MEASURING ECONOMIC DIVERSIFICATION IN HAWAII

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PREFACE

This report represents part of READ's efforts under Act 148 (SLH 2007) and the State's Innovation Initiative to develop information on emerging industries and measures for economic diversification, growth and stability in Hawaii. The report was prepared by Dr. Khem Raj Sharma, the Chief of Economic Research Branch, under the direction of Dr. Pearl Imada Iboshi, the Head of READ. The author is thankful to several READ's economists for their comments and feedback on the report, in particular Mr. Robert Shore, Dr. Eugene Tian, and Dr. Binsheng Li.

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1. INTRODUCTION

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 is 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 for promoting economic growth and maintaining stability. 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. Besides several other programs, 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.

To date, there has been no formal study analyzing economic diversification in Hawaii, or a study on the effect of diversification on economic performance and stability. To fill this gap, this study examines the degree of economic diversification in Hawaii and examines some measures of diversity for Hawaii. Specifically, the report will:

1. Review the relevant literature for standard approaches and methods in measuring regional economic diversification, performance and stability

2. 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

3. 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

The determination of 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.

2.   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

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

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

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

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 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:

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[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.

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:

$$LQ_i = \frac{S_i^{Reg}}{S_i^{US}}$$

where $i = 1, 2, \ldots N$ sectors, S_i^{Reg} is the employment share in a region's *i*th 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:

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

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.

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[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.

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 elasticities 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 elasticities 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 industrial mix effect (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) for is obtained by summing the competitive share effects for all sectors in the region as:

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

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, 2006).

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 elasticities 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 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.

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[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).

3.   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, in recent years, especially after 2001, Hawaii
has consistently outperformed the U.S. in several key economic indicators.

Figure 1. Annual Total Job Growth, 1980-2006

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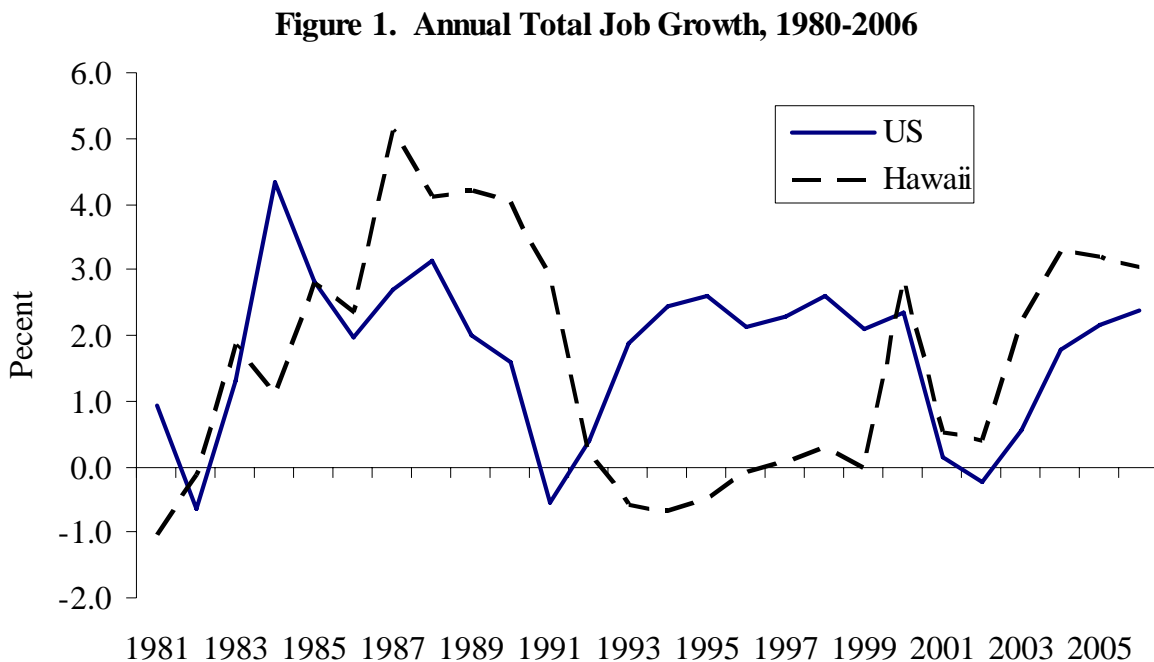
Figure 2. Average Annual Unemployment Rates (seasonally not adjusted), 1980-2006
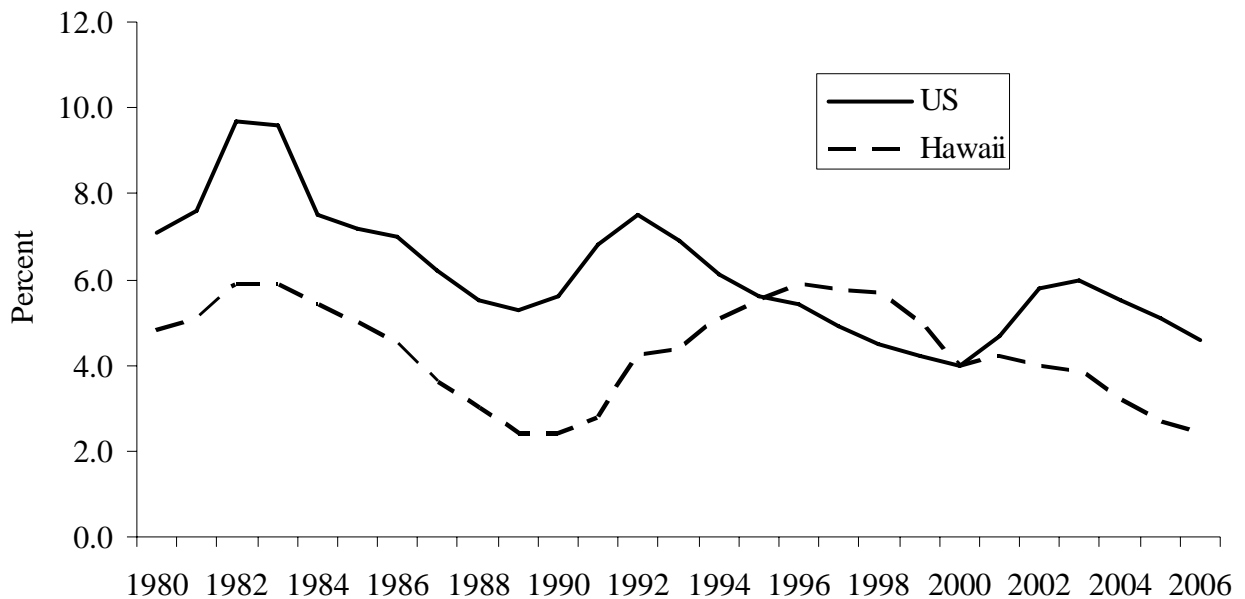
According to the U.S. Bureau of Economic Analysis (BEA) employment data, between 2001 and 2006, total jobs increased at an annual rate of 2.0 percent for Hawaii and 1.1 percent for the U.S., as compared to 0.6 percent and 2.3 percent, respectively, during 1995-2000 (Figure 1). This pattern was also evident in unemployment statistics from the U.S. Bureau of Labor Statistics (BLS). For example, during 2001–2006, unemployment rates averaged 3.4 percent for Hawaii, as compared to 5.3 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 2001–2006, real personal income increased 2.8 percent per annum in Hawaii, compared to 2.0 percent for the U.S., while in 1995–2000 period real income grew 1.9 percent per annum in Hawaii vs. 3.9 percent in the U.S (Figure 3). Similarly, during 2001–2006, real gross domestic product (GDP) (formerly gross state product or GSP) grew at an annual rate of 3.2 percent in Hawaii, as compared to 2.3 percent for the U.S (Figure 4). During 1997–2000, Hawaii real GDP declined at an annual rate of 0.2 percent, while the U.S. real GDP increased 4.2 percent[5].

