



**AgEcon** SEARCH

RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

*No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.*

# The Composition of Industry and the Duration of State Recessions

Angela Kuhlmann<sup>#</sup>, Christopher S. Decker<sup>\*</sup> and Mark E. Wohar<sup>\*</sup>

*Professional Research Consultants <sup>#</sup> and University of Nebraska at Omaha<sup>\*</sup> – USA*

**Abstract.** In this paper, we investigate the determinants of the duration of state level recessions in the United States that occurred over the period 1979 to 1997. Contrary to much of the existing related literature, we find that a significant factor that influences the duration of state recessions is whether a state's degree of industrial diversity is increasing or decreasing. Specifically, we find that states that are becoming more diverse have recessions of shorter duration. In states where diversity is decreasing, recessions are longer in duration. This finding, we believe, is a hopeful message for states that are relatively more concentrated since it seems to indicate that their initial level of diversity is not as important as their change in diversity. Therefore, this could mean that as long as a state can accelerate its industrial diversification, they may be able to reduce the duration of their recessions.

## 1. Introduction

In recent years, many states have been dealing with budget dilemmas, and cuts at the national level have further worsened their financial situation. This has raised many questions and increased the focus on economic performance at the sub-national level. Why are some states better able to recover from downturns in economic activity while other states find it difficult? A substantial academic literature has developed largely to address this question of regional cyclicalities. Recent studies include Crone and Clayton-Matthews (2005), Owyang et al. (2005), and Crone (2005).

While the empirical literature has identified many factors that contribute to answering this question, this study finds that when the focus is on the duration of recessionary episodes, it is not just, as some studies imply, the diversity of the industry mix within a state that matters, but rather the changing composition of that mix that plays a dominant and statistically significant role in determining whether a state recovers quickly from a downturn in economic activity or languishes for long periods of time.

More specifically, the objectives of this paper are 1) to test whether state-level recessions are more likely or

less likely to persist as they increase in duration, and 2) to investigate what factors and characteristics of state economies influence the duration of recessions, with special attention given to the influence of industry diversity (a factor which has not been showcased in earlier work). With respect to the first point, by employing a duration modeling framework and controlling for various factors, we find that most recessions are more likely to end as their duration increases given that they have not ended already. With respect to the second objective, we find that a number of factors are significantly related to longer recessions. The factors associated with longer recessions include decreases in industrial diversity, high unemployment, decreases in real income per capita, high proportions of non-white workers, small total populations, and increases in population growth.

The most interesting and noteworthy finding of this study is that the initial level of industrial diversity in a state is not what significantly influences recession duration, but rather whether or not industrial diversity is increasing. We find that in states where diversity is increasing, recessions are shorter in duration. In states where diversity is decreasing, recessions are longer in duration. This finding is a hopeful message

for states that are relatively more concentrated since it seems to indicate that their initial level of diversity is not as important as their change in diversity. Therefore, this could mean that as long as a state can accelerate its industrial diversification, they may be able to reduce the duration of their recessions.

The economic performance of a state can be evaluated in various ways using a wide range of macroeconomic measures. Some of the most common measures of performance include unemployment, per capita income growth, labor productivity growth, and job creation. This paper extends earlier work in this area by focusing on a less commonly used, and possibly more revealing, measure of economic performance. The measure of economic performance we focus on is a coincident index of state business cycles. This index utilizes consistent economic measures across all 50 states and it is available at a quarterly frequency, whereas alternative measures such as gross state product are only available on an annual basis.

Business cycles, and recessions in particular, are a vast and complex topic of study. Simply defined, a recession is a significant decline in economic activity spread across an economy, lasting at least two quarters, normally measured by declines in real GDP, real income, employment, industrial production, and wholesale-retail sales. The causes of recessions are numerous and always a topic of debate among economists. Recession triggers can include shocks to supply and demand, policy errors, financial crises, or even psychological reactions to significant events (Davis et al., 1996, p. 84). Recessions end when an economy has adjusted and recovered from such triggers, often with the aid of policy changes. The factors that influence the duration of a recession are the primary focus of this research.

There are several reasons for examining the duration of recessions as opposed to studying their depth, where measures of per-capita income growth or employment growth would be more applicable as yardsticks. States are increasingly relying on their "rainy day funds" to meet budget shortfalls in the short run to avoid raising taxes and/or cutting expenditures (Wagner and Elder, 2004). The longer the duration of a recession, the more likely it is that a state's rainy day funds will dry up. Moreover, the longer a recession continues, the longer it will be before a state has extra revenue to begin replenishing their rainy day funds. If revenue fails to rebound quickly enough, spending cuts and/or tax increases may have to be larger than previously necessary in order to replenish these emergency funds. Furthermore, people have increased anxiety during state economic downturns, which can lead to increased public

pressure on policymakers to stimulate employment and income growth. In short, economic conditions are in general of greater concern when such conditions are poor.

