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MEASURING ECONOMIC DIVERSIFICATION IN HAWAII

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It is widely held that a diversified economy is less sensitive to the ups and downs associated with any particular industry because risk is spread more evenly across a number of industries. With diversification, even if some industries are suffering, other stronger industries will help the economy maintain healthy growth. The presence of many industries would be expected to offer opportunities for employment in growing sectors to compensate for employment losses in declining sectors.

Some regional economists and policy makers regard diversification as employment insurance, with more diversified economies experiencing lower unemployment during cyclical downturns. It is also argued that the more diversified the economy becomes, the more resilient it becomes to external events and developments.

While diversity has often been promoted as a means to achieve the twin goals of economic stability and growth (Kort, 1979; Siegel et al., 1994), it has also been recognized that other aspects of a region's economic structure, such as regional comparative advantage and natural resources are also important. It is argued that indiscriminate diversification (i.e., diversity for the sake of diversity) will not necessarily bring economic growth and stability (Smith and Gibson, 1998). Akpadock (1996) also notes the concern of community development practitioners that the economic diversity does not always promote stability, economic growth and low employment.

With a demise of plantation agriculture coupled with limited potential for much further growth in tourism due to local capacity constraints as well as increased competition from emerging destinations worldwide, economic diversification continues to become a topic of increasing interest in Hawaii. The interest in diversification becomes particularly intense when uncertainties emerge over tourism and federal government activities, the two key pillars of Hawaii's economy.

Aiming to promote economic diversification and growth in order to create high paying jobs, recent development efforts in Hawaii have focused on developing high-tech, knowledge-based (computer and information related) and other emerging industries, including biotechnology, non-fossil fuel energy alternatives, ocean sciences, astronomy, and film and performing arts products. Most notable of these efforts in recent years is Act 221 passed in 2001 and amended in 2004 (Act 215), providing qualified Hawaii-based businesses with 100 percent tax credit in new investment and 20 percent tax credit in qualified research and development.

With the development of the state's Innovation Initiative and passage of Act 148 in 2007, Hawaii has embarked on a series of measures aiming to develop foundations for an innovation economy and nurturing emerging industries. The act has mandated DBEDT to create and periodically update a database which defines and measures Hawaii's emerging industries. It also tasks DBEDT to develop appropriate outcome measures to assess the effectiveness of the state's innovation initiative and other development efforts in promoting economic diversification, growth and stability in Hawaii.

Against this backdrop, this particular study looks at economic diversification and its impact on economic performance in Hawaii.

In 2008, DBEDT completed the first study analyzing economic diversification in Hawaii. The 2008 study examined the degree of economic diversification in Hawaii and examined some measures of diversity for Hawaii. This study is an update of the 2008 study using the most recent data available. Similar to the 2008 study, this study will also:

1. Estimate various measures of economic diversification, performance and stability, and examine their patterns over time for Hawaii

    a. Compare industries' share in total economic activity (employment and GDP) between Hawaii and the U.S. and determine how the state's economic structure has changed over time relative to the national economy

    b. Construct diversity rankings for the other states to compare how diversified the Hawaii's economy is relative to the nation and other states

2. Determine the impact of economic diversification on total employment and measure economic performance and stability in Hawaii

    a. Analyze the relationships between the degree of economic diversification and changes in total employment (or unemployment) in the economy

    b. Determine if increased diversification (specialization) has resulted in more economic stability (instability) in Hawaii

Defining an optimum or ideal industry mix for Hawaii would need to account for a wide range of economic, theoretical, and political issues and hence is beyond the scope of this study.

However, by relating estimated measures of diversity with some broader measures of economic growth and stability and their fluctuations over time, the report provides a potential approach to determining the effect of industry mix on economic performance.

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METHODOLOGY

There have been numerous studies by regional economists that have attempted to develop measures of economic diversity and statistically test whether changes in a region's industrial structure are related to its economic stability and performance.[1] To test these hypotheses, researchers have constructed various scalar measures of regional economic diversity using different economic theories. Similarly, various measures of economic performance and instability have also been constructed. Variability in regional unemployment or income are the most popular measures of economic stability, while the level of unemployment and real per capita income growth are commonly used to account for regional economic performance.

2.1. Measures of Economic Diversity

Different economic theories tend to result in different concepts, terms, and measures of economic diversity. Eight measures are summarized below.

Industrial Organization Theory

Under this theory, a more diversified sector (i.e., less concentrated) is assumed to be more competitive (Scherer, 1980). A region with a greater number of sectors and/or a more even distribution of economic activity is associated with higher diversity (Malizia and Ke, 1993). Based on this definition, measures of concentration ratios, such as the Ogive and the Entropy indexes, have been used as measures of economic diversity.

Following McLaughlin (1930) and Tress (1938), the Ogive index of economic diversity can be constructed as follows:

Ogive Index

$$Ogive\ Index = \sum_{i=1}^{N} \frac{\left(S_i - 1/N\right)^2}{1/N}$$

where N is the number of sectors in an economy, and S_i is the sectoral share of economic activity for the ith sector, usually expressed as the employment share.[2] The more equally a region's economic activity is distributed among its sectors, the greater the diversity (Rodgers, 1957). With N sectors, an equal distribution implies that S_i is equal to $1/N$, the ideal share for each sector, and the Ogive index equals zero, meaning perfect diversity. A more unequal distribution of sectoral activity will result in a higher value of the Ogive index. It should, however, be noted that the measure is sensitive to the level of sectoral aggregation (i.e., the chosen number of

[1] *See* Izraeli and Murphy (2003) and Siegel, Johnson and Alwang (1995) for detailed reviews of these studies.

[2] Because there is no need to inflate or deflate the data as is the case with dollar values, employment has been the most commonly used indicator of economic activity over time. Some studies have also used income and GDP.

sectors, *N*) used to organize the data. However, Grossberg (1982) and Jackson (1984) have shown that, depending on the value of *N*, a region's economic structure can be defined as being either diverse or specialized, both relative to other regions and over time.

Following Smith and Gibson (1988), the Entropy index of economic diversity can be defined as follows:

Entropy Index

$$Entropy\ \ Index = \sum_{i=1}^{N} S_i\ ln\left(\frac{1}{S_i}\right) = -\sum_{i=1}^{n} S_i\ ln(S_i)$$

where *N* is the number of sectors, S_i is share of economic activity in *i*th industry and *ln* is natural logarithm. The Entropy measure compares the existing employment or income distributions among industries in a region to an equiproportional distribution. Higher Entropy index values indicate greater relative diversification, while lower values indicate relatively more specialization. The maximum value of the measure would result with the equal distribution of employment among all industries. The minimum value of zero (maximum specialization) would occur if employment were concentrated in one industry. On the other hand, if employment were distributed equally among the *N* sectors, the Entropy index would reach its maximum value, indicating perfect diversity. Although both Ogive and Entropy indexes yield similar diversity rankings to regions, the Entropy index is the more popular measure of sectoral concentration among the regional scientists.

Herfindahl Index

The Herfindahl index, is a widely-used measure of market concentration in the industrial organization literature (Scherer, 1980), but has also been used as a measure of economic diversity (Tauer, 1992). The Herfindahl index indicates the extent to which a particular regional economy is dominated by a few firms and can be expressed as follows:

$$Herfindahl\ \ Index = \sum_{i=1}^{n} S_i^2$$

where S_i is the share of employment in the *i*th industry. The Herfindahl index varies from 0 (when the economy has a large number of industries, with small and equal employment shares – high diversity) to 1 (when one sector accounts for all economy's employment – full specialization). Thus, a decline in the index signifies less concentration in the dominant industry or greater diversification. An increase indicates more concentration in the dominant sector or greater specialization.

Thus, according to Ogive, Entropy and Herfindahl measures, the more equal distribution of employment among a large number of industries mean higher level of economic diversity. One limitation of these indexes is that they do not tell whether total regional employment is increasing or decreasing. For example, increased diversification may come with a decrease in

total employment, which may not be a desired outcome. Ideal would be to have increased diversity with employment gains.

Following McLaughlin (1930) and Tress (1938), it has been hypothesized that the more diverse the economic activity of a region, the more stable is its economic performance. This hypothesis has been widely tested in the literature using the Ogive, Entropy and Herfindahl indexes, but the empirical findings are not robust.

Economic Base Theory

Economic base theory (also called export base theory) views regional economic growth as being driven by exogenous final demands, primarily exports. Industries contributing to exogenous (or external) final demand are termed *basic* industries and those serving primarily endogenous (or internal) demand are termed *non-basic* industries. The distinction between a region's basic and non-basic sectors is often illuminated by calculating a location quotient (*LQ*) as follows:

$$LQ_i = \frac{Si^{\mathrm{Re}\,g}}{S_i^{US}}$$

where $i = 1, 2, \ldots N$ sectors, S_i^{Reg} is the employment share in a region's ith industry, S_i^{US} is the corresponding share for the U.S.[3] Thus, the *LQ* compares the regional share of economic activity to the corresponding share found at the national level. A *LQ* of one indicates that the share of an industry in the regional economy and the national economy are the same; a value of the *LQ* greater (or smaller) than one means that regional economy has a greater (or smaller) share of that industry in its economy than nationally.

Sectors with *LQ* greater than 1 are defined as basic (export) sectors and part of their output is assumed to be exported outside the region, while sectors with LQ less than 1 are known as non-basic sectors and their outputs are assumed to be sold within the local economy.

LQ greater than 1 is one of the most widely used measures of specialization in a given sector and industrial concentration of a regional economy. The summation of sectoral *LQ*s, also referred to as the coefficient of specialization, is used as a measure of regional specialization (Hoover and Giarratani, 1985). Similarly, the reciprocal of the sum of location quotients (*LQ*s) weighted by industry shares gives the Hachman index of economic diversity as follows:

[3] Location quotient can also be calculated in terms of both output, income or value added, but it is typically calculated based on employment because the sectoral employment data are often more readily available at the local level.

$$Hachman\ \ Index = \frac{1}{\sum_{i=1}^{N}\left[\left(S_i^{Reg} / S_i^{US}\right) \times S_i^{Reg}\right]} = \frac{1}{\sum_{i=1}^{N}\left[LQ_i \times S_i^{Reg}\right]}$$

where S_i^{Reg} is a region's share of employment in the *i*th industry, S_i^{US} is the U.S. share of employment in the *i*th industry, and *N* is the number of industries. The Hachman index is an indicator that measures how closely the region's industry employment distribution compares to that of the U.S. This measure is bounded between 0 and 1, where 1 means the region has exactly the same industrial structure as the U.S., and 0 means it has a totally different industrial structure.

Regional Business Cycle Theory

As in economic base theory, the regional economic instability in regional business cycle theory is also assumed to result from fluctuations in the demand for exports, especially those with high income elasticity of demand (such as luxury goods). It has been hypothesized that economic instability can be explained in terms of differences in the mix of stable and unstable sectors. To test this relationship, a region's share of stable or unstable sectors has been used as a measure of economic diversity.

Durable goods generally tend to have high short-run income elasticity of demand and hence it is assumed that a region will experience more cyclical fluctuations the higher the share of durable goods in its export mix or the higher the share of employment or income in durable goods sectors (Malizia and Ke, 1993). Thus, the region's employment or income share in the durable goods sectors has also been widely used as a measure of economic diversity, with a smaller share of durable goods in total economic activity indicating higher diversity or vice versa (Domazlicky, 1980).

Another hypothesis under the regional business cycle theory is that the more similar a region's sectoral composition is to that of the nation's, the higher will be the economic stability. This hypothesis is tested using the national averages index (*NAI*), calculated as follows:

$$NAI = \sum_{i=1}^{N} \frac{\left(S_i^{Reg} - S_i^{US}\right)^2}{S_i^{US}}$$

where S_i^{Reg} is the *i*th sector's share of economic activity in the region, S_i^{US} is the U.S. average of share of economic activity in the *i*th sector, and *N* is the number of sectors. As the region's share of economic activity approaches the U.S. share for all sectors, the *NAI* approaches zero. As the region's shares diverge from the U.S. economy, the *NAI* becomes increasingly larger. The *NAI* can be considered a relative measure of economic diversity because it measures the amount of disparity between the U.S. and the region's industry distributions. The NAI is accepted as a more reasonable standard with which to gauge a region's industry structure than other alternatives (Sherwood-Call, 1990).

Trade Theory

According to trade theory, economic exchange is driven by regional differences in endowments, preferences and comparative advantage. Trade theory assumes that specialization in production will lead to economic growth. Regions differ in terms of natural, human and technological resources, infrastructure and other spatial factors. Institutional factors, such as tax structure, environmental regulations, education, and labor laws can also influence regional comparative advantage.

The comparison of the economic performance of a region's industrial sectors relative to a reference economy is usually determined by using a shift-share analysis. The shift-share analysis, enables the researcher to decompose employment growth or decline (CHANGE) in a particular region over a given time period into three components: (1) the national growth effect (*NGE*), which is the amount of change in the region's total employment due to national economic factors – the change that would occur if all the industries in the region grew at the same rate as the nation, (2) the industrial mix effect (*IME*), which is the amount of change the region would have experienced had each of its industries grown at their national rates, less the national growth effect, and (3) the competitive share effect (*CSE*), which is the difference between actual change in employment and the employment change to be expected if each industrial sector grew at the national rate. These components are calculated as follows:

The national growth effect for the *i*th sector (NGE_i) can be expressed as follows:

$$NGE_i = E_i^{REG} \cdot g^{US}$$

where E_i^{REG} is the region's base year employment in the ith sector and g^{US} is the growth rate during the period of analysis for all sectors in the nation. The overall national growth effect (*NGE*) for the region can be computed as the sum of the national growth effects for all sectors as:

$$NGE = \sum_{i=1}^{N} NGE_i = \sum_{i=1}^{N} E_i^{REG} \cdot g^{US}$$

Similarly, the industrial mix effect for the *i*th sector (IME_i) can be calculated as follows:

$$IME_i = E_i^{REG} \left(g_i^{US} - g^{US} \right)$$

where g_i^{US} is the growth rate during the period of analysis for the *i*th sector in the nation and the notations have been defined above. The summation of all sectors' industrial mix effect gives the overall industrial mix effect (*IME*) for the region as

$$IME = \sum_{i=1}^{N} IME_i = \sum_{i-1}^{N} E_i^{REG}\left(g_i^{US} - g^{US}\right).$$

The IME accounts for the effect of the region's industrial composition. For example, a region with a high (low) concentration of high growth industries will have a positive (negative) industrial structure effect.