As shown in Figure 3, Hawaii also experienced a much 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 4.0 percent in Hawaii vs. 2.3 percent for the U.S. During that period, Hawaii's unemployment rate averaged 3.5 percent as compared to the 6.1 percent

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[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.

unemployment rate for the nation. Real personal income increased at an average annual rate of 3.2 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.

Figure 3. Annual Real Perosnal Income Growth, 1990-2006

Figure 4. Annual Real GDP Growth, 1997-2006
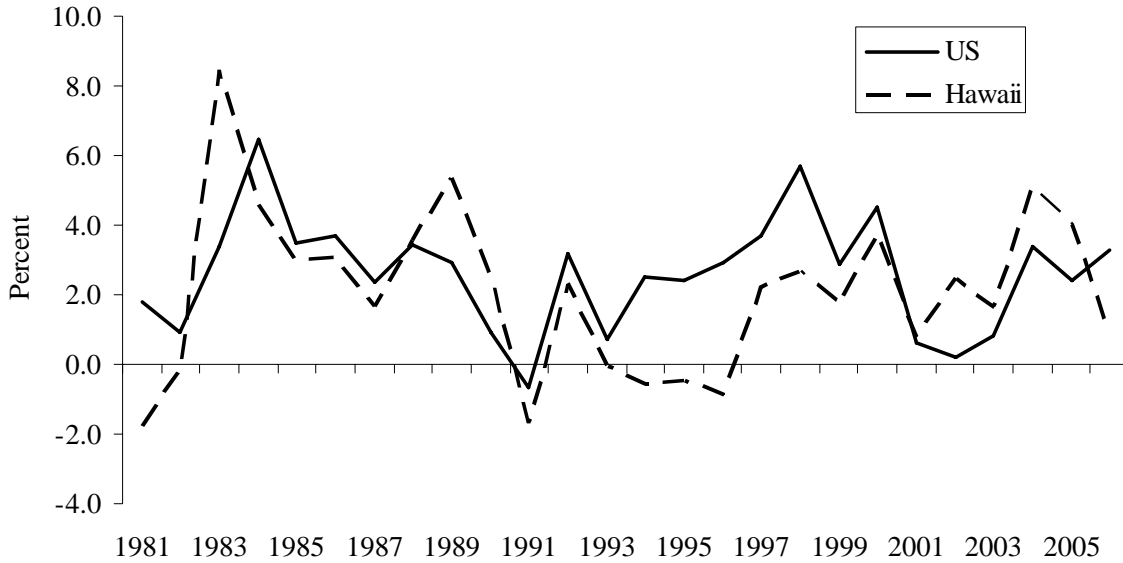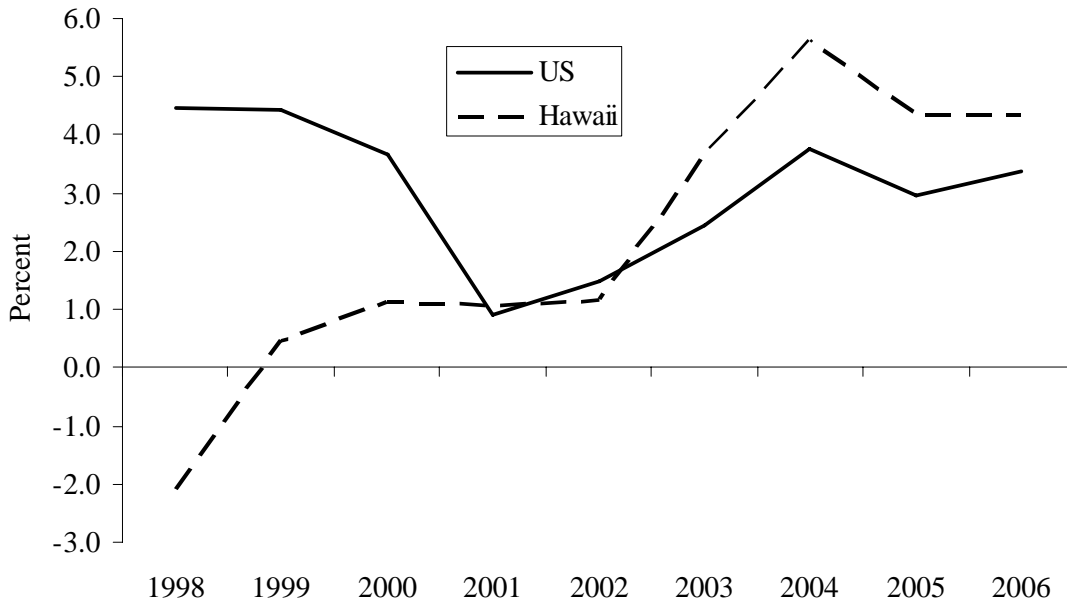

Besides the above differences in the levels of economic growth between Hawaii and the U.S., the two economies also showed notable differences with respect to measures of variation in

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economic performance. For example, during 1980-2006, Hawaii's annual percentage change in total jobs (i.e. wage and salary plus proprietors' jobs) varied from a decrease of 1.1 percent to an increase of 5.1 percent, with an average change of 1.6 percent and a standard deviation of 1.8 percent. The total job change for the U.S. ranged from a decrease of 0.6 percent to an increase 4.3 percent, with an average change of 1.7 percent and a standard deviation of 1.2 percent. Similarly, the 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 2.1 percent and a standard deviation of 2.4 percent. The annual real income change for the U.S. varied from a decline of 0.7 percent to an increase of 6.5 percent, with a mean change of 2.6 percent and a standard deviation of 1.6 percent. Thus, in terms of both annual total job and real personal income change, during 1980-2006 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 2006 ranged from a low of 2.4 percent to a high of 5.9 percent, with a period average of 4.3 percent and a standard deviation of 1.2 percent, while the U.S. unemployment rate varied from a minimum of 4.0 percent to a maximum of 9.7 percent, averaging 6.1 percent for the period with a standard deviation of 1.5 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 available only for total jobs (wage/salary plus proprietors' jobs) from 1990, sectoral employment distributions between Hawaii and the U.S. are compared using the total jobs starting from that year.[6] For 1997 and 2006, the two economies are also being compared in terms of real GDP shares by industry.