From a labor perspective, longer recessions lead to longer durations of unemployment. More workers become discouraged and drop out of the labor force, leading to corresponding declines in consumption that further exacerbate the impacts of a recession. Furthermore, the longer a state recession persists, the more likely it is that workers will begin to migrate to more prosperous states. Research has shown that gross migration flows tend to fall during national recessions due to factors such as increased difficulties finding a new job or lower earnings in previously attractive destinations (Armstrong and Taylor, 2000, p. 158). However, net migration flows among regions are more complex. Cebula (2005) finds that both per capita income and expected per capita income have statistically significant positive impacts on interstate migration flows. If a recession is very short, it is unlikely that the expected earnings differential would outweigh the immediate costs of migrating. On the other hand, if relatively large disparities between states persist, then a longer recession will eventually induce workers to migrate as the gap between job opportunities and earnings increases between their home state and a more prosperous destination state.<sup>1</sup>

In terms of the effect of industrial diversity on the duration of a contraction, it is hypothesized that more industrially diverse states experience shorter recessions as the greater number of industries are able to absorb cyclical unemployment, again acting like a shock absorber, cushioning the state from a downturn in economic activity. Regions experience different shocks to output depending on their industry mix because economic shocks tend to affect certain industries more deeply.

## 2. Determinants of state economic activity

Nearly all studies examining regional variations in economic performance find industrial diversity to have a statistically significant effect on economic performance. The difference lies in how they measure industrial diversity. Many studies use industry pro-

---

<sup>1</sup> Along similar lines, if a state recession persists, new small firms will be less likely to locate in that state where the business climate appears to be depressed. While this has not been researched to our knowledge, it is a possibility. Firms may recognize that certain states recover from economic downturns more quickly and this could affect their location decisions. This is an area of future research which we are currently exploring.

portions to indicate the predominance of certain industries.

For example, Garcia-Mila and McGuire (1993) use the shares of employment in certain industries, like farming and non-durable manufacturing, as determinants in explaining employment growth rates and variability at the state level. After controlling for variation in industry growth at the national level and for the composition of fast and slow growth industries at the state level, they find that industrial mix still has a significant effect on 1969-1985 state growth rates.

Owyang et al. (2005) also use employment shares of certain industries as explanatory variables in their analysis of growth rates. They examine growth rates within recessions and expansions separately. Their general conclusion is that industrial mix affects growth rates during recessions but not during expansions. Their results indicate that differences in recession growth rates are predominately influenced by industrial mix, while expansion growth rates are related to differences in demographics and not to industrial composition.

Rather than employment shares, Carlino and Sill (2001) use the share of total output accounted for by certain industries as an independent variable in their regressions. They analyze cycle and trend growth rates separately, and they find that industry mix has a differential effect on real income growth. However, the implications of their study are not clear because the effect of industry mix is sometimes positive and sometimes negative, depending on which region and which growth rate (cycle or trend) they examine.

There are many alternatives to using industry shares to measure diversity, as outlined in Wundt (1992) and critiqued by Wagner (2000). One common measure, and the one that is used here, is the Herfindahl Index, which measures the sum of squared industrial employment shares by state. Formally, this index is  $\sum(E_{is}/E_s)^2$ , where  $E_{is}/E_s$  is the employment share of industry  $i$  in state  $s$ .

The higher this index, the more a state's economy is concentrated in the hands of a few industries, i.e. the less diverse the economy is. Simon and Nardinelli (1992) and Izraeli and Murphy (2003) both use this approach. Simon and Nardinelli (1992) find that in all years studied, except during the Depression years of 1930 and 1931, more industrially diversified cities experienced lower unemployment. They attribute this to the portfolio effect, or in other words, workers can find employment more easily when there are a greater number of industries in the region.<sup>2</sup> During 1930 and

1931, more diversified cities actually experienced higher unemployment. The authors speculate that wages adjust downward more quickly in specialized regions, therefore preventing lay-offs, because of the limited probability that workers will quit and change industries. Only during these two years, did the wage adjustment effect outweigh the portfolio effect.