Finally, the regional competitive share effect for the *i*th sector (CSE_i) can be calculated as follows:

$$CSE_i = E_i^{REG}\left(g_i^{REG} - g_i^{US}\right).$$

Thus, overall regional competitive share effect (CSE) is obtained by summing the competitive share effects for all sectors in the region as:

$$CSE = \sum_{i=1}^{N} CSE_i = \sum_{i=1}^{N} E_i^{REG}\left(g_i^{REG} - g_i^{US}\right).$$

A positive competitive share effect implies the region's economic performance is superior to the national average.

So, combining all three effects, actual change (CHANGE) in total employment for the region can be expressed as follows:

$$CHANGE = \sum_{i=1}^{N} E_i^{REG} \cdot g^{US} + \sum_{i-1}^{N} E_i^{REG}\left(g_i^{US} - g^{US}\right) + \sum_{i=1}^{N} E_i^{REG}\left(g_i^{REG} - g_i^{US}\right)$$

Since its introduction in the 1960s (Edwards, 1967; Steed, 1967; Brown, 1969; Stilwell, 1969), the shift-share analysis has been used extensively to analyze differences between national and regional growth rates in variables, such as, employment, exports, and productivity (Andrikopoulos et al., 1990; Peh, 1999; Coughlin and Pollard, 2001; Gabe, 2009).

Portfolio Theory

Portfolio theory was originally applied to financial assets. Using the mean return as a proxy for expected returns (*E*) and the variance (*V*) as proxy of risk, the Markowitz (1959) portfolio method determines the set of mean-variance (*E*-*V*) efficient portfolios.

Conroy (1974, 1975) first proposed a portfolio-theoretic approach to analyzing economic diversification. Since then numerous studies have employed the portfolio theory for the analysis of economic diversification. If every sector is considered an individual regional investment, then the bundle of sectors can be viewed as a portfolio of investments.

For financial investments, there exists a relationship (trade-off) between their expected returns and associated risk. For a regional economy with a portfolio of sectors, one could also hypothesize a similar relationship (trade-off) between risk (economic instability) and expected returns (income, employment or output growth).

Every region is endowed with a limited set of resources, producing a stream of stochastic returns (such as income, employment and output). In this context, economic diversification aims to reduce instability in aggregate income and employment growth (returns) to the region by allocating its limited resources to the portfolio of sectors. By capturing the characteristics of individual industries and inter-industry relationships on regional growth and instability, the portfolio framework assists policy makers in developing appropriate diversification strategies which can serve the twin purpose of stimulating economic growth and stabilizing the economy. Following Markowitz (1959), a region's portfolio variance (σ_P^2) can be computed as follows:

$$\sigma_p^2 = \sum_{i=1}^{N} S_i^2 \sigma_i^2(X_i) + \sum_{i=1}^{N} \sum_{j=1, j\neq i} S_i S_j \sigma_{ij}(X_i, X_j)$$

where S_i and S_j are the shares of economic activity (employment, income or output, X) in the ith and jth sectors, σ_i^2 is the variance of economic activity for the ith sector, σ_{ij} is the covariance of economic activities for the ith and jth sectors. Thus, the portfolio variance for any given region (i.e., regional instability) is the weighted sum of the variances (individual sectors' fluctuations) and covariances (intersectoral fluctuations) for a given economic activity. Thus, the regional economic stability is not only sensitive to fluctuations of the individual sectors, but also to the correlation of fluctuations between sectors.

Some studies have used the portfolio variance as a measure of economic diversity, with a lower σ_P^2 indicating a more diversified economy (Conroy, 1974; Brewer and Moomaw, 1985; and Wundt, 1992). These studies have also claimed that, compared to other measures of diversity (the Ogive index, Entropy index, and national average index) the portfolio variance is a superior measure of economic diversity in explaining regional economic instability. However, as pointed out by Sherwood-Call (1990), it is inappropriate to use the portfolio variance to test the hypothesized relationship between diversity and instability, because the portfolio variance does not measure diversity independent of instability.

Location Theory

Location theory looks at the spatial distribution of economic activity, including the development of spatial clusters. The theory holds that the cost of production is lower in industrial clusters and this is an important reason for specialization and regional competitive advantage (Hoover and Giarratani, 1985). Economic clusters also benefit from linkages between a region's firms and sectors. However, a diverse economy with unlinked firms and sectors may also benefit from economic clusters. For example, firms and sectors having offsetting patterns of cyclical fluctuations may operate more efficiently if they are located together, thus providing some stability to an otherwise unstable situation. The mobility of labor among the firms and sectors

and a region's size are assumed to be positively related to economic stability. Earlier studies have also found a positive relationship between population mobility and economic diversity.

Economic Development Theory

According to economic development theory, economic diversification is viewed as driven by simultaneous changes in production, consumption and trade patterns (Schuh and Barghouti, 1988; Barghouti et al., 1990; and Petit and Barghouti, 1992). It has been argued that diversification may be expedited by forces of unbalanced growth, especially the faster growth of sectors with high income elasticity of demand.

To evaluate growth and instability impacts, the knowledge of the types of sectors and intersectoral linkages is needed. According to Hirschman (1989), the process of diversification can be viewed in terms of changes in an input-output (I-O) matrix. Various measures of intersectoral linkages based in the I-O matrices have been used in the literature (Deman, 1991; Jensen et al., 1991). Similarly, Wagner and Deller (1993) suggest a measure of economic diversity based on intersectoral linkages detailed in an I-O matrix.

Input-Output Model: A Unified Framework

Recognizing the need for a better framework that is capable of combining diverse viewpoints of economic diversity and performance presented above under different economic theories, Siegel et al. (1994, 1995) have developed an alternative approach based on an I-O model for the analysis of economic diversity and diversification.[4] The I-O model provides a comprehensive framework for modeling not only a region's economic structure in terms of production, consumption, and trade relationships (including the level and mix exogenous final demands), but also the region's economic performance as a direct function of its economic structure.

The I-O framework enables the researcher to compare the growth and stability impacts of different diversification strategies involving changes in the level and mix of exogenous final demands, for example, an export promotion program. It is also possible to determine similar impacts resulting from changes in input-output relationships in the I-O matrix. Import substitution is a popular diversification strategy and its impacts can be modeled using the I-O model. These impacts can be measured for the economy as a whole as well as for specific sectors. The sectoral distribution of growth and stability impacts can also be derived. This will allow policymakers to rank different policies based on their growth and stability objectives and preferences with respect to growth and stability trade-offs.

The main limitation of using this approach on a regional basis is the lack of consistent I-O tables over time. Regional input-output models (such as IMPLAN, REMI, and RIMS models) would provide the necessary data to produce the baseline relationship between economic structure and

[4] For mathematical details involved in the derivation of measures of economic diversity and instability using the I-O-based approach, see Siegel, Johnson and Alwang (1995).

performance, but the problem is the lack of time series data on exogenous final demands to estimate their expected growth and variance.

2.2. Measures of Economic Instability

Unemployment Instability Index (UII)

$$UII_t(\%) = \left| \frac{U_t - \hat{U}_t}{\hat{U}_t} \right| \times 100$$

where U_i is annual average monthly unemployment level for year t and $\hat{U}_t$ is an approximation of the long-term unemployment trend. The measure is an absolute percentage deviation of unemployment relative to its long-term trend value. Higher values of UII would indicate greater instability relative to the long-term trend. Some authors have used employment data instead of unemployment.

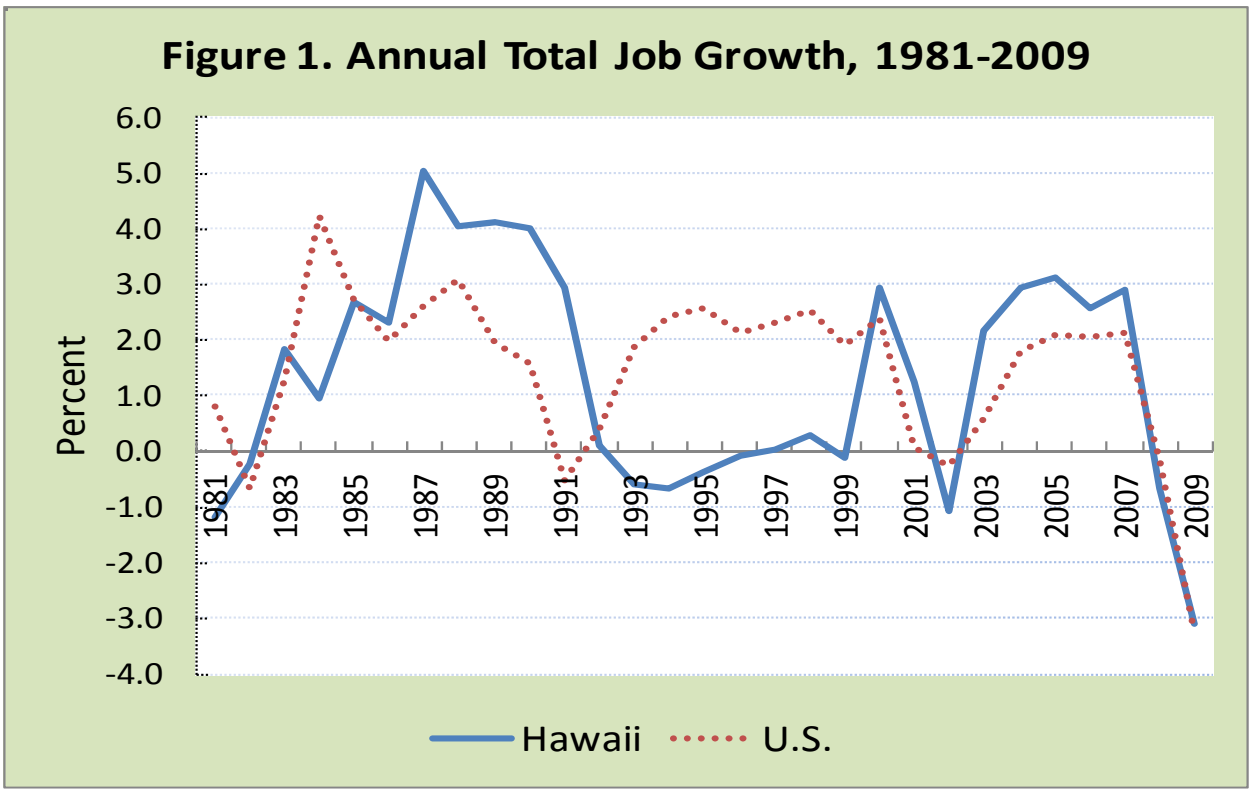
ANALYSIS AND RESULTS

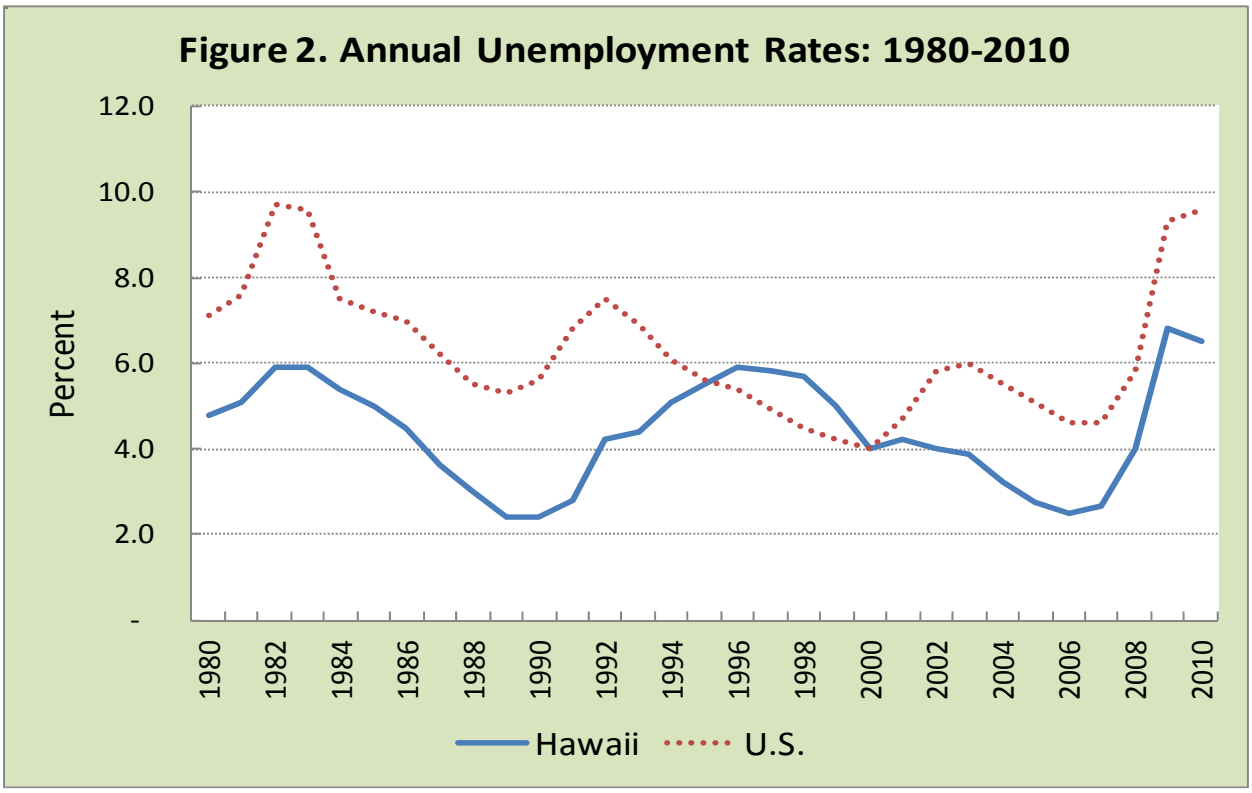
3.1. Recent Economic Trends for Hawaii and the U.S.