Between 1990 and 2006, the U.S. economy added nearly 39 million total jobs (a cumulative growth of 28.0 percent or an average annual growth of 1.6 percent). For Hawaii, total jobs increased by 133,800 during that period (a cumulative increase of 18.3 percent or an annual increase of 1.1 percent). Job growth was much higher in the U.S. during 1990-2000, while the growth was higher in Hawaii during 2000-2006 (Table 1).

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[6]   Wage and salary data by NAICS industry from BEA are available from 2001 only.

Table 1. Total Employment by Sector for the U.S. and Hawaii, 1990, 2000 and 2006

	Employment (total jobs)			Cumulative change	
	1990	2000	2006	1990-2000	2000-2006
U.S.					
Total employment	139,380,900	166,758,800	178,342,900	19.6%	6.9%
Farming	3,153,000	3,113,000	2,876,000	-1.3%	-7.6%
Forestry, fishing and related activities	944,725	1,056,368	1,013,600	11.8%	-4.0%
Mining	889,658	770,053	887,200	-13.4%	15.2%
Utilities	760,187	625,781	572,700	-17.7%	-8.5%
Construction	7,382,469	9,613,345	11,580,000	30.2%	20.5%
Manufacturing	18,191,199	17,829,608	14,766,400	-2.0%	-17.2%
Wholesale trade	5,760,690	6,341,776	6,545,300	10.1%	3.2%
Retail trade	16,167,072	18,544,350	19,199,400	14.7%	3.5%
Transportation and warehousing	4,258,580	5,460,182	5,767,200	28.2%	5.6%
Information	3,069,944	4,039,287	3,610,300	31.6%	-10.6%
Finance and insurance	6,904,885	7,953,601	8,467,300	15.2%	6.5%
Real estate and rental and leasing	4,365,888	5,448,487	7,706,000	24.8%	41.4%
Professional and technical services	7,806,696	10,546,452	11,701,000	35.1%	10.9%
Management of companies and enterprises	1,366,270	1,802,743	1,890,700	31.9%	4.9%
Administrative and waste services	5,752,324	9,843,144	10,701,900	71.1%	8.7%
Educational services	2,046,975	2,844,824	3,700,300	39.0%	30.1%
Health care and social assistance	11,381,907	15,331,268	17,616,500	34.7%	14.9%
Arts, entertainment, and recreation	2,213,450	3,223,115	3,618,400	45.6%	12.3%
Accommodation and food services	8,336,093	10,600,522	11,960,200	27.2%	12.8%
Other services	7,396,888	8,826,894	10,155,500	19.3%	15.1%
Government and government enterprises	21,232,000	22,944,000	24,007,000	8.1%	4.6%
Hawaii					
Total employment	730,455	763,284	864,266	4.5%	13.2%
Farming	14,610	12,744	11,796	-12.8%	-7.4%
Forestry, fishing and related activities	5,477	5,628	3,905	2.8%	-30.6%
Mining	422	538	556	27.5%	3.3%
Utilities	3,012	2,841	3,079	-5.7%	8.4%
Construction	43,304	33,015	47,803	-23.8%	44.8%
Manufacturing	23,039	19,446	18,655	-15.6%	-4.1%
Wholesale trade	21,980	20,769	22,544	-5.5%	8.5%
Retail trade	84,820	85,498	89,927	0.8%	5.2%
Transportation and warehousing	27,227	28,598	33,793	5.0%	18.2%
Information	12,657	13,877	12,702	9.6%	-8.5%
Finance and insurance	28,223	25,786	26,041	-8.6%	1.0%
Real estate and rental and leasing	29,360	33,591	46,091	14.4%	37.2%
Professional and technical services	34,524	37,634	44,058	9.0%	17.1%
Management of companies and enterprises	4,352	5,904	7,749	35.7%	31.3%
Administrative and waste services	32,716	44,865	58,613	37.1%	30.6%
Educational services	9,728	14,074	17,776	44.7%	26.3%
Health care and social assistance	47,142	59,965	70,359	27.2%	17.3%
Arts, entertainment, and recreation	15,825	19,987	22,127	26.3%	10.7%
Accommodation and food services	85,572	91,598	100,825	7.0%	10.1%
Other services	34,735	40,653	50,794	17.0%	24.9%
Government and government enterprises	171,730	166,273	175,073	-3.2%	5.3%

Source: U.S. Bureau of Economic Analysis.

During 1990–2000, the U.S. industries added 27.4 million total jobs, a cumulative increase of 19.6 percent over the period (or 1.8 percent increase per annum). For the same period, Hawaii added 32,800 total jobs, 4.5 percent more than that in 1990 (i.e., an annual increase of just 0.4 percent).

During 2000–2006, the nation's industries added 11.6 million total jobs, a total increase of 6.9 percent for the period (1.1 percent per annum), while Hawaii's industries added nearly 101,000 total jobs, a 13.2 percent growth for the period (2.1 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 2006 (Table 1). The largest decrease was in manufacturing, which lost more than 3.4 million total jobs (-18.8 percent) in the U.S. and nearly 4,400 jobs (-19.0 percent) in Hawaii. Most of the U.S. manufacturing decline occurred during 2000-2006, while most 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 2006 was farming, loosing 277,000 jobs (-8.8 percent) and 2,800 jobs (-19.3 percent), respectively. Forestry, fishing, hunting and related activities in Hawaii and utilities in the U.S. also experienced significant job losses during 1990-2006, declining 28.7 percent and 24.7 percent, respectively. Finance and insurance also lost about 2,200 total jobs (-7.7 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 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.[7] Certain tourism-related sectors, most notably accommodation and food services and to some extent arts, entertainment and recreation and transportation sectors 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 2006, 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 activity has remained fairly constant.

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 66-67 percent in 1990 to about 71-72 percent in 2006. 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 share in total employment decreased from 13.1 percent in 1990 to 8.3 percent in 2006 percent for the U.S. and from about 3.2 percent to 2.2 percent for Hawaii. Similarly, the farming share decreased from 2.3 percent to 1.6 percent for the U.S. and from 2.0 percent to 1.4 percent in Hawaii (Figures 5 & 6).