Similarly, Izraeli and Murphy (2003) find that a lower Herfindahl index (again, indicating higher industrial diversification) is associated with lower unemployment, supporting their thesis that diversification can reduce unemployment. They rely on state-level data and according to their results, a 10-point decrease in the Herfindahl Index is associated with almost a tenth of a percentage point decrease in the unemployment rate. Therefore, the authors support state policies targeting a more diversified industrial base as a means to provide more employment security during economic downturns.<sup>3</sup>

### 3. Nonparametric analysis

This paper employs duration methods based on Kiefer (1988) and Greene (1993). In general, duration analysis is very useful for studying the lengths of certain events or the probability that an event will occur given that it has not already occurred. The literature in economics has drawn from that of other fields in which duration data have been used to study such things as the useful lives of electronic components, the survival times of organ transplant recipients, and the probability of natural disasters occurring. In economics, duration analysis has most commonly been applied to research on lengths of unemployment spells.

The key concept in duration analysis is that this statistical method does *not* involve the unconditional probability of an event taking place (e.g., the probability of an unemployment spell ending at exactly 6

---

activities, usually spread across multiple industries, allow labor to be reallocated more efficiently when one industry experiences a downturn.

<sup>3</sup> The Herfindahl Index is one of several measures of diversity used in empirical analysis (Wagner, 2000). Alternative common measures include the entropy, or log-share, index, the percent durables index and portfolio variance. Taken together, these various measures have both strengths (most notably, ease of computation) and weaknesses. Studies comparing these various measures, however, appear to be very sparse and, while beyond the scope of this paper, would be a fruitful avenue for further research. What little is known suggests that the empirical implications of these various measures are likely to produce similar results. Wundt (1992), for instance, compares the explanatory power of these various measures in predicting regional cyclical employment behavior and finds most of the measures to be statistically significant. That said, we proceed with using the Herfindahl index, largely because this study most closely follows Izraeli and Murphy in terms of the explanatory variables used in the full parametric estimation section.

---

<sup>2</sup> This portfolio effect is similar to the notion of agglomeration economies. A large number of geographically concentrated economic

weeks independent of all other time periods) but rather the conditional probability of an event happening (e.g., the probability of an unemployment spell ending at 6 weeks given that it did not end at 5 weeks). Unconditional probabilities are the emphasis when specification is in terms of probability distributions, but the hazard function specification explained below emphasizes the conditional probabilities (Kiefer, 1988). As Kiefer points out, individuals tend to reason in terms of conditional probabilities anyway, so duration analysis better links the theory to the econometric estimation.

There are two types of duration analysis conducted here. The first is nonparametric analysis, which provides information as to the behavior of the conditional probability of interest. The second type of analysis, conducted below, is full parametric analysis, which considers the determinants of the conditional probability of interest. In this paper, our duration analysis basically involves examining the conditional probability that a recession will end in period  $t$  given that it has not yet ended in period  $t-1$ . The conditional probability function, or the hazard function, is defined as

$$\lambda(t) = f(t) / [1-F(t)], \tag{1}$$

where  $F(t) = \Pr (T \leq t)$  is the cumulative distribution function and  $f(t) = dF(t)/dt$  is the corresponding density function (Kiefer, 1988).  $T$  is a random variable denoting duration and  $t$  can be viewed as the realization of that variable. Thus  $F(t)$  is the probability of a duration  $T$  ending at time  $t$ . Then  $f(t)$  is the associated density. The hazard function, then, is a conditional probability, indicating the likelihood of a recession ending at time  $t$ , i.e.  $f(t)$ , given that the recession has “survived” until time  $t$ , i.e.  $[1-F(t)]$ .<sup>4</sup>

The behavior exhibited by the hazard as  $t$  increases provides clues as to the likelihood of events ending after a particular length of time. For instance, if  $d\lambda(t)/dt > 0$ , then the hazard function is upward sloping and indicates positive duration dependence, meaning the probability of a recession ending increases as the length of the recession increases. If  $d\lambda(t)/dt < 0$ , then the function is downward sloping and indicates negative duration dependence, meaning the probability of a recession ending increases as the length of the recession decreases.

Whether or not the data exhibits positive or negative duration dependence is an empirical question (but one that has significant ramifications for full parametric

analysis – discussed below). To investigate the behavior exhibited by our recession duration data, we follow Kiefer (1988) and construct an empirical measure of our hazard,  $\hat{\lambda}(t)$ , in the following way. First, the recessions (of sample size  $n$ ) are ordered from shortest duration to longest duration,  $t_1 < t_2 < t_3 \dots < t_k$ . The number of completed durations  $k$  is usually smaller than  $n$  due to some observations having the same duration length. For example, there are 17 recessions in our dataset that lasted for three quarters. For this particular dataset,  $n$  equals 148 and  $k$  equals 23.