Most of the research on economic diversification has focused on development of measures of economic diversity and its influence on economic performance and stability. It is widely held that increased diversification leads to higher levels of economic stability and performance.

Therefore, this section examines recent trends on levels and variations of key indicators of Hawaii's economic performance, based on measures presented in the last section. Since some of the estimated measures of economic diversity for Hawaii are directly related to the overall economic structure in the U.S., the key indicators of the U.S. economy are also discussed.

Hawaii's economy went through a period of stagnation through most of the 1990s, while the U.S. economy experienced a strong growth. However, from 2001 to 2009, Hawaii has outperformed the U.S. in most of the years in several key economic indicators.





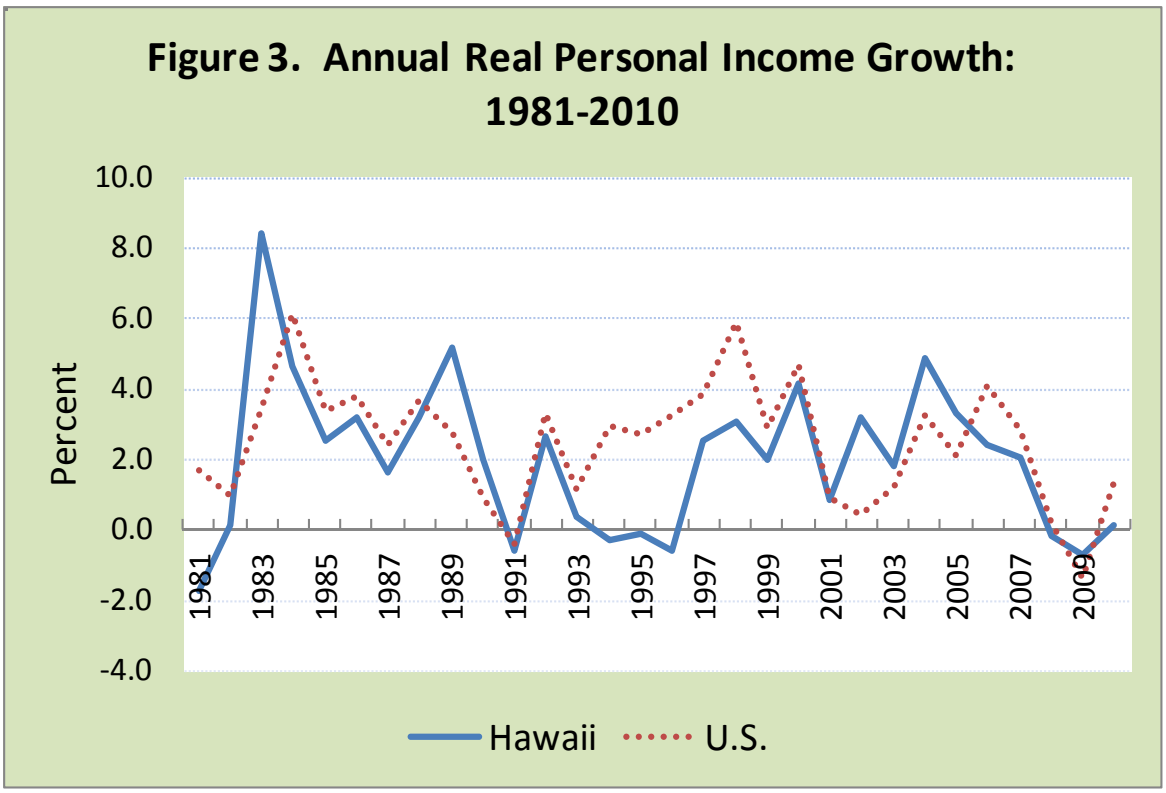
According to the U.S. Bureau of Economic Analysis (BEA) employment data, between 2001 and 2009, total jobs increased at an annual rate of 1.1 percent for Hawaii and 0.6 percent for the U.S.,

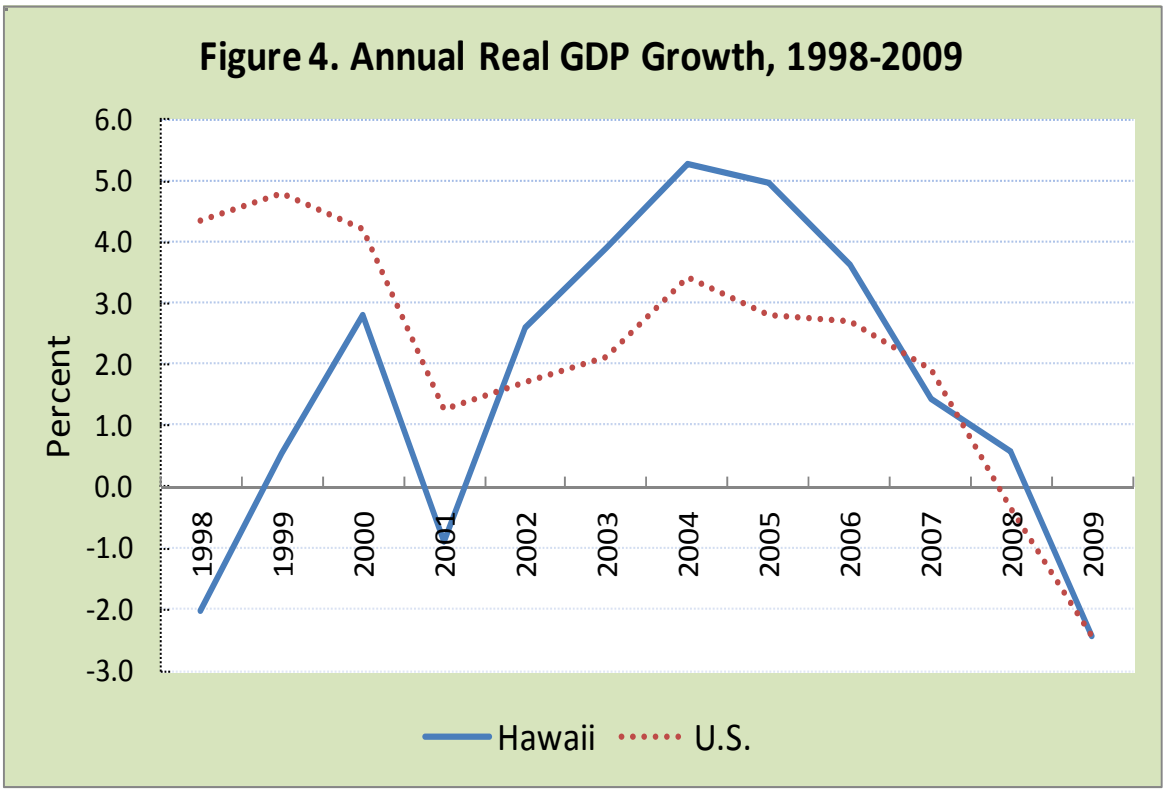
as compared to 0.6 percent and 2.3 percent, respectively, during 1995-2000 (Figure 1). This pattern was also evident in unemployment statistics from the U.S. Bureau of Labor Statistics (BLS). For example, during 2001–2010, unemployment rates averaged 4.0 percent for Hawaii, as compared to 6.1 percent for the U.S. In contrast, during 1995–2000, average unemployment rate was higher at 5.3 percent for Hawaii, compared to 4.8 percent for the U.S (Figure 2).

The above difference in Hawaii and the U.S. employment patterns was also reflected in real personal income and GDP growth. During 2001–2010, real personal income increased 1.9 percent per annum in Hawaii, compared to 1.5 percent for the U.S., while during 1995-2000 real income grew 2.2 percent per annum in Hawaii vs. 4.1 percent in the U.S (Figure 3). Similarly, during 2001–2009, real gross domestic product (GDP) (formerly gross state product or GSP) grew at an annual rate of 2.5 percent in Hawaii, as compared to 1.5 percent for the U.S (Figure 4). During 1997–2000, Hawaii real GDP increased at an annual rate of 0.4 percent, while the U.S. real GDP increased 4.5 percent[5].

Hawaii also experienced a stronger economic growth than the nation as a whole during the second half of 1980s. For example, between 1985 and 1990 total jobs increased at an annual rate of 3.9 percent in Hawaii vs. 2.2 percent for the U.S. During that period, Hawaii's unemployment rate averaged 3.5 percent as compared to the 6.1 percent unemployment rate for the nation. Real personal income increased at an average annual rate of 3.0 percent for Hawaii vs. 2.7 percent for the U.S. Thus, the data suggest some cyclical variations in economic growth for both Hawaii and the U.S. Economic diversification has been recommended to maintain economic stability.

[5] Because of a discontinuity in data due to the adoption of a new methodology by BEA in estimating GDP in 1997 and thereafter, for GDP comparison, the 1997-2000 period was chosen instead of the 1995-2000 period for other indicators.





Besides the above differences in the levels of economic growth between Hawaii and the U.S., the two economies also showed notable differences with respect to measures of variation in

economic performance. For example, during 1980-2009, Hawaii's annual percentage change in total jobs (i.e. wage and salary plus proprietors' jobs) varied from a decrease of 3.1 percent to an increase of 5.0 percent, with an average change of 1.3 percent and a standard deviation of 2.0 percent. The total job change for the U.S. ranged from a decrease of 3.2 percent to an increase of 4.2 percent, with an average change of 1.5 percent and a standard deviation of 1.5 percent. Similarly, Hawaii's annual change in real personal income in the same period varied from a decrease of 1.8 percent to an increase of 8.4 percent, with an average change of 2.0 percent and a standard deviation of 2.2 percent. The annual real income change for the U.S. varied from a decline of 1.4 percent to an increase of 6.1 percent, with a mean change of 2.5 percent and a standard deviation of 1.7 percent. Thus, in terms of both annual total job and real personal income change, during 1980-2009 Hawaii appears to have experienced more variability in economic activity than the U.S. as a whole.

One of the most widely tested hypotheses in the literature is that the unemployment is more stable in a more diverse economy. However, in terms of unemployment, Hawaii's economy seems to be more stable than the U.S. For example, Hawaii's average annual unemployment rate between 1980 and 2010 ranged from a low of 2.4 percent to a high of 6.8 percent, with a period average of 4.4 percent and a standard deviation of 1.3 percent, while the U.S. unemployment rate varied from a minimum of 4.0 percent to a maximum of 9.7 percent, averaging 6.3 percent for the period with a standard deviation of 1.6 percent.

3.2. Industrial Structure in Hawaii vs. the U.S.

Because some of the estimated measures of economic diversity for Hawaii depend on the difference in industrial structure between Hawaii and the U.S. as a whole, some of the major differences between the two economies are discussed in this section.

Since the North American Industry Classification (NAICS) employment data for all U.S. states from BEA are now available only from 1990 to 2009, sectoral employment distributions between Hawaii and the U.S. are compared using the total jobs starting from that year. For 1997 and 2009, the two economies are also being compared in terms of real GDP shares by industry.

Between 1990 and 2009, the U.S. economy added about 35.5 million total jobs (a cumulative growth of 25.6 percent or an average annual growth of 1.2 percent). For Hawaii, total jobs increased by about 111,000 during that period (a cumulative increase of 15.4 percent or an annual increase of 0.8 percent). Job growth was much higher in the U.S. during 1990-2000, while the growth was higher in Hawaii during 2000-2009 (Table 1).

During 1990-2000, the U.S. industries added 27.0 million total jobs, a cumulative increase of 19.5 percent over the period (or 1.8 percent increase per annum). For the same period, Hawaii added 32,400 total jobs, 4.5 percent more than that in 1990 (i.e., an annual increase of just 0.4 percent).