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[7]   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

Sector	U.S.	Hawaii
Mining	0.6%	0.1%
Utilities	0.5%	0.4%
Mgt. of companies & enterprises	1.0%	0.6%
Forestry, fishing & related activities	0.7%	0.7%
Educational services	1.5%	1.3%
Information	2.2%	1.7%
Farming	2.3%	2.0%
Arts, entertainment & recreation	1.6%	2.2%
Wholesale trade	4.1%	3.0%
Manufacturing	13.1%	3.2%
Transportation & warehousing	3.1%	3.7%
Finance & insurance	5.0%	3.9%
Real estate	3.1%	4.0%
Administrative & waste services	4.1%	4.5%
Professional & technical services	5.6%	4.7%
Other services	5.3%	4.8%
Construction	5.3%	5.9%
Health care & social assistance	8.2%	6.5%
Retail trade	11.6%	11.6%
Accommodation & food services	6.0%	11.7%
Government	15.2%	23.5%

Share

Figure 6. Employment Shares by Sector for Hawaii and the U.S., 2006

Sector	U.S.	Hawaii
Mining	0.5%	0.1%
Utilities	0.3%	0.4%
Mgt. of companies & enterprises	1.1%	0.9%
Forestry, fishing & related activities	0.6%	0.5%
Educational services	2.1%	2.1%
Information	2.0%	1.5%
Farming	1.6%	1.4%
Arts, entertainment & recreation	2.0%	2.6%
Wholesale trade	3.7%	2.6%
Manufacturing	8.3%	2.2%
Transportation & warehousing	3.2%	3.9%
Finance & insurance	4.7%	3.0%
Real estate	4.3%	5.3%
Administrative & waste services	6.0%	6.8%
Professional & technical services	6.6%	5.1%
Other services	5.7%	5.9%
Construction	6.5%	5.5%
Health care & social assistance	9.9%	8.1%
Retail trade	10.8%	10.4%
Accommodation & food services	6.7%	11.7%
Government	13.5%	20.3%

Share

The industrial distributions of 2006 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 2006, the share of real estate, rental and leasing 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 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.

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Figure 7. Real GDP (2000 chained dollars) by Sector for Hawaii and the U.S., 2006
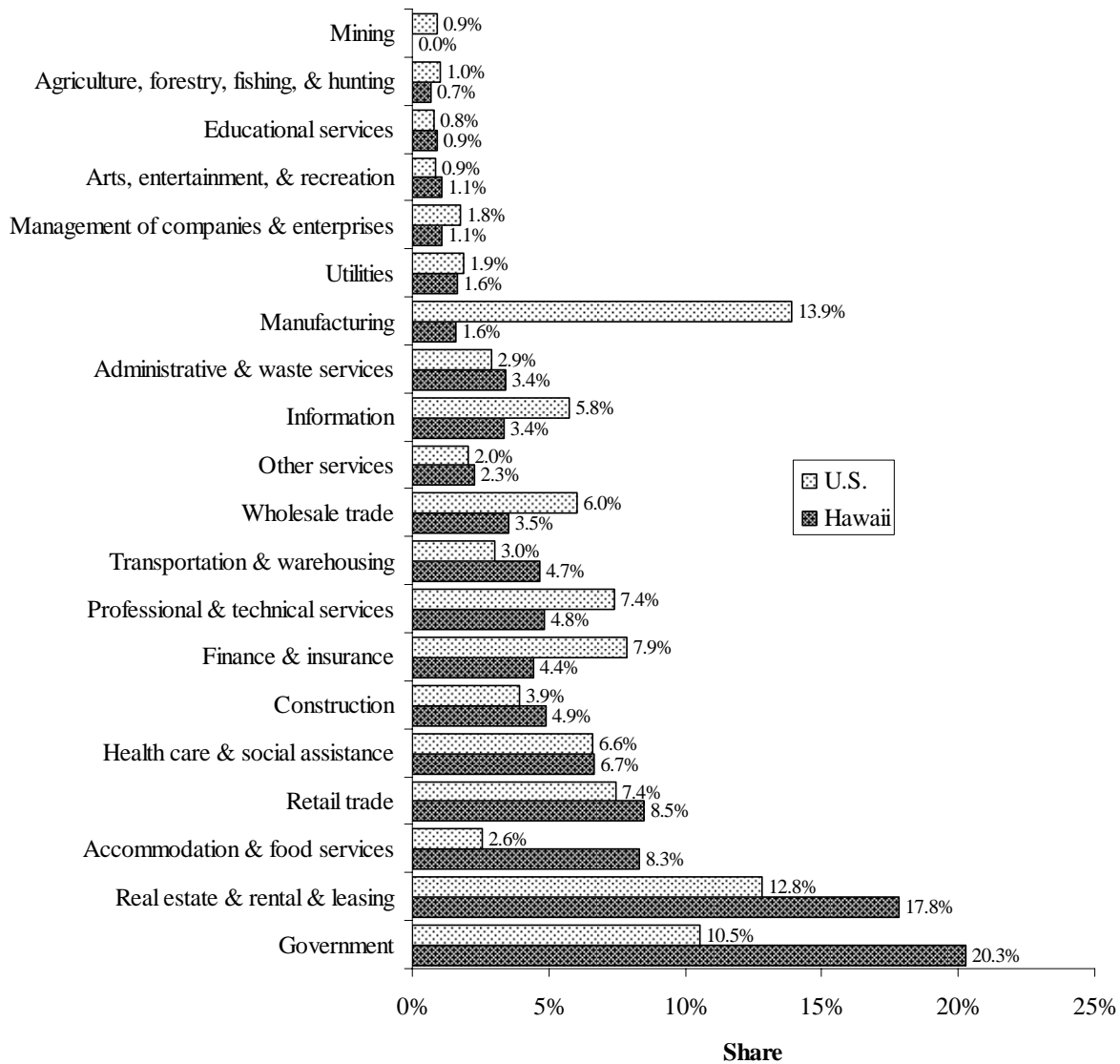
3.3. Location Quotients (LQ)

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 switched from a basic sector in 1990 to a non-basic sector in 2006, 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 2006
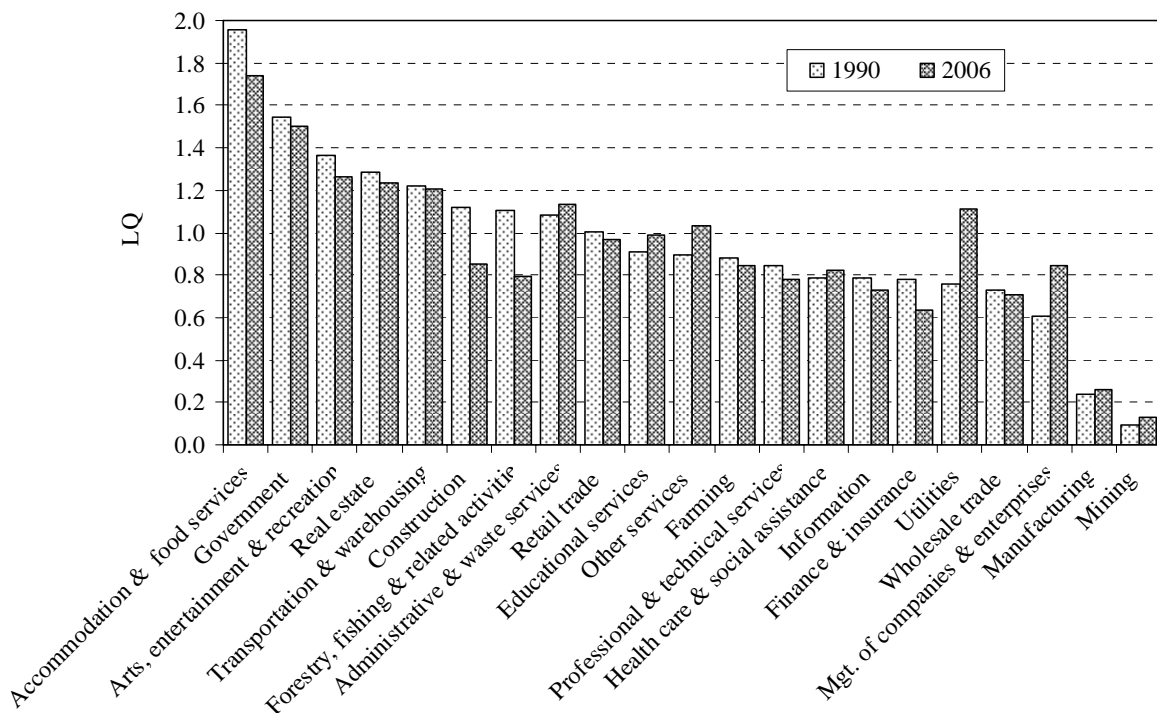
3.4. *Measures of Economic Diversity for Hawaii*

