic; however, it does address a regional economy’s size, presence of multiple



specializations, and linkages among industries. The method proposed by Wundt and Martin (1993) is best described as a constrained dynamic index; it also addresses a regional economy's size, presence of multiple specializations, and linkages among industries. The diversity index proposed by Wagner and Deller (1998) is static and addresses a regional economy's size, presence of multiple specializations, and linkages among industries. The last three methods use the (I-A) matrix of an I-O model to address the issue of a regional economy's size, presence of multiple specializations, and linkages among industries.

This discussion begs the question of what the standard should be when measuring diversity? Is it a real economy or a hypothetical one? How should this standard be represented mathematically? This illustrates the importance of a consistent and agreed upon definition of diversity.

### ***Static vs. Dynamic***

Diversity is static measurement, while diversification and growth are dynamic concepts. Of the diversity measures examined, only two are dynamic – the portfolio measure (Conroy 1972 and 1974 and Brown and Pheasant 1985) and the model presented by Siegel et al. (1993a, 1994, 1995a, and 1995b). The combined portfolio I-O model is described as quasi-dynamic or constrained dynamic diversity measure. A more correct description of these should be diversification measures. A common trait is that the variance, which describes the dynamic nature of the economy is a function of time. Most regional economies are not static systems; as economies grow or contract over time, their structure changes. The structural change over time could be due to natural growth/contraction, directed growth/contraction resulting from implementing a diversification policy, or both.

The policy question paraphrased from Siegel et al. (1995b) – What is the relationship between a region's changing economic structure and diversity? – is more interesting in light of how variance is measured. This is especially true when trying to determine the efficacy, in terms of growth and stability, of diversification policies. This leads to an interesting set of questions. When estimating the variance, is it possible to separate the natural variance from the diversification policy-driven variance? What is the covariance relationship between natural variance and diversification policy-driven variance? What are the regional economic implications of a positive, zero, or negative covariance?

The last question can be addressed indirectly. As was pointed out earlier, the portfolio measure uses variance as a measure of economic diversity; the lower the variance the more diversified the regional economy. By definition, using a variance-covariance matrix to capture economic performance is not independent of the concept of stability. Fur-

thermore, stability, as defined by Malizia and Ke (1993), is defined as “the absence of variation in economic activity over time.” In addition, Wundt and Martin (1993) also state the variance is a measure of instability that should be minimized. This would imply that a negative covariance between natural variance and diversification policy driven variance would be preferred. A zero covariance would imply that the diversification policy had no effect on stability. A positive covariance would imply that the diversification policy would increase instability.

### ***Diversity Indices vs. Growth and Stability***

Diversity has often been promoted as a means to achieve the economic goals of stability and growth, again a static concept versus a dynamic process. However, the intent is to associate a given level of diversity now with growth and stability some time in the future. This can be done statistically using a diversity index and measures of growth and stability. Siegel et al. (1995a) identify three sources of error: 1) cross-sectional error, 2) measurement error, and 3) time-series error. Statistically, these errors make the estimates of a random variable’s variance incorrect. In regression analysis, cross-sectional error is usually associated with heteroscedasticity, and time-series error is associated with serial correlation or temporal autocorrelation. This causes the regression parameters to be unbiased but inefficient (Johnston 1984 and Pindyck and Rubinfeld 1981). This is not only an important consideration when calculating variances associated with the diversification measures, but also important when examining the statistical relationship between a diversity index and growth and instability.

A fourth source of error not identified by Siegel et al. is spatial autocorrelation. Spatial autocorrelation is a measure of how much correlation and interdependency there is between neighboring data points (Johnston 1984 and Pindyck and Rubinfeld 1981). Again this is not only an important consideration when calculating variance associated with diversification measures, but also important when examining the statistical relationship between a diversity index and growth and instability.

There is one more concern with spatial autocorrelation: how it affects the definition of a standard, in particular, a base economy that is used to create a diversity index. Regional economies are related. This is of particular concern when dealing with contiguous economic regions. The classic example of this is the literature showing the relationships between an economic core and its periphery or between an urban and rural area (Kilkenny 1998, Nijkamp and Poot 1998, Henery et al. 1997, Barkley et al. 1996, Hughes and Holland 1994, and Waters et al. 1994). There is a spatial autocorrelation component that exists between the urban and ru-

ral economies. If the urban center is defined as the base economy or standard, then a spatial autocorrelation component exists between the two diversity index data points. A concern is whether the spatial autocorrelation is explained or the causes of the spatial autocorrelation are unexplained. The concern is primarily unexplained spatial autocorrelation. Stated differently, how does the spatial association among the economies affect the spatial association among diversity index data points in terms of the spatial autocorrelation of the regression errors? How does the definition of the base economy as a standard, impact this?