Table 1. Total Employment by Sector for the U.S. and Hawaii, 1990, 2000, and 2009

	Employment (total jobs)			Cumulative change		
	1990	2000	2009	1990-2000	2000-2009	1990-2009
U.S.						
Total employment	138,330,900	165,370,800	173,809,200	19.5%	5.1%	25.6%
Farming	3,153,000	3,117,000	2,632,000	-1.1%	-15.6%	-16.5%
Forestry, fishing, and related activities	765,700	851,400	836,300	11.2%	-1.8%	9.2%
Mining	878,700	757,000	1,358,500	-13.9%	79.5%	54.6%
Utilities	755,200	621,800	600,200	-17.7%	-3.5%	-20.5%
Construction	7,333,600	9,540,300	9,505,000	30.1%	-0.4%	29.6%
Manufacturing	18,123,100	17,750,600	12,393,700	-2.1%	-30.2%	-31.6%
Wholesale trade	5,702,700	6,270,700	6,161,900	10.0%	-1.7%	8.1%
Retail trade	16,089,100	18,455,400	17,702,100	14.7%	-4.1%	10.0%
Transportation and warehousing	4,272,500	5,466,100	5,499,300	27.9%	0.6%	28.7%
Information	3,069,900	4,031,300	3,359,300	31.3%	-16.7%	9.4%
Finance and insurance	6,803,900	7,833,600	9,432,000	15.1%	20.4%	38.6%
Real estate and rental and leasing	4,385,000	5,446,600	7,534,100	24.2%	38.3%	71.8%
Professional, scientific, and technical services	7,298,600	10,023,600	11,828,800	37.3%	18.0%	62.1%
Management of companies and enterprises	1,366,300	1,801,700	1,962,600	31.9%	8.9%	43.6%
Administrative and waste services	5,803,300	9,903,100	9,939,300	70.6%	0.4%	71.3%
Educational services	2,032,000	2,825,800	3,923,400	39.1%	38.8%	93.1%
Health care and social assistance	11,184,900	15,026,200	18,782,100	34.3%	25.0%	67.9%
Arts, entertainment, and recreation	2,202,400	3,199,200	3,822,000	45.3%	19.5%	73.5%
Accommodation and food services	8,323,100	10,574,500	12,005,100	27.1%	13.5%	44.2%
Other services, except public administration	7,555,900	8,937,900	9,882,500	18.3%	10.6%	30.8%
Government and government enterprises	21,232,000	22,937,000	24,649,000	8.0%	7.5%	16.1%
Hawaii						
Total employment	724,262	756,682	835,523	4.5%	10.4%	15.4%
Farming	14,610	12,839	11,876	-12.1%	-7.5%	-18.7%
Forestry, fishing & related	4,371	4,553	3,538	4.2%	-22.3%	-19.1%
Mining	420	500	1,181	19.0%	136.2%	181.2%
Utilities	2,987	2,822	3,613	-5.5%	28.0%	21.0%
Construction	42,691	32,746	43,034	-23.3%	31.4%	0.8%
Manufacturing	22,875	19,362	16,917	-15.4%	-12.6%	-26.0%
Wholesale trade	21,008	20,272	21,607	-3.5%	6.6%	2.9%
Retail trade	84,367	85,523	83,368	1.4%	-2.5%	-1.2%
Transportation & warehousing	27,252	28,640	27,678	5.1%	-3.4%	1.6%
Information	12,659	14,000	11,079	10.6%	-20.9%	-12.5%
Finance & insurance	27,940	25,567	29,389	-8.5%	14.9%	5.2%
Real estate	29,522	30,640	38,035	3.8%	24.1%	28.8%
Professional & technical	31,750	35,809	45,166	12.8%	26.1%	42.3%
Mgt. of companies & enterprises	4,353	5,911	7,203	35.8%	21.9%	65.5%
Administrative & waste services	33,054	45,346	53,681	37.2%	18.4%	62.4%
Educational services	9,699	14,052	18,953	44.9%	34.9%	95.4%
Health care & social assistance	45,658	58,327	72,381	27.7%	24.1%	58.5%
Arts, entertainment & recreation	15,706	19,743	21,857	25.7%	10.7%	39.2%
Accommodation & food services	85,405	91,412	94,869	7.0%	3.8%	11.1%
Other services	36,205	42,622	49,137	17.7%	15.3%	35.7%
Government	171,730	165,996	180,961	-3.3%	9.0%	5.4%

Source: U.S. Bureau of Economic Analysis

During 2000-2009, the nation's industries added 8.4 million total jobs, a total increase of 5.1 percent for the period (0.6 percent per annum), while Hawaii's industries added about 78,800 total jobs, a 10.4 percent growth for the period (1.1 percent growth per annum).

Although total jobs increased, several individual sectors experienced significant job decreases in both the U.S. and Hawaii between 1990 and 2009 (Table 1). The largest decrease was in manufacturing, which lost more than 5.7 million total jobs (-30.2 percent) in the U.S. and nearly 6,000 jobs (-26.0 percent) in Hawaii. Most of the U.S. manufacturing decline occurred during 2000-2009, while about 60 percent of Hawaii's manufacturing job losses occurred during the 1990s. Another sector that experienced significant job losses in both Hawaii and the U.S. between 1990 and 2009 was farming, lost 521,000 jobs (-15.5 percent) in the U.S. and 2,700 jobs (-18.7 percent) in Hawaii, respectively. Forestry, fishing, hunting and related activities in Hawaii and utilities in the U.S. also experienced significant job losses during 1990-2009, lost 19.1 percent and 20.5 percent, respectively. Information also lost about 1,600 total jobs (-12.5 percent) in Hawaii.

A more detailed comparison of sectoral employment distributions between Hawaii and U.S. provides further insights into differences in the industrial structure between the two economies. In terms of shares in total employment, the manufacturing sector was much larger in the U.S, while the government sector was relatively much larger in Hawaii although both of these gaps have narrowed over time.[6] Certain tourism-related sectors, most notably accommodation and food services and to some extent arts, entertainment and recreation had larger shares in total employment in Hawaii than in the U.S. The employment shares in the rest of the sectors were more or less similar between the U.S. and Hawaii.

Between 1990 and 2009, the U.S. and Hawaii both saw increasing shares of services-producing private sectors in total employment, while the share of the goods-producing sectors (i.e., farming and manufacturing) has decreased. The share of construction sector increased slightly in the U.S., but decreased slightly in Hawaii.

Interestingly, the overall share of the private services sector in total employment was almost the same for Hawaii and the U.S, increasing from about 63-65 percent in 1990 to about 69-70 percent in 2009. Within the services sector, the share of accommodation and food services in total employment in Hawaii was almost twice the corresponding share for the U.S.

The manufacturing sector's share in total employment decreased from 13.1 percent in 1990 to 7.1 percent in 2009 for the U.S. and from about 3.2 percent to 2.0 percent for Hawaii. Similarly, the farming share decreased from 2.3 percent to 1.5 percent for the U.S. and from 2.0 percent to 1.4 percent in Hawaii (Figures 5 & 6).

[6] This is due to a larger federal government share in Hawaii than in the U.S.

Figure 5. Employment Shares by Sector for Hawaii and the U.S., 1990

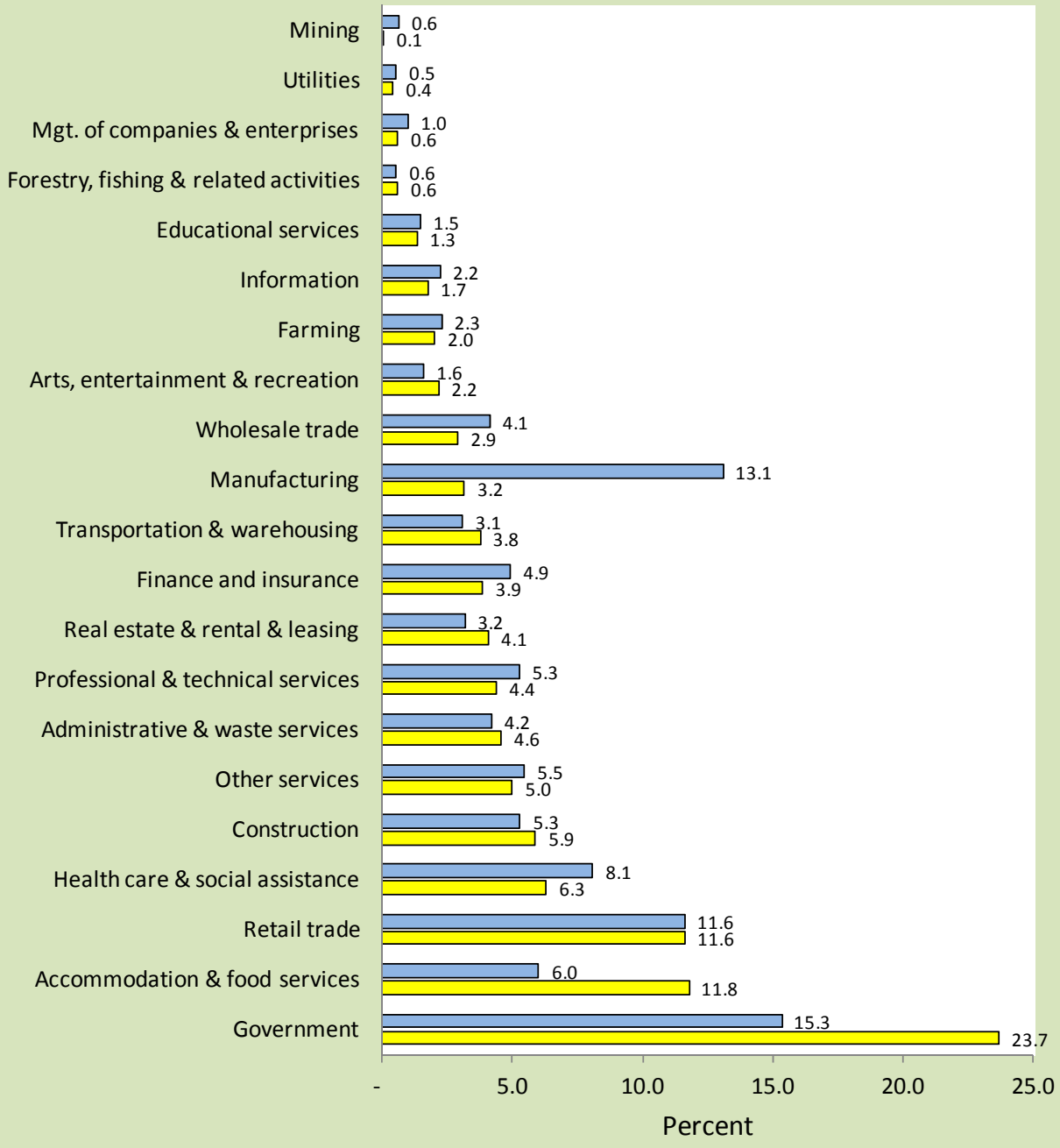
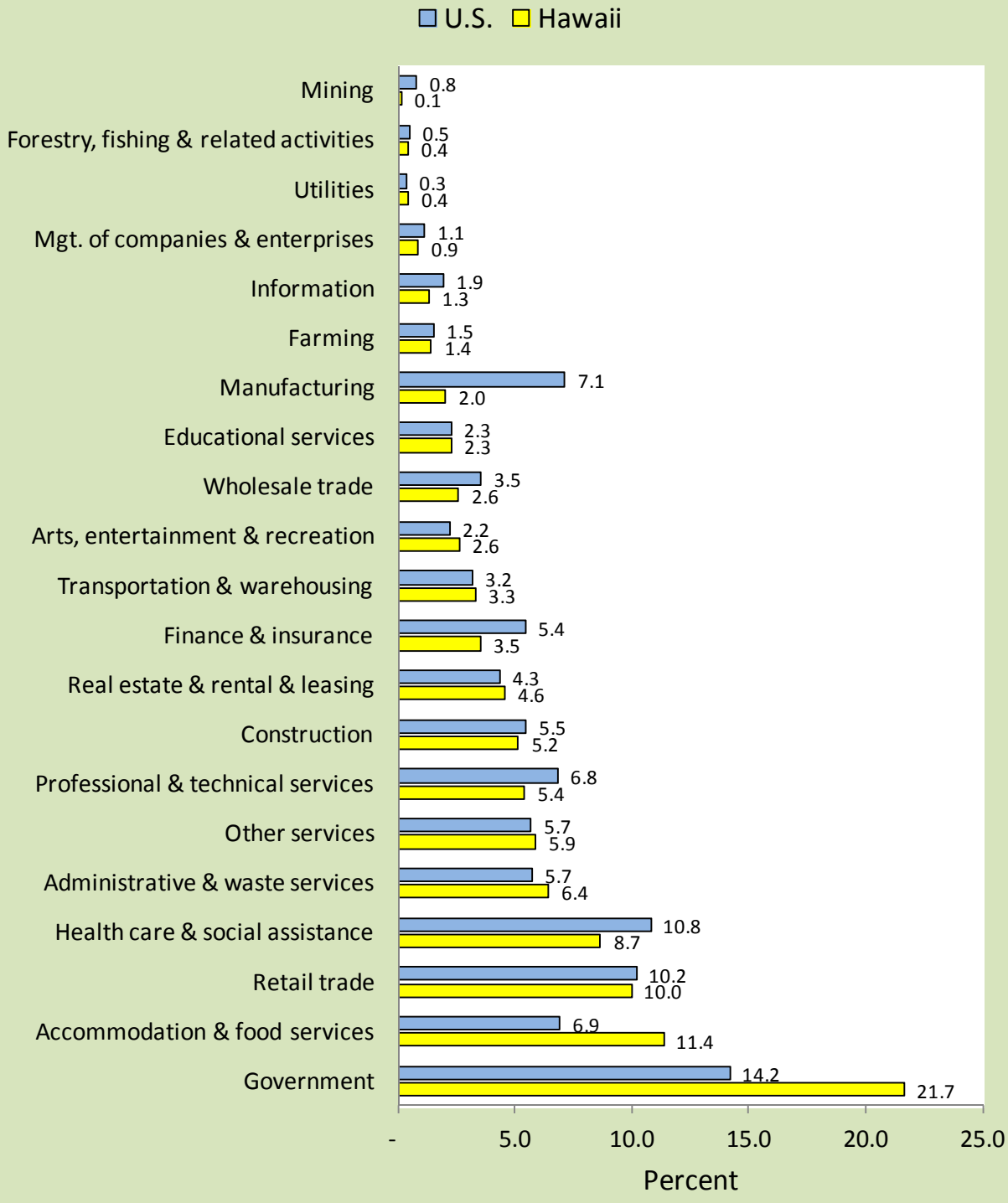
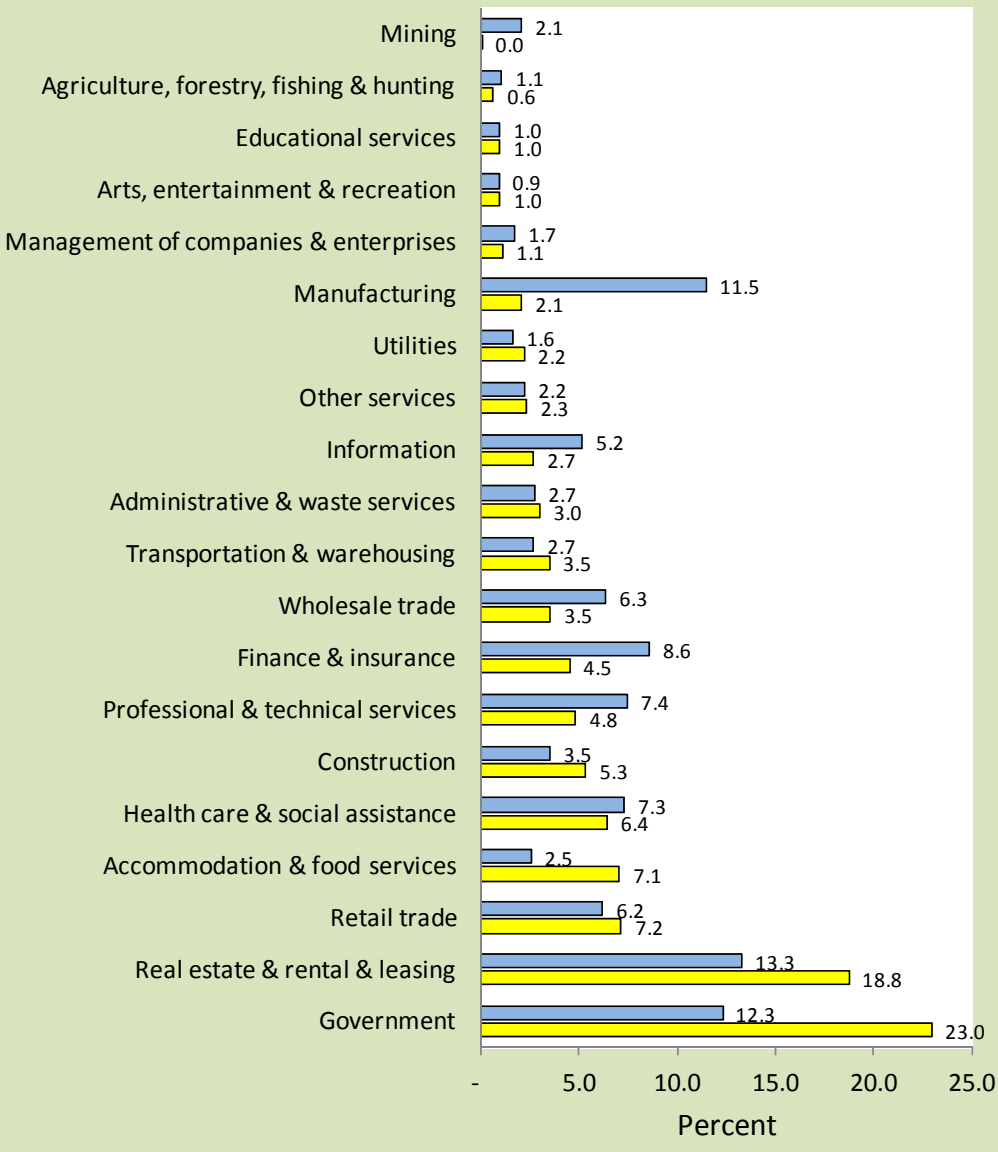