In this report, 1990-2006 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.[8] Since, most indexes are sensitive to the number of industries used in the analysis, two levels of

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[8]   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.

industrial aggregation were used.[9] To see changes in diversification patterns over time within Hawaii, the indexes were computed using 74 sectors for each year between 1990 and 2006. However, to compare Hawaii with other U.S. states, the indexes were calculated using 21 sectors for 1990, 2000 and 2006.[10]

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.

As can be seen from the figures, in all cases the estimated 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 suggest that Hawaii's economy appears to have become more diversified over time. In other words, the sectoral shares 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

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[9]   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.

[10]   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.

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 indexes over time remained the same regardless of the number of sectors used in the analysis as well as whether or not the manufacturing sector is included or excluded in computations.

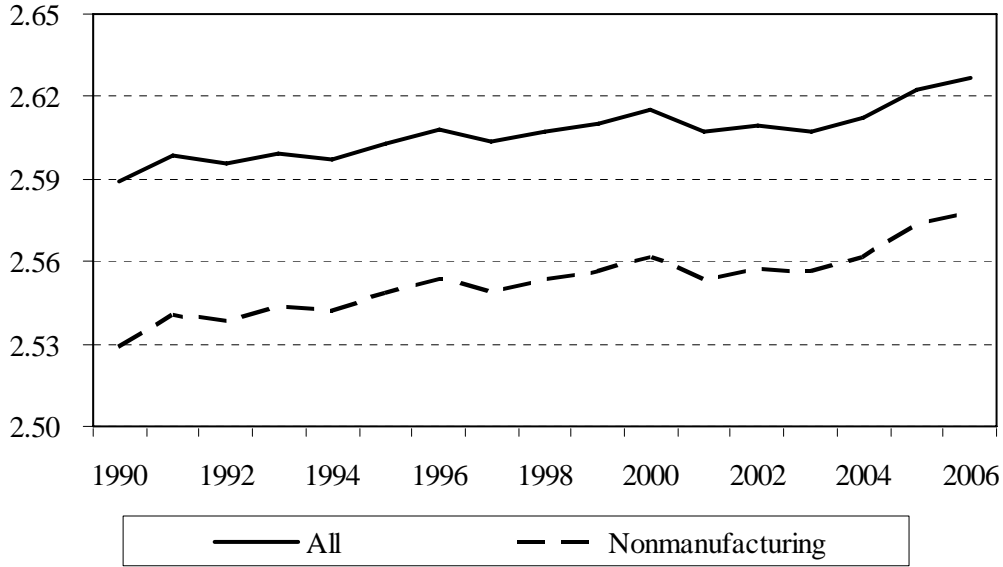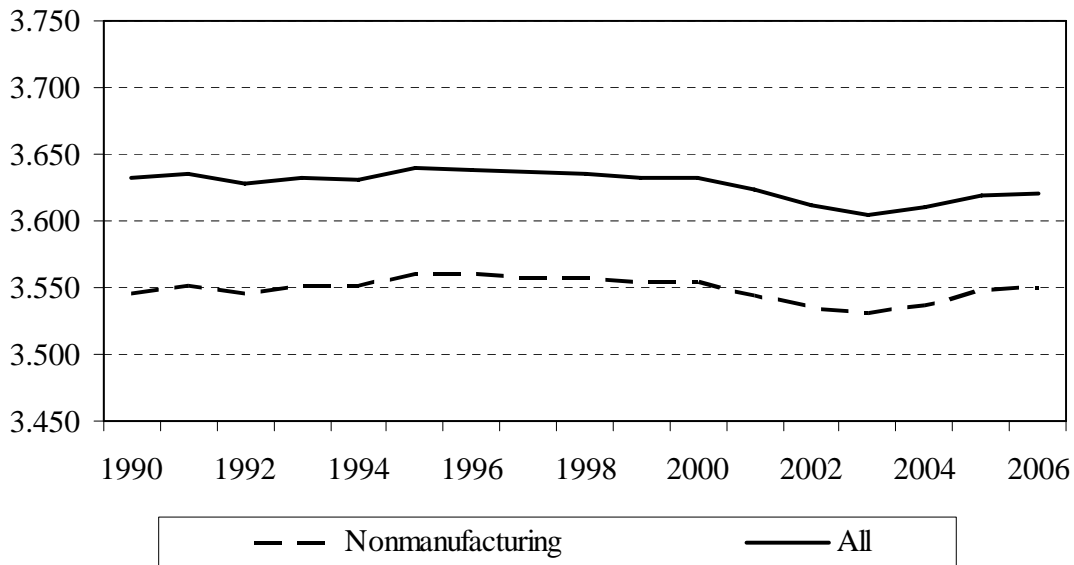**Figure 9. Entropy Index of Diversification for Hawaii (21 Sectors), 1990-2006**

Figure 10. Entropy Diversification Index for Hawaii (74 sectors), 1990-2006
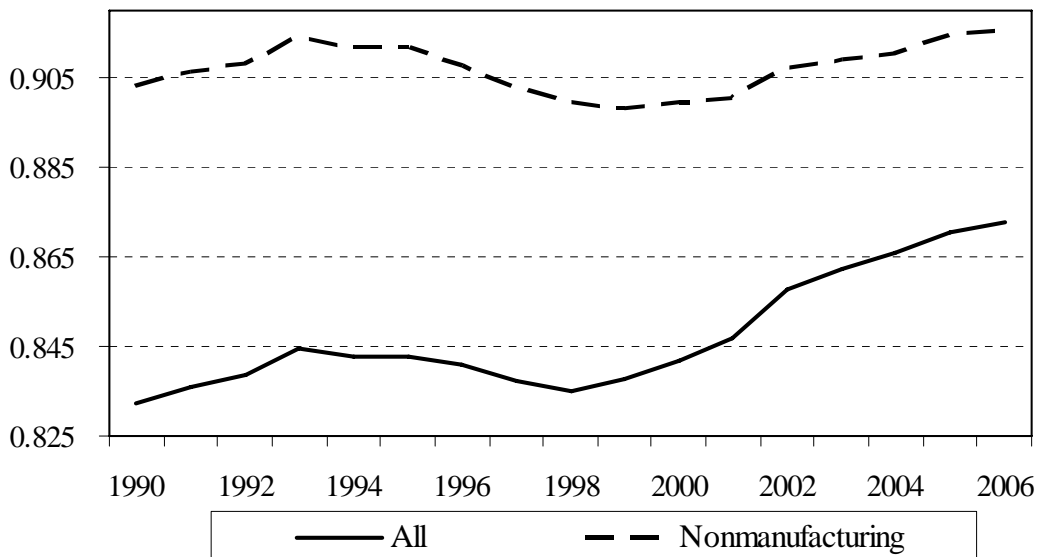
Hachman Index

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.[11] The Hachman index shows how similar or dissimilar a given region's economic structure is relative to that of the U.S., signifying one of the most diversified economies. 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 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.