Then let  $h_j$  be the number of recessions that ended before duration  $t_j$ , for  $j = 1, \dots, k$ . Let  $n_j$  be the number of recessions that did *not* end before duration  $t_j$ :

$$n_j = \sum_{i \geq j}^k h_i \tag{2}$$

Thus, a convenient sample estimator for  $\hat{\lambda}(t)$  is:

$$\hat{\lambda}(t) = h_j / n_j \tag{3}$$

The above expression measures the number of recession completions at  $t_j$  over the number of recession “survivors” at  $t_j$ , thereby mimicking a standard hazard function.

In principle, one could plot  $\hat{\lambda}(t)$  but, as a matter of practical application, in many instances this yields limited direct insights, particularly with relatively small data sets. Instead, the estimated survivor function,  $S(t) = 1 - F(t)$ , is calculated and is interpreted in the opposite way of the hazard function. A downward sloping survivor function indicates positive duration dependence while an upward sloping survivor function indicates negative duration dependence.

The corresponding empirical survivor function is:

$$\hat{S}(t_j) = \prod_{i=1}^j (1 - \hat{\lambda}_i) \tag{4}$$

Following Kiefer (1988), this survivor estimator is obtained by setting the estimated conditional probability of a recession ending at  $t_j$  equal to the observed relative frequency of recessions ending at  $t_j$ .

Finally, the integrated hazard, defined as

$$\Lambda(t) = \int_0^t \lambda(t) dt, \text{ and calculated from our data as}$$

$$\hat{\Lambda}(t_j) = \sum_{i \leq j} \hat{\lambda}(t_j). \tag{5}$$

is also commonly investigated since the resulting plots are smoother and thus easier to interpret than the hazard estimate itself. If the integrated hazard is increasing at an increasing rate, then the series exhibits posi-

<sup>4</sup>1-F(t) is often referred to as the survivor function, typically labeled S(t), in that it measures the probability of a recession lasting or “surviving” until a certain quarter given that it did not end in the previous quarter.

tive duration dependence, if it appears to be increasing at a decreasing rate, then the series exhibits negative duration dependence.

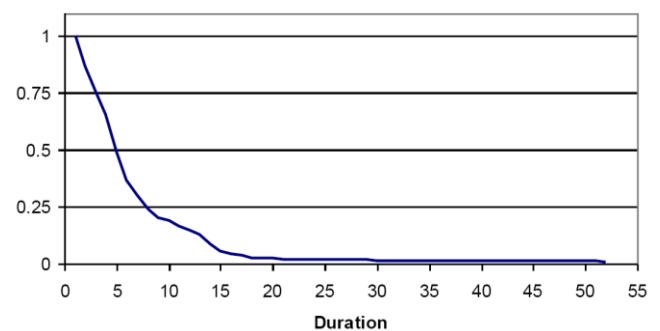
The data we employ here is state level recession duration data that measures the length of time over which a state recession lasts, measured as the number of quarters. This data was recently published by Owyang et al. (2005) and is based on Crone and Clayton-Matthews' (2005) coincident indexes generated for US states. The means of generating these indexes used techniques employed by Stock and Watson (1989).<sup>5</sup> The advantage of the Stock and Watson method is that it provides a single measure of a state's economy by combining several monthly indicators. They specifically base their measure on four indicators: (1) nonagricultural employment, (2) the unemployment rate, (3) average hours worked in manufacturing, and (4) real wage and salary disbursements. These coincident indexes are particularly useful for comparing the length, depth, and timing of state recessions because they utilize consistent economic measures across all 50 states and they are available at a greater frequency than gross state product, for example, which is only available on an annual basis. The coverage of our model is restricted to Owyang et al.'s data, which, as published, is quarterly and covers the period 1979:1 through 2002:4, although for a number of reasons discussed later on, we restrict our attention to a sub-set of this data in our full parametric analysis presented below. Table 1 lists some descriptive statistics for these data.

**Table 1.** Recession duration data (in quarters)

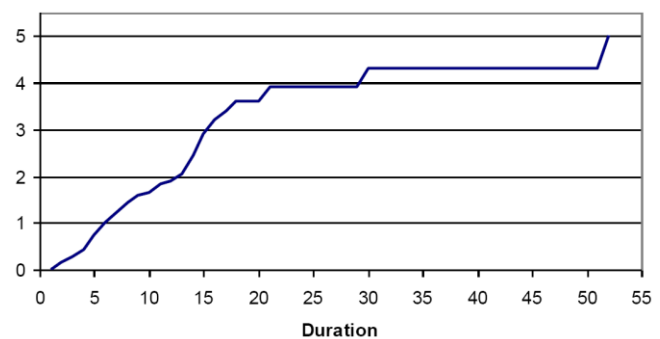
	All Observations	Without Alaska & Hawaii's censored recessions
Mean	7.05	6.58
Median	5	5
Maximum	52	21
Minimum	2	2
Std. Dev.	5.95	4.25
N	148	146