Figure 6. Employment Shares by Sector for Hawaii and the U.S., 2009



The industrial distributions of 2009 real GDP in the U.S. and Hawaii shown in Figure 7 can be used to compare shares of industries in total employment relative to total GDP. Notably, in 2009, the share of real estate in real GDP was 3-4 times higher than that sector's share in total employment. One of the reasons for this is the inclusion of imputed value of owner-occupied dwellings in total GDP even if it makes no contribution to total employment. Similarly, the GDP share of the utilities sector was 4-5 times higher than their respective employment share. On the other hand, the GDP shares of accommodation and food service and retail trade were considerably smaller than their respective employment shares. This could perhaps be due to higher proportions of part-time jobs and generally lower wages in these sectors. For other sectors, the GDP shares were comparable to employment shares in both Hawaii and the U.S.

Figure 7. Real GDP Shares by Sector for Hawaii and the U.S., 2009

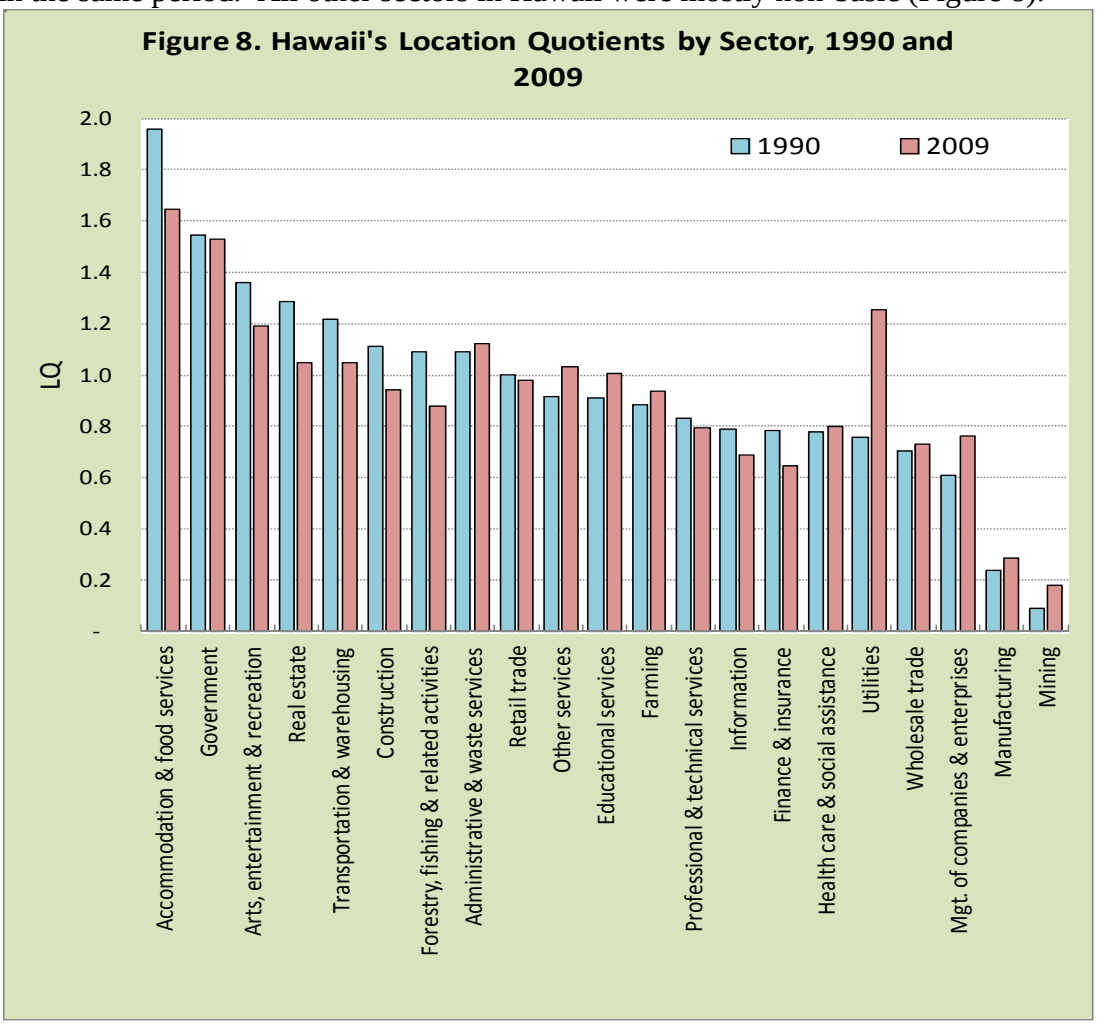


3.3. Location Quotients (LQ)

As mentioned previously, location quotients (LQs) are used as a tool to target industrial sectors to promote regional economic growth by expanding exports. The LQs are calculated as industries' employment shares for a region divided by the corresponding industries' shares in the U.S. as a whole. A LQ greater than 1.0 indicates a higher local employment concentration of an industry relative to the U.S. Sectors with a LQ greater than 1.0 are known as basic sectors and it is assumed that part of their output is exported outside the region. Sectors with a LQ less than 1.0 are defined as non-basic sectors and part of their regional demand is expected to be met by imports. Values less than 1.0 indicate a lower local employment concentration in that industry. The LQ greater than 1 suggests a comparative advantage, while LQ less than 1 suggests a comparative disadvantage.

As expected, most of the tourism-related sectors, including accommodation and food service, arts, entertainment and recreation, real estate, and transportation were found to be basic sectors in Hawaii. Because of large federal government activity, the government sector also had a LQ of greater than one. While construction, forestry, fishing & related activities switched from basic sectors in 1990 to non-basic sectors in 2009, utilities changed from a non-basic to a basic sector in the same period. All other sectors in Hawaii were mostly non-basic (Figure 8).

Figure 8. Hawaii's Location Quotients by Sector, 1990 and 2009



3.4. Measures of Economic Diversity for Hawaii

In this report, 1990-2009 BEA data on total jobs (wage and salary plus proprietors' jobs) by industry were utilized to compute the various indexes of economic diversity for Hawaii.[7] Since most indexes are sensitive to the number of industries used in the analysis, two levels of industrial aggregation were used.[8] To see changes in diversification patterns over time within Hawaii, the indexes were computed using 74 sectors for each year between 1990 and 2009. However, to compare Hawaii with other U.S. states, the indexes were calculated using 21 sectors for 1990, 2000 and 2009.[9]

Among the various indexes proposed under different economic theories presented in Section 2 of this report, the Entropy and Hachman indexes were computed. The Entropy index comes from the industrial organization theory and no reference economy is involved in its calculation. The Hachman index originates from the economic base theory. Since the Hachman index tells how similar or dissimilar a regional economy is relative to the national economy, this index is perhaps a more suitable measure for comparing diversity among regions or states.

As discussed earlier, the manufacturing sector accounts for a much smaller share of total economic activity in Hawaii than in the U.S. This is one of the major sources of disparity in industrial structure between Hawaii and the overall U.S. Given this disparity, it may not be appropriate in measuring Hawaii's economic diversity relative to the U.S. economy or other states. In order to overcome this, the above measures of diversity were also computed by excluding the manufacturing sector.

The results of the above analyses are presented below. First, changes in diversification patterns are examined for Hawaii, followed by rankings of U.S. states in terms of economic diversity. The hypothesis that diversity leads to economic stability is also examined.

Entropy Index

The results from the calculations of Entropy index of economic diversity for Hawaii are shown in Figures 9 and 10. The results for 21 sectors are shown in Figure 9 and those for 74 sectors are shown in Figure 10. Also shown in the figures are the results without the manufacturing sector.

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[7] 1990 is the earliest year for which employment data by NAICS industry are available from BEA. One could calculate the diversity indexes for earlier years using the data by SIC industry, but such results would not be comparable.

[8] Simply by the definition/construction of most indexes, the higher the number of industries, *ceteris paribus*, more diverse the economy is. Intuitively, the economy with more industries is considered more diverse than with fewer sectors.

[9] The number and type of industries were simply based on industry observations that had non missing data. When all the states were considered together, the data had more industries with missing data and needed to be aggregated and hence fewer sectors to include in the analysis. However, when Hawaii was considered alone, more industries had complete information and hence more sectors in the analysis.

Figure 9. Entropy Index of Diversification for Hawaii (21 Sectors), 1990-2009

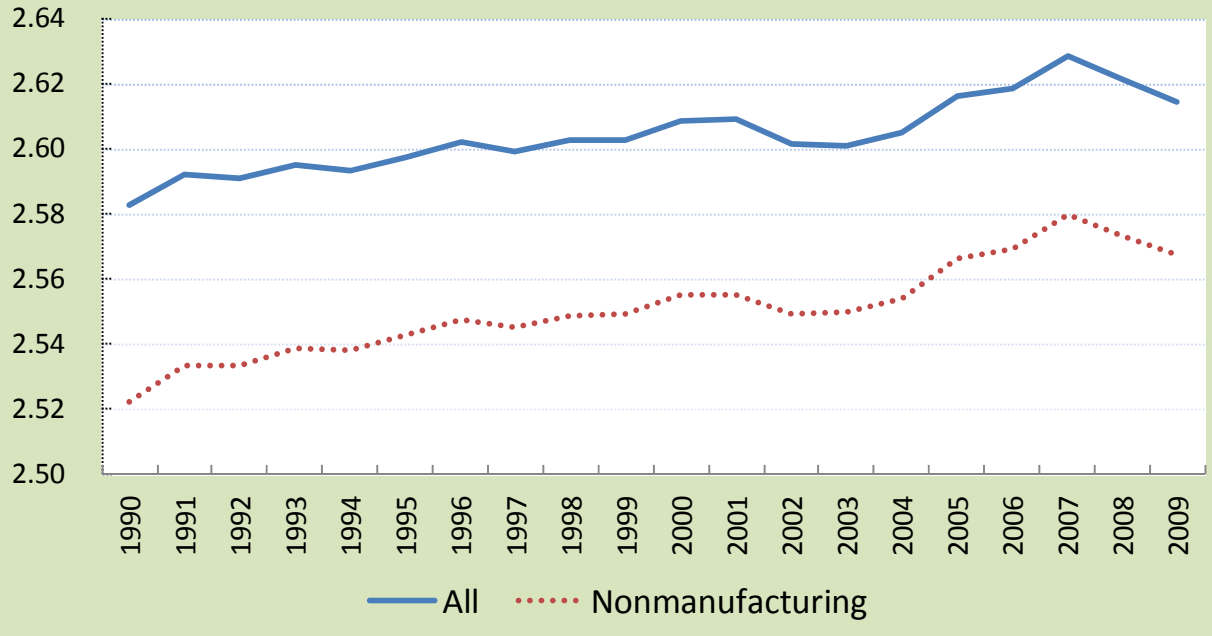
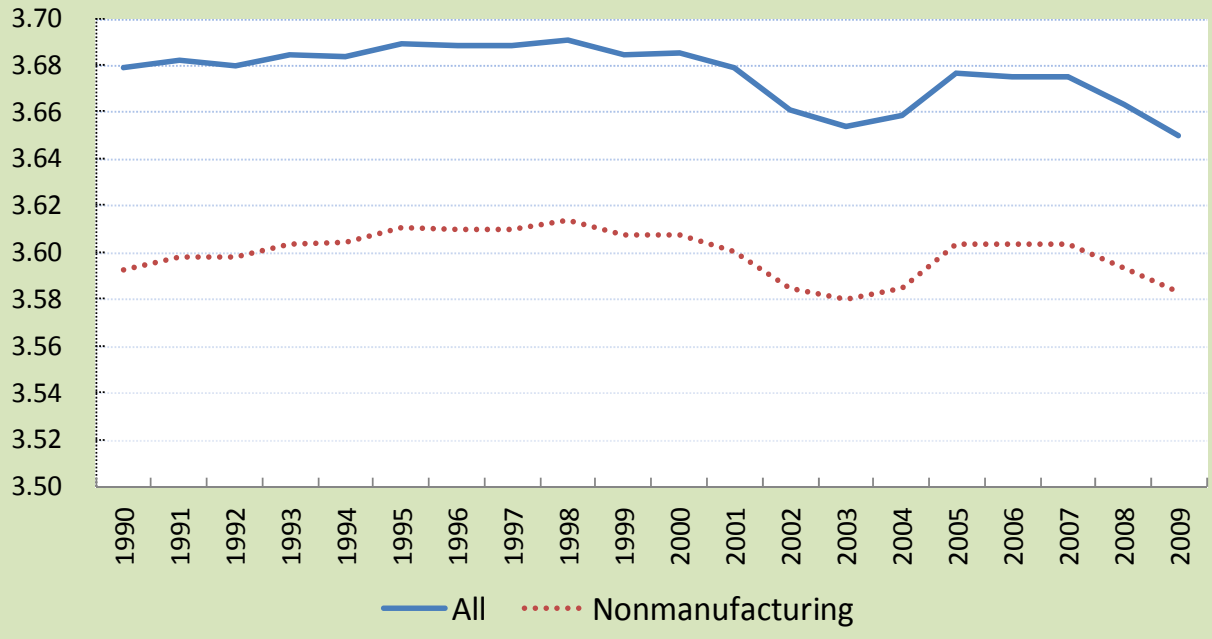