Unlike the entropy index that showed a slight increasing trend, the Hachman index exhibited a slight cyclical pattern, with the highest values in 1993 and 2003 and the lowest values during 1997-1998.

Figure 11. Hachman Diversification Index for Hawaii (21 sectors), 1990-2006

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

Figure 12. Hachman Diversification Index for Hawaii (74 Sectors), 1990-2006
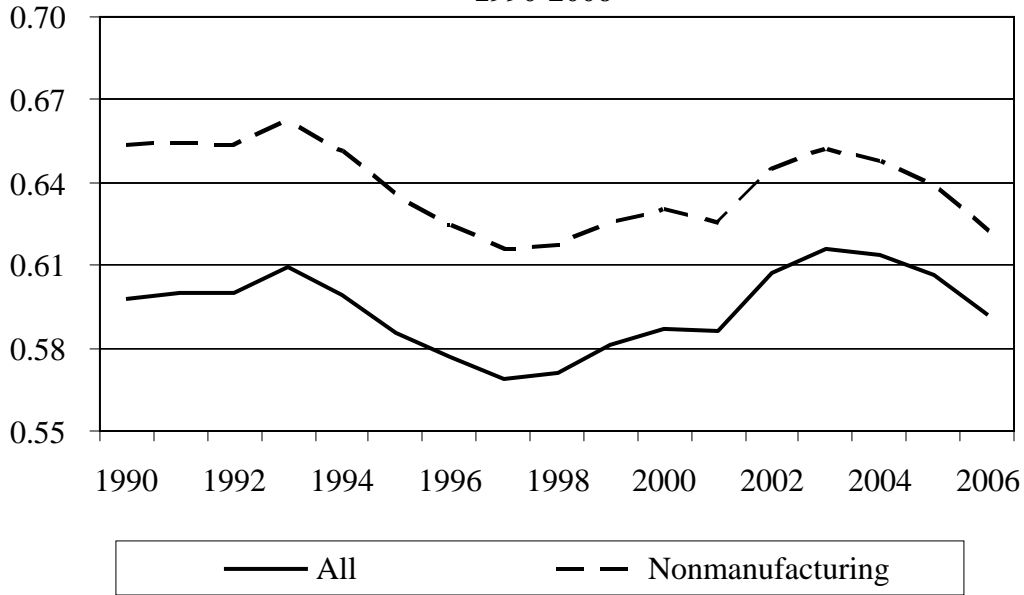
States Diversity Rankings

Both the entropy and Hachman indexes were calculated for all U.S. states for 1990, 2000, and 2006 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 48th in 2006. It was interesting that the exclusion of manufacturing had virtually no impact on Hawaii's entropy rankings.

The states' diversity rankings based on the Hachman index are presented in Table 3. Ranked 42nd in both 1990 and 2006 and 45th in 2000, again Hawaii appeared to be one of 10 most dissimilar economies compared to the overall structure of the U.S. economy. Excluding manufacturing improved Hawaii's ranking to 33rd in 1990, 40th in 2000, and 34th in 2006.

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Table 2. Entropy Index of Diversification for the U.S. States, 1990, 2000 and 2006 (21 sectors)

	1990		2000		2006	
	Index	Rank	Index	Rank	Index	Rank
United States	2.713		2.743		2.754	
Alabama	2.593	45	2.650	43	2.679	44
Alaska	2.554	49	2.633	47	2.624	49
Arizona	2.698	15	2.718	18	2.716	26
Arkansas	2.646	31	2.685	31	2.717	25
California	2.737	3	2.778	1	2.769	2
Colorado	2.742	1	2.761	2	2.768	3
Connecticut	2.660	29	2.695	29	2.707	31
Delaware	2.692	20	2.708	23	2.713	27
District of Columbia	2.229	51	2.310	51	2.292	51
Florida	2.719	8	2.730	13	2.730	17
Georgia	2.687	22	2.731	12	2.736	15
Hawaii	2.589	46	2.615	49	2.627	48
Idaho	2.727	6	2.738	8	2.748	10
Illinois	2.705	12	2.728	14	2.749	8
Indiana	2.607	43	2.643	45	2.681	42
Iowa	2.666	27	2.694	30	2.723	21
Kansas	2.697	16	2.716	20	2.729	19
Kentucky	2.685	23	2.697	27	2.725	20
Louisiana	2.726	7	2.734	10	2.748	9
Maine	2.642	33	2.680	35	2.684	41
Maryland	2.639	34	2.655	41	2.667	46
Massachusetts	2.689	21	2.717	19	2.730	16
Michigan	2.624	40	2.650	44	2.696	39
Minnesota	2.735	4	2.743	7	2.760	6
Mississippi	2.561	48	2.637	46	2.663	47
Missouri	2.728	5	2.757	5	2.767	4
Montana	2.695	19	2.727	15	2.742	13
Nebraska	2.697	17	2.734	11	2.745	12
Nevada	2.598	44	2.596	50	2.617	50
New Hampshire	2.642	32	2.675	37	2.701	32
New Jersey	2.683	24	2.711	21	2.720	24
New Mexico	2.632	36	2.670	38	2.681	43
New York	2.704	14	2.720	17	2.720	23
North Carolina	2.569	47	2.655	40	2.696	37
North Dakota	2.620	41	2.696	28	2.712	28
Ohio	2.629	39	2.676	36	2.710	30
Oklahoma	2.718	9	2.736	9	2.746	11
Oregon	2.715	10	2.757	4	2.771	1
Pennsylvania	2.680	25	2.709	22	2.729	18
Rhode Island	2.608	42	2.661	39	2.701	33
South Carolina	2.553	50	2.617	48	2.668	45
South Dakota	2.646	30	2.699	25	2.711	29
Tennessee	2.631	37	2.697	26	2.721	22
Texas	2.739	2	2.759	3	2.765	5
Utah	2.708	11	2.749	6	2.754	7
Vermont	2.705	13	2.706	24	2.696	38
Virginia	2.637	35	2.682	32	2.684	40
Washington	2.696	18	2.725	16	2.739	14
West Virginia	2.676	26	2.680	34	2.699	35
Wisconsin	2.631	38	2.653	42	2.700	34
Wyoming	2.660	28	2.681	33	2.697	36