### ***Scalar vs. Matrix***

The only method for examining diversity that does not provide a single number or scalar diversity measure is the one proposed by Siegel et al. (1993a, 1994, 1995a, and 1995b). Jackson et al. (1990) gives two critiques of relying on a scalar measure. The first criticism states that by using a scalar representation of economic activity, there is very little knowledge gained of how this activity has created changes in the matrix representing the interactions among these industries. In the diversity measures identified under the sections entitled equiproportional, type of industries, and expected value-variance, this criticism holds. Diversity is estimated measuring only the direct effect of each industry; this translates, in mathematical terms, into a diagonal matrix whose size denotes the number of endogenous industries and the diagonal elements are scaled to represent either employment or income. The off-diagonal elements are zero; consequently, these diversity measurements do not include any interactions among the industries. The diversity measure proposed by Wagner and Deller (1998) does take the interactions among the industries into account directly by estimating the condition number of the (I-A) matrix. However, no research has been done to date that examines the sensitivity of condition number to changes in the (I-A) matrix and its effect on their diversity index.

The second criticism states that the strength of these interactions may be the most useful indicators in terms of growth. Again, for the diversity measures identified under the sections entitled equiproportional, type of industries, and expected value-variance, this criticism holds for the same reasons stated above. However, as shown by Wagner and Deller (1998), the strength of the interactions increase the size of the condition number. Again, what is not known is the sensitivity of the condition number to small changes in the interactions.

### ***Computational Ease vs Information***

The various diversity measures examined are given in order of data requirements and computational ease, with equiproportional measurements the easiest to calculate and the portfolio and I-O measurements

the most difficult. In addition, diversity measures should facilitate the short-term and long-term policy and economic development goals of growth and stability. As is stated earlier, the equiproportional and type of industry methods are used most often due to data requirements. Unfortunately, these methods are challenged both on theoretical and empirical fronts. The portfolio and I-O measures have greater data requirements and are more expensive to estimate. The methods that rely on some aspect of the variance-covariance matrix to capture economic performance are not independent of stability itself, thus not lending themselves to subsequent statistical tests of the hypothesis linking diversity with growth and stability. In addition, the measure proposed by Wagner and Deller (1998) is insensitive to industry output levels, and the sensitivity of the condition number to structural changes in a region's economy as reflected in the (I-A) matrix is unknown. However, they do show that their diversity measure is statistically related to increased growth and increased stability (although weakly).

As a result, no one methodology for calculating a diversity or diversification measure is critique free. These measures should not be view as the only variable in creating a regional development policy promoting economic growth and stability. Other variables may include location, trade, labor, relative input costs, and infrastructure, etc. (Kilkenny 1998, Nijkamp and Poot 1998, Wagner and Deller 1998, Henery et al. 1997, and Barkley et al. 1996). However, I feel that the I-O approaches are better than the others are because these approaches include the size, the presence of multiple specializations, and the linkages present among industries within a region's economy in measuring diversity and its relationship to growth and stability.

## **4. Conclusions**

There have been many historical definitions of diversity and diversification leading to a variety of diversity measures and some confusion. However, the objective of diversity and diversification is clear-- growth and stability of a region's economy. Consequently, a policy goal is to take advantage of both the benefits of economic growth and stability. Interestingly, the performance measures for evaluating the success of the policy are often growth and stability. Therefore, the relationship between diversity and growth and stability is important.

Diversity is often used in combining the short-run policy goal of growth within the long-run policy goal of stability. Unfortunately, the empirical literature examining the relationship between diversity and growth and stability is inconclusive, in part, due to the variety of diversity measures resulting from inconsistency within the literature on defin-

ing diversity. I have proposed that the two key points in defining diversity are that it is, first, a static concept that, second, examines the size, the presence of multiple specializations, and the linkages present among industries within a region's economy. Consequently, a subjective diversity measure may do more harm than good when used as the only variable to guide changes in the structure of a region's economy to satisfy the short-run and long-run goals of growth and stability, respectively.

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