Figure 10. Entropy Diversification Index for Hawaii (74 Sectors), 1990-2009



As can be seen from the figures, in all cases the Entropy values were estimated to be substantially larger than zero (the Entropy value of zero would imply the maximum specialization), indicating that Hawaii's economy is a fairly diversified economy. The increasing trends of the estimated Entropy values based on 21 sectors suggest that Hawaii's economy appears to have become more diversified over time. In other words, the sectoral shares of the 21 sectors in total economic activity have become more equitable.

Because the Entropy index is directly proportional to the number of industrial sectors, higher the number of sectors, higher will be value of the Entropy measures. Thus, as expected, the estimated Entropy measures were somewhat higher for 74 sectors than those for 21 sectors. For the same reason, the exclusion of the manufacturing sector caused the index to decrease. However, the behavior of the estimated Entropy indexes bases on 74 sectors over time was different from that of the Entropy trend based on 21 sectors. The trends of the estimated Entropy values based on 74 sectors decreased slightly from 1990 to 2009. In other words, the sectoral shares of the 74 more detailed sectors in total economic activity have become slightly less equitable over time.

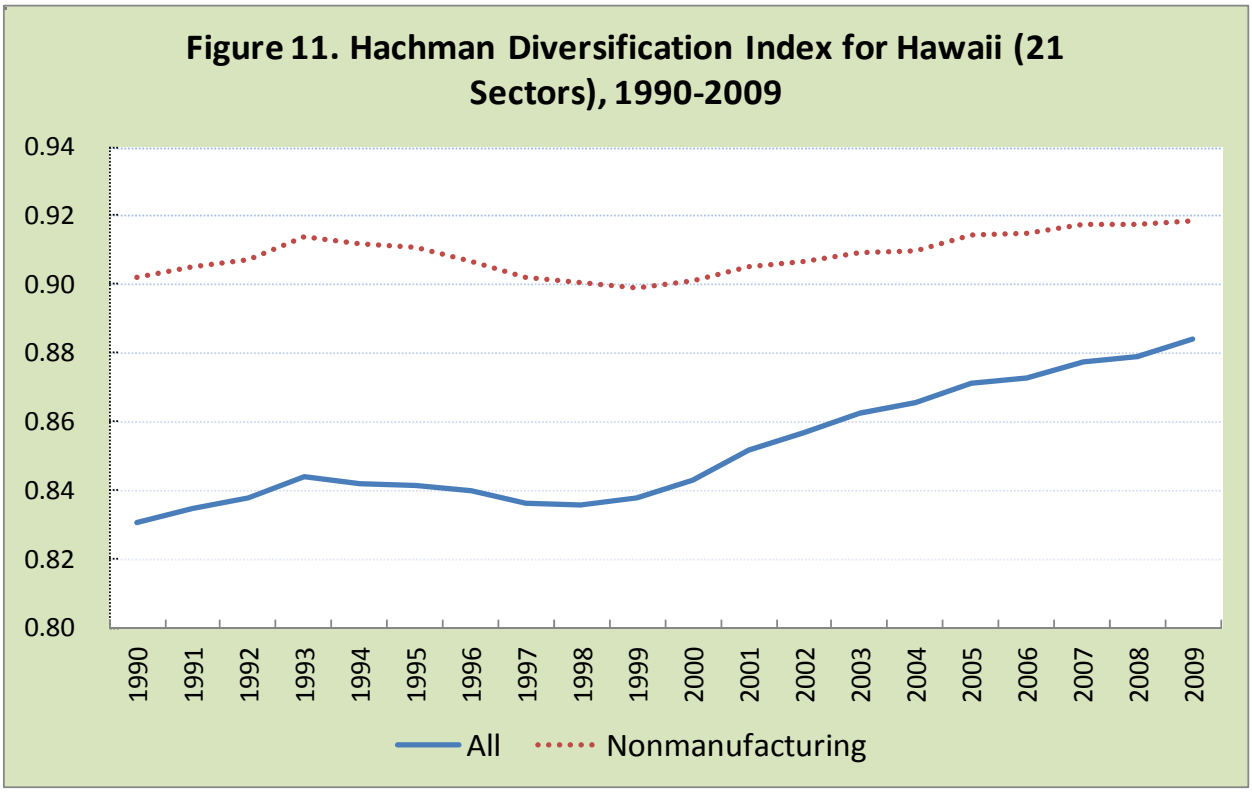
Hachman Index

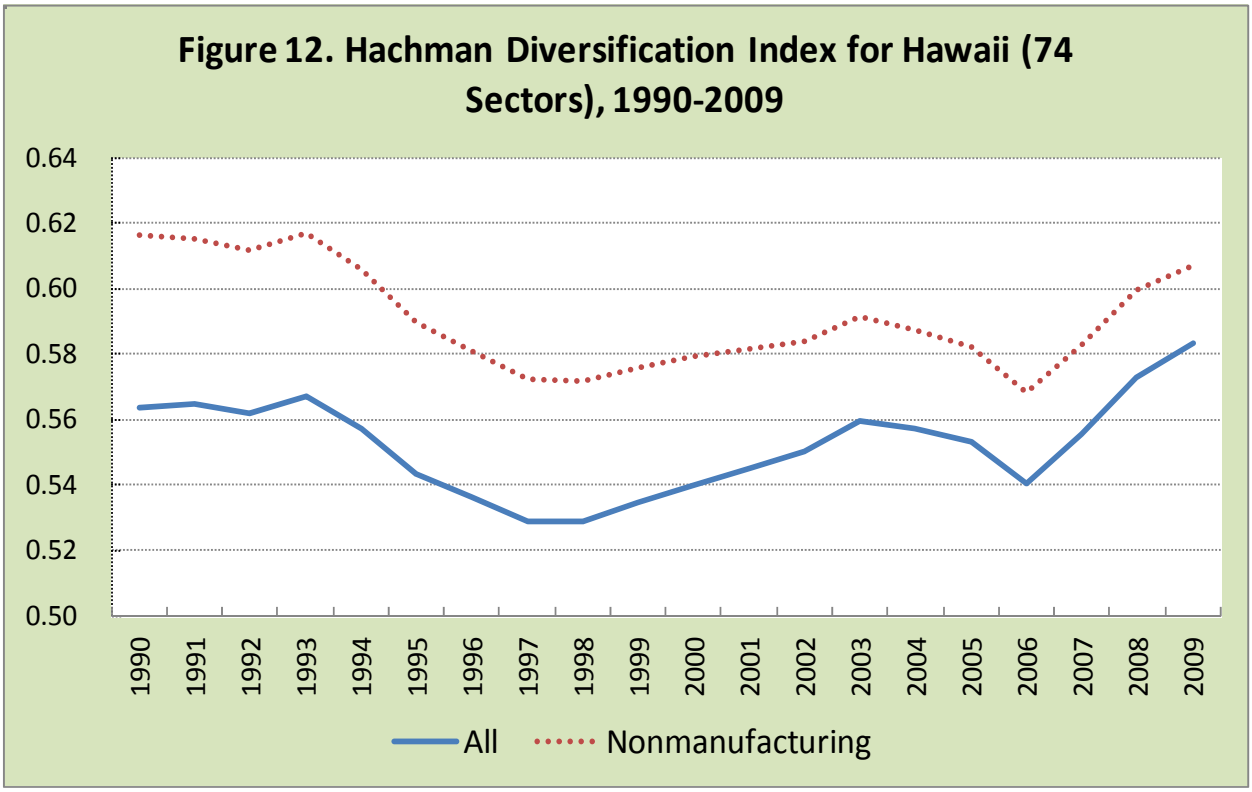
While the Entropy index for a region only accounts for that region's industrial structure, the Hachman index accounts for disparity between the economic structure of a region and that of a reference economy. In estimating the Hachman measure of economic diversity for a state or a region, it has been a standard practice to use the U.S. as the reference economy.[10] The Hachman index shows how similar or dissimilar a given region's economic structure is relative to that of the U.S. Hachman Index values closer to one would mean that the region's economic structure is very similar to that of the nation. Values closer to zero would mean that the region has a very different industrial structure as compared to the nation.

Figure 11 shows the results for the Hachman index of economic diversification for Hawaii for 21 sectors, while Figure 12 shows the corresponding results for 74 sectors. In both cases, the estimated Hachman values were closer to one than to zero, meaning that Hawaii's economic structure is relatively similar to that of the U.S. as a whole. As expected, the disparity diminished when the economy was represented in terms of 21 sectors (more aggregation) and it increased when the computations involved 74 sectors (less aggregation). As expected, excluding the manufacturing sector also reduced the disparity, thereby causing the Hachman value to increase.

Similar to the Entropy index based on 21 sectors, the Hachman index based on 21 sectors also exhibited an upward trend over time, especially from 1998 to 2009. However, the Hachman index based on 74 sectors mainly exhibited a cyclical pattern, decreased from 1993 to 1998, increased from 1998 to 2003, decreased again from 2003 to 2006, and increased again from 2006 to 2009.

[10] Studies involving counties have also used the state as the reference in computing the Hachman index.





States Diversity Rankings

Both the Entropy and Hachman indexes were calculated for all U.S. states for 1990, 2000, and 2009 and state diversity rankings were determined for each of those years. Due to data limitations, as mentioned earlier, the state rankings were based on 21 sectors. In order to make Hawaii more comparable with other states, calculations were also performed without the manufacturing sector.

As shown in Table 2, based on the Entropy index Hawaii appeared to be one of the five least diversified states in the U.S. Hawaii ranked 46th in 1990, 49th in 2000 and 50th in 2009. Excluding the manufacturing sector, Hawaii ranked 49th in 1990, 2000, and 2009 in Entropy rankings.

The states' diversity rankings based on the Hachman index are presented in Table 3. Ranked 42nd in both 1990 and 2009 and 44th in 2000, again Hawaii appeared to be one of 10 most dissimilar economies compared to the overall structure of the U.S. economy. Excluding the manufacturing sector improved Hawaii's ranking to 33rd in 1990, 40th in 2000, and 37th in 2009.

Impact on Economic Instability

In order to test the hypothesis that increased diversity would reduce economic instability, two regression analyses were employed in this report. The first was a time-series regression to estimate the relationship between economic diversity and instability in Hawaii. For that, annual deviations of unemployment rate relative to its long-term trend were computed using the annual average unemployment rate data and regressed on the annual estimates of diversity indexes. Consistent with several previous studies, the results did not show significant relationships.

The second analysis involved testing the above relationship using the results for all the states. This cross sectional regression analysis was to estimate the relationship between the states' deviations of unemployment rates in 2000 and 2009 relative to the average unemployment rate between 2000 and 2009 and the diversity indexes for 2000 and the 2009. The results also did not show significant relationships. However, the coefficients between the size of GDP and diversity measures were positive and significant, suggesting that larger states are more diverse than their smaller counterparts.