Table 3. Hachman Index of Diversification for the U.S. States, 1990, 2000 and 2006 (21 sectors)

	1990 Index	1990 Rank	2000 Index	2000 Rank	2006 Index	2006 Rank
Alabama	0.947	18	0.954	16	0.956	19
Alaska	0.600	48	0.665	48	0.713	49
Arizona	0.965	9	0.956	12	0.957	18
Arkansas	0.895	34	0.903	37	0.907	39
California	0.977	3	0.972	6	0.974	5
Colorado	0.954	13	0.944	20	0.959	15
Connecticut	0.931	27	0.944	22	0.949	21
Delaware	0.937	23	0.932	26	0.932	28
District of Columbia	0.562	51	0.570	50	0.571	50
Florida	0.940	21	0.925	30	0.934	26
Georgia	0.974	4	0.983	1	0.984	1
Hawaii	0.832	42	0.842	45	0.873	42
Idaho	0.841	41	0.890	40	0.917	35
Illinois	0.981	1	0.981	2	0.981	2
Indiana	0.937	22	0.923	32	0.919	32
Iowa	0.852	40	0.896	39	0.891	40
Kansas	0.929	29	0.944	21	0.933	27
Kentucky	0.882	37	0.917	33	0.917	34
Louisiana	0.885	36	0.907	36	0.918	33
Maine	0.912	32	0.924	31	0.920	31
Maryland	0.934	25	0.938	25	0.945	23
Massachusetts	0.908	33	0.913	35	0.912	37
Michigan	0.967	7	0.956	13	0.969	8
Minnesota	0.961	10	0.973	5	0.968	10
Mississippi	0.888	35	0.902	38	0.907	38
Missouri	0.967	6	0.968	7	0.971	7
Montana	0.811	44	0.845	43	0.861	43
Nebraska	0.878	38	0.914	34	0.916	36
Nevada	0.599	49	0.647	49	0.725	48
New Hampshire	0.953	15	0.951	18	0.957	17
New Jersey	0.952	16	0.954	17	0.961	13
New Mexico	0.863	39	0.882	41	0.890	41
New York	0.931	26	0.929	28	0.930	29
North Carolina	0.922	30	0.957	11	0.977	4
North Dakota	0.675	47	0.760	47	0.774	47
Ohio	0.954	12	0.967	9	0.969	9
Oklahoma	0.822	43	0.851	42	0.810	45
Oregon	0.948	17	0.968	8	0.962	12
Pennsylvania	0.966	8	0.963	10	0.965	11
Rhode Island	0.921	31	0.926	29	0.936	24
South Carolina	0.930	28	0.940	24	0.957	16
South Dakota	0.748	45	0.828	46	0.836	44
Tennessee	0.946	19	0.955	14	0.960	14
Texas	0.936	24	0.946	19	0.947	22
Utah	0.978	2	0.980	3	0.981	3
Vermont	0.954	14	0.940	23	0.934	25
Virginia	0.956	11	0.955	15	0.951	20
Washington	0.970	5	0.976	4	0.972	6
West Virginia	0.745	46	0.843	44	0.798	46
Wisconsin	0.940	20	0.929	27	0.926	30
Wyoming	0.570	50	0.562	51	0.453	51

Impact on Economic Instability

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

The second procedure involved testing the above relationship using the results for all the states. The correlation coefficients were computed between the states' diversity indexes for 1990 and the variances of monthly unemployment levels from 1990 to 1995 and between 2000 diversity indexes and monthly unemployment variances from 2000 to 2005. The estimated correlation coefficients were insignificant. However, the correlations between the size of GDP and diversity measures were positive and significant, suggesting that larger states are more diverse than their smaller counterparts.

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 2006.[12] To account for different economic conditions, the study period is broken down to two sub-periods – 1990 to 2000 and 2000 to 2006.

As mentioned previously, Hawaii added nearly 134,000 jobs between 1990 and 2006, an increase of more than 18.3 percent (Tables 1 and 4). Of this, nearly 33,000 jobs were added between 1990 and 2000 (and an increase of 4.5 percent) (Table 5) and nearly 101,000 jobs were added between 2000 and 2006 (a 13.2 percent increase) (Table 6).

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[12] 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, 1990-2006

	Total change (1990-2006)	National growth effect	Industrial mixed effect	Competitive share effect
90-91	20,930	-4,062	1,963	23,030
91-92	1,565	3,016	2,480	-3,931
92-93	-4,293	14,161	1,795	-20,249
93-94	-5,133	18,187	701	-24,021
94-95	-3,572	19,247	127	-22,945
95-96	-489	15,732	415	-16,635
96-97	565	16,806	-383	-15,858
97-98	2,170	19,118	-542	-16,406
98-99	-102	15,469	1,301	-16,872
99-00	21,188	17,321	2,295	1,572
00-01	3,877	1,171	4,363	-1,657
01-02	3,019	-1,753	6,389	-1,617
02-03	16,547	4,254	3,620	8,673
03-04	25,954	13,937	1,668	10,349
04-05	26,059	17,451	529	8,079
05-06	25,526	20,029	467	5,030
90-06	**133,811**	**190,084**	**27,187**	**-83,460**

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

	Change (1990-2000)	National growth effect	Industrial mixed effect	Competitive share effect
Farm employment	-1,866	2,286	-2,465	-1,686
Forestry, fishing, related activities, and other	151	1,110	-418	-541
Mining	116	114	-196	198
Utilities	-171	594	-1,235	470
Construction	-10,289	6,550	2,892	-19,731
Manufacturing	-3,593	3,558	-4,076	-3,075
Wholesale trade	-1,211	3,886	-1,856	-3,241
Retail trade	678	15,633	-3,660	-11,295
Transportation and warehousing	1,371	5,115	1,996	-5,740
Information	1,220	2,362	1,305	-2,447
Finance and insurance	-2,437	4,888	-1,027	-6,298
Real estate and rental and leasing	4,231	5,602	1,335	-2,706
Professional and technical services	3,110	6,655	4,471	-8,016
Management of companies and enterprises	1,552	1,064	490	-2
Administrative and waste services	12,149	6,794	13,698	-8,343
Educational services	4,346	2,216	1,762	368
Health care and social assistance	12,823	9,828	6,053	-3,058
Arts, entertainment, and recreation	4,162	3,226	3,577	-2,641
Accommodation and food services	6,026	15,726	5,381	-15,080
Other services, except public administration	5,918	6,896	-157	-821
Government and government enterprises	-5,457	30,892	-17,719	-18,631
Total	**32,829**	**134,994**	**10,151**	**-112,316**