Table 2. Entropy Index of Diversification for the U.S. States, 1990, 2000 and 2009 (21 sectors)

	1990		2000		2009	
	Index	Rank	Index	Rank	Index	Rank
United States	**2.709**		**2.740**		**2.756**	
Alabama	2.589	45	2.646	44	2.692	39
Alaska	2.551	49	2.630	46	2.615	49
Arizona	2.692	17	2.713	19	2.724	24
Arkansas	2.641	31	2.680	32	2.734	18
California	2.733	4	2.774	1	2.769	4
Colorado	2.740	1	2.760	2	2.773	2
Connecticut	2.660	28	2.697	25	2.707	32
Delaware	2.692	16	2.704	23	2.688	42
District of Columbia	2.197	51	2.272	51	2.246	51
Florida	2.715	8	2.723	15	2.731	21
Georgia	2.683	21	2.727	12	2.735	15
Hawaii	**2.583**	**46**	**2.609**	**49**	**2.614**	**50**
Idaho	2.683	22	2.727	13	2.735	16
Illinois	2.703	11	2.728	11	2.749	9
Indiana	2.605	43	2.641	45	2.702	34
Iowa	2.661	27	2.693	28	2.729	23
Kansas	2.695	14	2.713	20	2.740	13
Kentucky	2.680	24	2.692	30	2.732	20
Louisiana	2.722	6	2.730	10	2.743	10
Maine	2.639	33	2.679	33	2.689	41
Maryland	2.638	34	2.656	40	2.658	47
Massachusetts	2.688	20	2.718	18	2.717	27
Michigan	2.623	40	2.651	43	2.707	31
Minnesota	2.734	3	2.743	7	2.761	5
Mississippi	2.556	48	2.630	47	2.675	43
Missouri	2.726	5	2.754	3	2.760	6
Montana	2.691	19	2.724	14	2.743	11
Nebraska	2.693	15	2.732	9	2.751	8
Nevada	2.595	44	2.590	50	2.644	48
New Hampshire	2.641	32	2.673	37	2.706	33
New Jersey	2.683	23	2.713	21	2.717	26
New Mexico	2.630	36	2.665	38	2.669	46
New York	2.702	12	2.720	17	2.714	29
North Carolina	2.566	47	2.652	42	2.701	35
North Dakota	2.615	41	2.693	29	2.733	19
Ohio	2.627	39	2.676	36	2.722	25
Oklahoma	2.716	7	2.733	8	2.742	12
Oregon	2.712	9	2.753	5	2.771	3
Pennsylvania	2.679	25	2.710	22	2.740	14
Rhode Island	2.606	42	2.660	39	2.699	37
South Carolina	2.546	50	2.611	48	2.674	44
South Dakota	2.643	30	2.697	26	2.716	28
Tennessee	2.628	37	2.694	27	2.729	22
Texas	2.735	2	2.753	4	2.775	1
Utah	2.705	10	2.747	6	2.760	7
Vermont	2.702	13	2.704	24	2.700	36
Virginia	2.635	35	2.681	31	2.674	45
Washington	2.691	18	2.721	16	2.734	17
West Virginia	2.674	26	2.677	35	2.689	40
Wisconsin	2.627	38	2.653	41	2.712	30
Wyoming	2.657	29	2.678	34	2.695	38

Table 3. Hachman Index of Diversification for the U.S. States, 1990, 2000 and 2009 (21 sectors)

	1990		2000		2009	
	Index	Rank	Index	Rank	Index	Rank
Alabama	0.947	18	0.953	17	0.956	18
Alaska	0.583	49	0.649	48	0.716	49
Arizona	0.966	9	0.959	11	0.972	9
Arkansas	0.897	34	0.904	37	0.912	38
California	0.978	2	0.974	6	0.976	6
Colorado	0.954	13	0.944	22	0.957	17
Connecticut	0.931	27	0.945	20	0.947	20
Delaware	0.937	23	0.930	27	0.937	26
District of Columbia	0.557	51	0.566	50	0.591	50
Florida	0.940	21	0.926	30	0.955	19
Georgia	0.974	4	0.982	1	0.979	2
Hawaii	**0.831**	**42**	**0.843**	**44**	**0.884**	**42**
Idaho	0.845	41	0.896	40	0.926	32
Illinois	0.981	1	0.981	2	0.982	1
Indiana	0.938	22	0.924	31	0.935	27
Iowa	0.852	40	0.897	39	0.895	40
Kansas	0.929	28	0.944	21	0.926	31
Kentucky	0.883	37	0.919	32	0.933	28
Louisiana	0.884	36	0.908	36	0.912	39
Maine	0.903	33	0.915	33	0.922	35
Maryland	0.934	25	0.938	24	0.945	21
Massachusetts	0.908	32	0.913	34	0.917	37
Michigan	0.967	7	0.956	13	0.979	3
Minnesota	0.961	10	0.974	5	0.963	13
Mississippi	0.890	35	0.903	38	0.919	36
Missouri	0.967	6	0.968	8	0.975	7
Montana	0.807	44	0.842	45	0.874	43
Nebraska	0.878	38	0.913	35	0.928	30
Nevada	0.599	48	0.647	49	0.761	47
New Hampshire	0.952	15	0.950	18	0.958	16
New Jersey	0.952	16	0.954	16	0.959	14
New Mexico	0.863	39	0.880	41	0.892	41
New York	0.932	26	0.930	28	0.941	24
North Carolina	0.922	30	0.957	12	0.978	5
North Dakota	0.675	47	0.765	47	0.814	45
Ohio	0.955	12	0.968	9	0.973	8
Oklahoma	0.823	43	0.849	42	0.733	48
Oregon	0.951	17	0.969	7	0.959	15
Pennsylvania	0.967	8	0.964	10	0.965	12
Rhode Island	0.921	31	0.926	29	0.931	29
South Carolina	0.928	29	0.938	25	0.942	23
South Dakota	0.748	46	0.827	46	0.862	44
Tennessee	0.947	19	0.956	14	0.969	10
Texas	0.936	24	0.946	19	0.924	34
Utah	0.978	3	0.980	3	0.978	4
Vermont	0.953	14	0.939	23	0.938	25
Virginia	0.956	11	0.955	15	0.945	22
Washington	0.974	5	0.978	4	0.969	11
West Virginia	0.748	45	0.843	43	0.780	46
Wisconsin	0.940	20	0.930	26	0.924	33
Wyoming	0.572	50	0.565	51	0.525	51

3.5. Shift-Share Analysis

A problem with indexes of diversification is their lack of diagnostic information. Since most diversity indexes found in the literature are aggregate measures and provide little information about the performance of individual industries, the results may have very limited use in understanding the root economic problems or formulating policy. Most of the recent literature on industrial organization and regional economics relates to shift-share analysis as opposed to computing indexes for diversity, especially during the 1970s and 1980s. By decomposing a region's sector-specific growth in economic activity into three components, namely the national effect, industrial-mix effect and competitive share effect, the shift share analysis provides much more useful information about the substructure of the regional economy and for advancing development policies.

In this report, a dynamic shift-share analysis is applied to annual total job growth between 1990 and 2009.[11] To account for different economic conditions, the study period is broken down to two sub-periods – 1990 to 2000 and 2000 to 2009.

As mentioned previously, Hawaii added 111,261 jobs between 1990 and 2009, an increase of 15.3 percent (Tables 1 and 4). Of this, 32,420 jobs were added between 1990 and 2000 (and an increase of 4.5 percent) (Table 5) and 78,841 jobs were added between 2000 and 2009 (a 10.4 percent increase) (Table 6).

As can be seen from Table 4, if Hawaii added jobs at the same pace as the overall U.S., Hawaii would have had 185,754 more jobs in 2009 compared to 1990. Except for 1990-91, 2001-2002, and 2007-2008 when the U.S. economy was in a recession, annual job growth due to national effect was positive for every year. While industrial-mix effect in Hawaii was mostly positive over the study period, the competitive share effect was mostly negative during 1991-2002, changed to positive during 2002-2007, and changed back to negative during 2007-2009.

Tables 5 and 6 present the shift-share analyses by sector. As shown by Table 5, most of the job declines in Hawaii during the 1990s was due to large negative competitive effects in several major industries, in particular construction, government and government enterprises (due to decline in federal military employment), accommodation and food services, retail trade, and administrative and waste services. All these sectors in Hawaii had substantially lower job growth relative to job growth in the same sectors for the overall U.S. The negative competitive share effects in several of these sectors were offset by the positive national effect, especially in administrative and waste services, health care and social assistance, accommodation and food services, and retail trade.

[11] Most shift-share applications to regional employment changes have examined changes between the beginning and end years of the time interval, thereby failing to account for changes in industrial mix. The results obtained from this comparative static approach can be problematic if there are significant changes in industrial structure over time. This problem can be eliminated by calculating the national growth effect, the industrial mix effect, and the competitive effect in an annual basis and then summing the results over the study period. This approach is called dynamic shit-share analysis (Barff and Knight, 1988).

Table 4. Summary of Dynamic Shift-Share Analysis, 1990-2009

	Total change	National growth effect	Industrial mixed effect	Competitive share effect
90-91	21,185	-3,760	1,918	23,027
91-92	690	2,997	2,412	-4,719
92-93	-4,357	14,086	1,794	-20,236
93-94	-5,009	18,033	709	-23,750
94-95	-2,732	19,003	78	-21,813
95-96	-643	15,584	539	-16,767
96-97	365	16,920	-464	-16,091
97-98	2,252	18,707	-451	-16,004
98-99	-850	14,165	1,659	-16,674
99-00	21,519	17,474	2,020	2,025
00-01	9,545	638	3,748	5,159
01-02	-8,169	-2,070	6,577	-12,676
02-03	16,545	4,392	3,415	8,738
03-04	22,824	14,031	1,307	7,486
04-05	24,818	16,629	123	8,066
05-06	21,088	17,027	167	3,894
06-07	24,538	18,076	405	6,056
07-08	-5,711	-1,397	950	-5,264
08-09	-26,637	221,122	4,065	-2,856
90-09	**111,261**	**185,754**	**41,743**	**-116,237**

Table 5. Dynamic Shift-Share Analysis by Sector, 1990-2000

	Change (1990-2000)	National growth effect	Industrial mixed effect	Competitive Share effect
Farm employment	-1,771	2,856	-3,023	-1,604
Forestry, fishing, and related activities	182	854	-365	-307
Mining	80	82	-140	138
Utilities	-165	584	-1,112	363
Construction	-9,945	8,345	4,501	-22,791
Manufacturing	-3,513	4,471	-4,942	-3,043
Wholesale trade	-736	4,106	-2,014	-2,828
Retail trade	1,156	16,491	-4,083	-11,252
Transportation and warehousing	1,388	5,327	2,286	-6,225
Information	1,341	2,474	1,490	-2,623
Finance and insurance	-2,373	5,462	-1,233	-6,601
Real estate and rental and leasing	1,118	5,771	1,376	-6,029
Professional, scientific, and technical services	4,059	6,206	5,648	-7,795
Management of companies and enterprises	1,558	851	536	171
Administrative and waste services	12,292	6,461	16,890	-11,059
Educational services	4,353	1,896	1,893	564
Health care and social assistance	12,669	8,925	6,756	-3,012
Arts, entertainment, and recreation	4,037	3,070	4,038	-3,071
Accommodation and food services	6,007	16,694	6,408	-17,095
Other services, except public administration	6,417	7,077	-455	-205
Government and government enterprises	-5,734	33,569	-19,778	-19,524
Total	**32,420**	**141,573**	**14,678**	**-123,832**

Table 6 shows a different picture of job growth in Hawaii during 2001-2009. Except for farming, forestry and fishing activities, manufacturing, retail trade, transportation and warehousing, and information, all other sectors experienced solid job growth during this period. While construction was the main drag for Hawaii's economic growth in the previous record, construction, along with government and government enterprises, health care and social assistance, administrative and waste services, real estate, and professional and technical services, was the main driver of Hawaii's growth in recent years. About half of the sectors had negative industrial-mix effects, some of them were more than offset by positive national and competitive share effects. Similarly, a few negative competitive effects were similarly offset by positive national and industrial mix effects.

Table 6. Dynamic Shift-Share Analysis by Sector, 2001-2009

	Change (2001-2009)	National growth effect	Industrial mixed effect	Competitive Share effect
Farm employment	-413	616	-2,335	1,306
Forestry, fishing, and related activities	-465	201	-27	-639
Mining	630	28	350	253
Utilities	902	136	-205	971
Construction	9,293	1,692	-2,767	10,368
Manufacturing	-2,748	986	-6,241	2,507
Wholesale trade	1,117	1,027	-1,256	1,346
Retail trade	-1,381	4,249	-6,824	1,194
Transportation and warehousing	-1,288	1,452	-1,340	-1,401
Information	-2,683	690	-3,031	-342
Finance and insurance	5,251	1,210	3,819	222
Real estate and rental and leasing	6,633	1,575	9,671	-4,613
Professional, scientific, and technical services	6,578	1,935	3,910	733
Management of companies and enterprises	978	312	302	364
Administrative and waste services	6,891	2,346	-715	5,260
Educational services	4,129	743	3,696	-310
Health care and social assistance	12,269	3,014	10,921	-1,666
Arts, entertainment, and recreation	2,083	992	3,112	-2,021
Accommodation and food services	3,285	4,592	5,559	-6,866
Other services, except public administration	4,713	2,228	1,728	758
Government and government enterprises	13,522	8,396	2,439	2,688
Total	**69,296**	**38,420**	**20,767**	**10,109**

3.6. Cluster Analysis

Combining information on competitive share effects of job growth from shift-share analysis in Section 3.5 with estimates on location quotients in Section 3.3 forms the basis for a cluster analysis. The cluster analysis has been widely used by development practitioners to identify a set of interrelated industries composed of firms that have competitive advantages in the region. The technique is also used to identify emerging clusters of firms that may present targets of opportunity for future development and promising sources of growth. This information is important to formulating appropriate economic development policies and programs to support the diverse needs of firms in the clusters.

The first step in the cluster analysis is to combine the results from the location quotients with the competitive share effects from shift-share analysis for all industries in the region. As discussed earlier, industries with a location quotient (LQ) greater than one are said to have a greater concentration in the region than in the nation as a whole and likely to export part of their output outside the region. Similarly, industries with positive competitive share (i.e., the growth rate in the region is above the growth rate in the nation) are believed to have competitive advantage of growing more rapidly in the region than in the nation. By combining these two descriptions that indicate strength and opportunity of growth in the region, as shown in Table 7, Hawaii's 20 private industries (i.e., excluding the government sector) could be divided into four distinct groups of industry clusters.

Industries with LQ greater than 1 and job growth in the region above the job growth in the nation (positive competitive share) are defined as growing base industries; industries with LQ greater than 1 and job growth in the region below the job growth in the nation (negative competitive share) are defined as transforming industries; industries with LQ less than 1 and positive competitive share are defined as emerging industries; and industries with LQ less than 1 and negative competitive share are defined as declining industries. It should be noted that not all growing base industries are necessarily the candidates needing targeted support.

Cluster analysis begins with an examination and refinement of industries in the growing base industry cluster (i.e., industries that are both concentrated and competitive in the state). Local industries that are both concentrated and growing only in response to local population growth, but are known not to export much outside the region, for instance the typical construction industry, should be eliminated, unless some specialized services are known to be exported outside the region. Other similar candidates for elimination would be retail trade and finance and insurance which mostly serve the needs of the local consumer base.

Because of lack of enough industry detail, some important parts of Hawaii's emerging clusters could be hidden in some larger industry categories located in other clusters. For example, the potential cluster of film and performing arts products is hidden in the arts, entertainment and recreation sector at this level of aggregation. On the other hand, some important activities, like biotechnology, may be spread out among a number of sectors such as health care and professional and technical services. Therefore, the next step in the cluster analysis is to refine this 20 sector analysis by breaking these aggregate industry groups to more detailed sectors.

Table 7. LQ and Competitive Share Analysis

	LQ 2009	Competitive Share*	Quadrant
Utilities	1.252	41	Growing Base Industry
Other services	1.034	5	Growing Base Industry
Educational services	1.005	2	Growing Base Industry
Administrative & waste services	1.124	-9	Transforming Industry
Transportation & warehousing	1.047	-27	Transforming Industry
Accommodation & food services	1.644	-33	Transforming Industry
Arts, entertainment & recreation	1.190	-34	Transforming Industry
Real estate	1.050	-43	Transforming Industry
Mining	0.181	127	Emerging Industry
Mgt. of companies & enterprises	0.763	22	Emerging Industry
Manufacturing	0.284	6	Emerging Industry
Farming	0.939	-2	Declining Industry
Wholesale trade	0.729	-5	Declining Industry
Health care & social assistance	0.802	-9	Declining Industry
Retail trade	0.980	-11	Declining Industry
Professional & technical	0.794	-20	Declining Industry
Information	0.686	-22	Declining Industry
Forestry, fishing & related	0.880	-28	Declining Industry
Construction	0.942	-29	Declining Industry
Finance & insurance	0.648	-33	Declining Industry

* Hawaii's cumulative job growth from 1990 to 2009 minus U.S. cumulative job growth from 1990 to 2009.

Discussion and Conclusions

With the decline in plantation agriculture (viz., sugar and pineapple) and limited prospects for long-term growth in the tourism sector due to local capacity constraints and increased competition from emerging destinations worldwide, Hawaii's economic development efforts continue to embrace economic diversification as a means to promote growth and stability.

This report has assessed concepts and measures of economic diversification, growth and stability. One of the objectives of the report was to develop an appropriate measure for tracking the effectiveness of development efforts on diversification and its impact on economic performance to guide and develop appropriate diversification strategies.

Several measures of economic diversity exist in the literature, with the Entropy, Hachman, and portfolio-based measures dominating empirical work. Among these measures, the Entropy and

Hachman indexes were estimated in this study using sectoral employment data from the Bureau of Economic Analysis for 1990-2009. The Entropy index defines economic diversity in terms of equality of distribution of activities across sectors in Hawaii, while the Hachman index defines it in terms of similarity in industrial structures between Hawaii and the overall U.S.

Besides computing the Entropy and Hachman indexes for each year to see changes in levels of diversity over time in Hawaii, both indexes were also estimated for all U.S. states for 1990, 2000 and 2009 and states' diversity rankings were constructed for those years to compare levels of diversity between Hawaii and other states in the U.S. Given the size of manufacturing sector as being one of the major sources of industrial disparity between Hawaii and other states, the states' diversity rankings were also computed by excluding that sector. The hypothesis of a positive relationship between industrial diversity and economic performance was tested by relating estimated diversity values for individual states with variations in their unemployment levels and GDP growth.

In terms of the values for both measures, Hawaii's level of diversity remained more or less flat over the study period. As compared to other states, as expected, Hawaii was one of the least diversified states in the U.S., both with and without the manufacturing sector. However, the results did not provide support for a positive association between levels of economic diversity and economic stability and growth. Instead, consistent with the work of Wagner and Deller (1993) using I-O models, the larger states were found to show higher levels of diversity. As noted by Wagner (2003), there is no one diversity measure that is free from critique.

As noted by Brown and Pheasant (1985), the choice of an equal distribution of activities across sectors as a reference point in calculating the Entropy measure and the use of national economy as a reference point in calculating the Hachman index are quite arbitrary, making both of these indexes sensitive to the level of industry aggregation and the choice of reference economy. Wagner and Deller (1993) assert these diversity measures are narrowly defined, usually focusing on the employment distributions across industries and failing to account for interindustry linkages and the relative size of the economy. Not specifically addressed in this report, the input-output approach has been promoted recently as a better approach because of its ability to account for interindustry linkages (Wagner and Deller, 1993; and Seigel et al., 1995). However its empirical application has still been quite limited mainly due to lack of consistent I-O data over time.

This report found that most conventional measures of economic diversity, such as Entropy and Hachman indexes, only provide an aggregate picture of industrial structure, with little or no information on the underlying economic issues that have caused the values and changes in the indexes.

The indexes also do not shed light on what industries should be targeted for recruitment, retention and expansion for promoting economic growth and stability, as opposed to promoting diversity for the sake of diversity.

In response to these concerns with the traditional measures of diversity, regional economists currently rely on other analytical tools that focus on specific industries or industry clusters,

including location quotients, shift-share analysis, and I-O models. For the same reason, location quotients and shift-share were also analyzed in this report.

Location quotients provided more information about the structure of the economy by identifying areas of specialty and concentration. Based on location quotients, as expected, most of the tourism related sectors, including accommodation and food service, arts, entertainment and recreation, real estate, and transportation were found to be more concentrated in Hawaii relative to the nation. Because of a larger federal government activity, the government sector also showed higher concentration in Hawaii. While the construction sector switched from a basic sector in 1990 to a non-basic sector in 2009, the utilities sector changed from a non-basic to a basic sector in the same period. All other sectors in Hawaii were mostly non-basic.

Another powerful diagnostic measure was found in the dynamic shift-share measure. Using shift-share analysis, job growth (or decline) in Hawaii's industries was explained in terms of three components, namely national effect, industrial-mix effect, and competitive share effect.

The results showed that negative or overall slow job growth in Hawaii in the 1990s was mostly due to large negative competitive effects in several major industries, including construction, government, accommodation and food services, retail trade, and administrative and waste services. The positive national effects more than offset the negative competitive effects in several sectors, notably administrative and waste services, health care and social assistance, accommodation and food services, and retail trade, resulting in overall positive job growth in these sectors.

The results showed a different picture of job growth in Hawaii during 2001-2009, with all three effects contributing to growth in most industries, with the exceptions of farming, forestry and fishing activities, manufacturing, retail trade, transportation and warehousing, and information.

Combining location quotients with competitive effects from shift-share analysis, the report was able to illustrate a framework for a cluster identification and analysis. Applying a similar approach to more detailed industry-level data will help to identify and facilitate understanding of emerging and growing industries or clusters of industries and to help in the formulation of appropriate development policies and programs to support their growth.

Instead of aggregate measures of economic diversity, a better approach from a policy standpoint in assessing effectiveness of such development efforts would appear to be the development of an index (such as an share in total employment) for targeted clusters of industries and to relate that to overall performance of the state's economy.

REFERENCES

Akpadock, F. 1996. Diversification trends of the regional economy of mill-town communities in northeast Ohio, 1980-1991. *Journal of the Community Development Society*, 27:177-196.

Andrikopoulos, A., J. Brox, and C. Carvalho. 1990. Shift-share analysis and the potential for predicting regional growth patterns: Some evidence for the Region of Quebec, Canada. *Growth and Change*, 21: 1-10.

Barff, A.B., and P.L. Knight III. 1988. Dynamic shift-share analysis. *Growth and Change*, 19: 1-10.

Barghouti. S., C. Timmer, and P. B. Siegel. 1990. Rural Diversification. Lessons from East Asia, World Bank Technical Paper #117. Washington, DC the World Bank.

Brewer, H.L., and R. Moomaw. 1985. A note on population size, industrial diversification, and regional instability. *Urban Studies*, 23:349-354.

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

Conroy, M.E. 1974. Alternative strategies for regional industrial diversification. *Journal of Regional Science*, 14:31-46.

Conroy, M.E. 1975. The concept and measurement of regional industrial diversification. *Southern Economic Journal*, 41:492-505.

Coughlin, C.C., and P.S. Pollard, 2001. Comparing manufacturing export growth across states: what accounts for the differences? *Review*, Federal Reserve Bank of St. Louis, Jan/Feb: 25-40.

Deman, S. 1991. Comparison of regional structures of production: A study in developing strategy. *Review of Regional Studies*, 20:60-75.

Domazlicky, B. 1980. Regional business cycles: A survey. *Regional Science Perspectives*, 10:15-34.

Edwards, J.A. 1967. Industrial structure and regional change: A shift-share analysis of the British Columbia Economy, 1961-1970. *Regional Science*, 10:307-317.

Gabe, T.M. 2009. Growth in creative occupations in U.S. metropolitan areas: A shift-share analysis. *Growth and Change*, 37: 396-415.

Grossberg, A.J. 1982. Metropolitan industrial mix and cyclical employment stability. *Regional Science perspectives*, 12:13-35.

Hirschman, A.O. 1989. Linkages. In *Economic development: The New Palgrave*, edited by J. Eatwell, M. Milgate, and P. Newman. New York: W.W. Norton and Company.

Hoover, E.M., and F. Giarratani. 1985. *An Introduction to Regional Economics.* 3rd edition. New York: Alfred A. Knopf.

Izraeli, O., and K.J. Murphy. 2003. The effect of industrial diversity on state unemployment rate and per capita income. *The Annals of Regional Science*, 37:1-14.

Jackson, R.W. 1984. An evaluation of alternative measures of regional industrial diversification. *Regional Studies*, 18:103-112.

Jensen, R.C., J.H.L. Dewhurst, G.R. West, and G.J.D. Hewings. 1991. On the concept of fundamental economic structure. In *Regional input-output modeling New development and interpretations,* edited by J.H.L. Dewhurst, G.J.D. Hewings, and R.C. Jensen. Hants, England: Avebury Academic Press.

Kort, J.R. 1979. The theory of regional economic stability differentials: Analysis, reformulation, and empirical evidence. Unpublished Ph.D. Dissertation, University of Tennessee, Knoxville.

Malizia, E.E., and S. Ke. 1993. The influence of economic diversity on unemployment and stability. *Journal of Regional Science*, Vol. 33, pp. 221-235.

Markowitz, H.M. 1959. *Portfolio Selection*, New York: Wiley Press.

McLaughlin, G. 1930. Industrial diversification in American cities. *Quarterly Journal of Economics*, 44:131-149

Peh, K.-H., and F.-C. Wong. 1999. Growth in Singapore's export markets, 1991-96: A shift-share analysis. *Asian Economic Journal*, 13:321–344

Petit, M. and S. Barghouti. 1992. Diversification: Challenges and opportunities. *In Trends in Agricultural Diversification: Regional perspectives*, edited by S. Barghouti, L. Gacbus, and D. Umali World Bank Technical Paper # 180. Washington D.C.: The World Bank.

Rodgers, A. 1957. Some aspects of industrial diversification in the United States. *Economic Geography*, 33:16-30.

Scherer, F.M. 1980. *Industrial market structure and economic performance*, Second Edition. Boston: Hougton Mifflin Company.

Schuh, E., and S. Barghouti. 1988. Agricultural diversification in Asia. *Finance and Development*, 25:41-44.

Siegel, P.B., J. Alwang, and T.G. Johnson. 1994. Toward an improved portfolio variance measure of regional economic stability. *Review of Regional Studies*, 24:71-86.

Siegel, P.B., J. Alwang, and T.G. Johnson. 1995. A structural decomposition of regional economic instability: A conceptual framework. *Journal of Regional Science*, 35:457-470.

Siegel, P.B., T.G. Johnson, and J. Alwang. 1995. Regional economic diversity and diversification. *Growth and Change*, 26:261-284.

Sherwood-Call, C. 1990. Assessing regional economic stability: A portfolio approach. *Economic Review.* Federal Reserve Bank of San Francisco, Winter:17-26

Smith, S.M., and C.S. Gibson. 1988. Industrial diversification in nonmetropolitan counties and its effect on economic stability. *Western Journal of Agricultural Economics*, 13:193-201.

Steed, G.P.E. 1967. Locational changes: A shift-share analysis of Northern Ireland's manufacturing mix. *Tijdschrift Voor Econ. Soc. Georgrailie*: 265-270.

Stilwell, F.J.B. 1970. Regional growth and structural adaptation. *Urban Studies*, 6:162-178.

Tauer, L.W. 1992. Diversification of production activities across individual states. *Journal of Production Agriculture,* 5:210-214.

Tress, R.C. 1938. Unemployment and the diversification of industry. *The Manchester School*, 9:140-152.

Wagner, J.E. 2000. Regional Economic Diversity: Action, concept, or state confusion. *The Regional Analysis & Policy*, 30:1-22.

Wagner, J.E., and S.C. Deller. 1993. A measure of economic diversity: An input-output approach. Center for Community Economic Development. Madison: University of Wisconsin-Extension, Staff Paper 93-3.

Wundt, B.D. 1992. Reevaluating alternative measures of industrial diversity as indicators of regional cyclical variations. *Review of Regional Studies*, 22:59-73.