Table 6. Dynamic Shift-Share Analysis by Sector, 2001-2006

	Total change (2001-2006)	National growth effect	Industrial mixed effect	Competitive share effect
Farm employment	-948	813	-1,771	10
Forestry, fishing & related activities	-1,723	284	-523	-1,484
Mining	18	36	43	-61
Utilities	238	195	-437	480
Construction	14,788	2,713	4,789	7,286
Manufacturing	-791	1,250	-4,764	2,723
Wholesale trade	1,775	1,427	-715	1,063
Retail trade	4,429	5,826	-2,819	1,422
Transportation & warehousing	5,195	1,993	-286	3,488
Information	-1,175	845	-2,285	265
Finance & insurance	255	1,674	-134	-1,284
Real estate & rental	12,500	2,642	10,840	-982
Professional & technical services	6,424	2,812	1,572	2,040
Mgt. of companies & enterprises	1,845	486	-125	1,485
Administrative & waste services	13,748	3,588	1,053	9,107
Educational services	3,702	1,121	3,043	-462
Health care & social assistance	10,394	4,536	4,487	1,371
Arts, entertainment, & recreation	2,140	1,438	986	-284
Accommodation & food services	9,227	6,517	4,935	-2,225
Other services	10,141	3,200	3,129	3,812
Government	8,800	11,694	-3,983	1,089
Total	**100,982**	**55,090**	**17,036**	**28,857**

As can be seen from Table 4, if Hawaii added jobs at the same pace as the overall U.S., Hawaii would have had about 190,000 more jobs in 2006 compared to 1990. Except for 1991-92 and 2001-2002 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 and positive during 2002-2006.

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 (due to decline in federal military employment), accommodation and food services, retail trade, and professional and administrative 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 management services, health services, accommodation and food services and retail trade.

Table 6 shows a completely different picture of job growth in Hawaii during 2001-2006. Except for farming, forestry and fishing activities, manufacturing, 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 administrative and waste management services, real estate, health, accommodation and food services, was the main driver of Hawaii's growth in recent years. A few sectors had negative industrial-mix effects, but they 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.


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 in with the competitive share effects from shift-share analysis for all industries in the region. As discussed earlier, industries with a location quotient greater than one are said 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 effects 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 Figure 13, Hawaii's 20 private industries (i.e., excluding the government sector) could be divided into four distinct groups of industry clusters.

Industries that are found in the upper-right quadrant of the four-quadrant figure (also called 'growing base industries') are natural candidates for clusters. It should be noted, however, that all parts of highly concentrated and competitive industries located in the upper-right quadrant are not necessarily the clusters needing targeted support and that some parts of an important cluster can be buried under larger industry groups in other quadrants. The best strategy is to construct the four-quadrant figure for both two-digit (i.e., about 20 sectors as in Figure 13) and more detailed, four- or six-digit industry groups.

Cluster analysis begins with an examination and refinement of industries in the upper-right quadrant (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 institutions and security brokers which mostly serve the needs of the local consumer base.

Figure 13. LQ and Competitive Share Four Quadrant Analysis
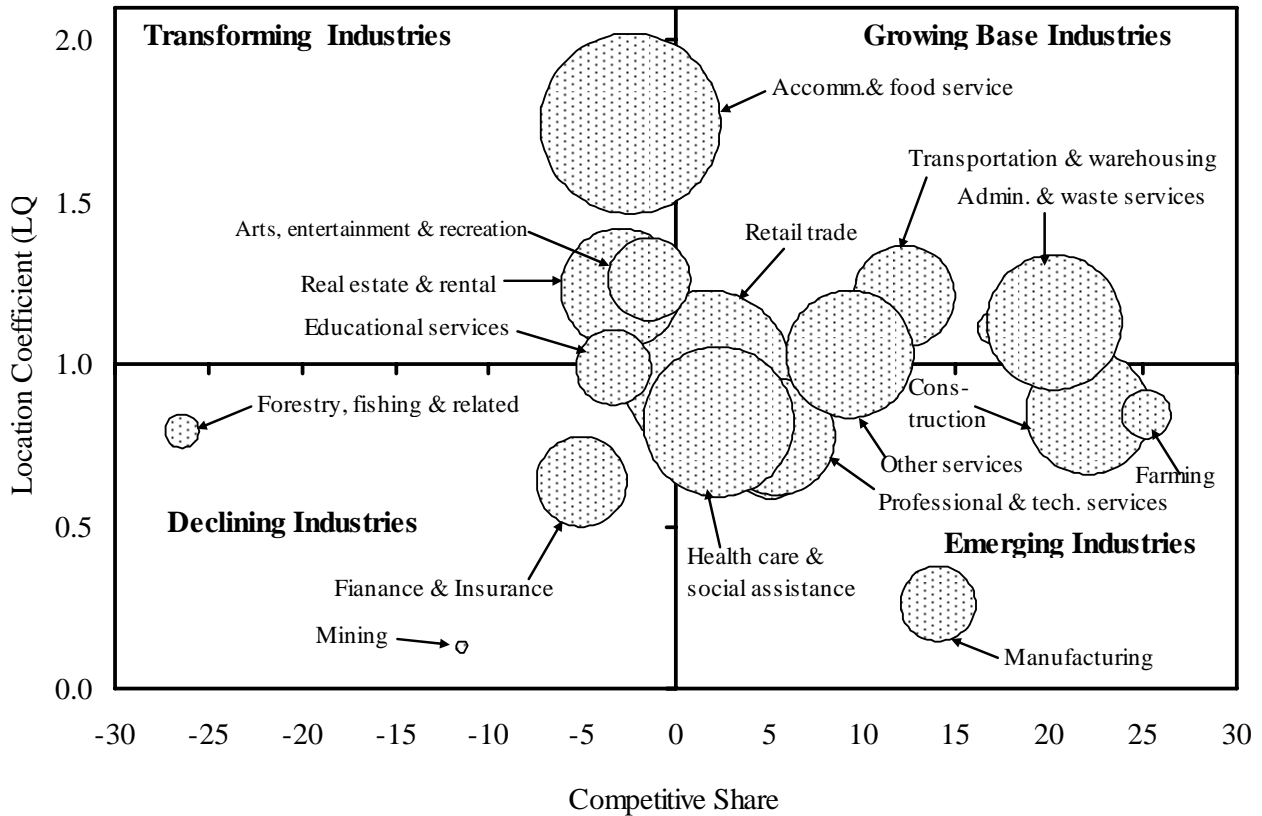
Because of lack of enough industry detail, some important parts of Hawaii's emerging clusters could be hidden in some larger industry categories located in other quadrants in Figure 13. For example, the potential cluster of film and performing arts products is hidden in the arts, entertainment and recreation 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 four-quadrant analysis by breaking these aggregate industry groups to more detailed, four-digit or six-digit industry codes, perhaps using data from the Bureau of labor Statistics, Quarterly Wage and Employment series.

4.   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 1990-2006. 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 50 U.S. states for 1990, 2000 and 2006 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 appeared 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. Nonetheless, this study shows that neither of these measures may be the best measure as the main factor affecting diversity appears to be size.

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 2006, 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 professional and administrative services. The positive national effects more than offset the negative competitive effects in several sectors, notably administrative and waste management services, health services, accommodation and food services, resulting in overall positive job growth in these sectors. The results showed a completely different picture of job growth in Hawaii during 2001-2006, with all three effects contributing to growth in most industries, with the exceptions of farming, forestry and fishing activities, manufacturing, 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 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.

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