Using this state level duration data, we calculated survivor and integrated hazard estimates, depicted in Figures 1 and 2 respectively.<sup>6</sup> From the survivor function, it appears that our data exhibits positive duration

dependence, suggesting that a recession is less likely to "survive" the longer it lasts. The integrated hazard appears to be increasing at an increasing rate over most of the range (except for two unusually long recessions) and so indicates positive duration dependence. This would seem a logical outcome for an economy encountering cyclical downturns. However, near the end of the integrated hazard function, the integrated hazard's slope, while still positive, appears to be increasing at a decreasing rate, indicating that after a certain point, the longer a recession lasts, the more likely it is to continue rather than end. While it is beyond the scope the current paper to test for certain, this might then be suggesting that for these states, the downturn may not be so much cyclical but structural.



**Figure 1.** Survivor function



**Figure 2.** Integrated hazard function

That said, the observations within our dataset causing this change in the shape of the integrated hazard are two recessions with durations of 30 and 52 quarters (for Hawaii and Alaska respectively), well in excess of other observed recession spells. While this suggests these observations to be outliers, Owyang et al. (2005) provide no information as to when these recessions actually ended, if ever. Therefore, instead of removing them as would typically be done with out-

<sup>5</sup> Stock and Watson's index is the latent factor estimated in a dynamic single-factor model using the Kalman filter.

<sup>6</sup> For completeness, the numerical calculations are presented in Table A2 of the appendix.

liers, they are treated as censored observations.<sup>7</sup> Censoring is a problem that is typically unavoidable in duration analysis so procedures have been developed to address such issues (Kiefer, 1988; Greene, 1993), and our estimation accounts for this censoring.

While this nonparametric analysis is beneficial, it would be much more complete if characteristics of the state economies could be included to explain variation in recession length. Such analysis requires full parametric maximum-likelihood estimation with an appropriate underlying probability distribution so as to interpret the direction and magnitude of each variable's impact on recession duration. We now turn our attention to such estimation.

#### 4. Full parametric estimation

The exponential, Weibull, and log-logistic are the most commonly employed distributional functions in duration analysis (Kiefer, 1988). Each exhibits different hazard function behavior. The hazard function of the exponential distribution, for instance, is constant over time and therefore reflects no duration dependence, a characteristic not indicated in our data. The hazard function of the Weibull distribution is either monotonically increasing (exhibiting positive duration dependence) or decreasing (negative duration dependence). Finally, the hazard function for a log-logistic distribution is non-monotonic and therefore, duration dependence varies based on duration itself.<sup>8</sup>

Since Figures 1 and 2 suggest positive duration dependence, we employ the Weibull distribution in our full parametric analysis. This has certain advantages as well, most notable of which is that it is relatively straightforward to quantitatively assess the impact of a given independent variable on the duration of a recession, something not easily or meaningfully possible with the log-logistic function (see Greene, 1993).<sup>9</sup>

#### 5. Model specification and data

Based on similar existing studies, mainly Izraeli and Murphy (2003), we conjecture that a number of factors will likely affect the duration of a recession in a particular state. The factor of particular interest in this

research effort is industrial diversity. Traditional Ricardian trade theory suggests that a state should specialize in one or more industries in which it has a comparative advantage (Armstrong and Taylor, 2000). However, this leaves a state susceptible to developments in those industries that occur outside the state and therefore outside its control. For example, the price of energy and other inputs may change, environmental policies may be tightened, or new innovations may reduce the competitiveness of a particular industry. Therefore, greater industrial diversity, rather than specialization, would theoretically help insulate a state from the economic influences outside of its control by giving it a wider array of industries to rely upon for stabilizing demand and employment.

The following general specification includes industrial diversity along with other factors that are expected to influence the duration of recessions. Descriptive statistics for all variables are in Table 2.

$$DURATION = f(DIV, DIVCH, U, RPICH, NWT, TEEN, OVER65, POP, POPCH, DENS) \quad (6)$$

**Table 2.** Descriptive statistics

Variable	Mean	Std. Dev.	Min.	Max.
DURATION	7.08	6.00	2.00	52.00
DIV	318.00	47.14	236.6	470.77
DIVCH	2.55	4.84	-8.13	36.26
U	5.96	1.83	2.22	12.43
RPICH	-0.98	2.65	-	4.01
NWT	12.74	10.51	0.74	63.95
TEEN	12.72	1.70	9.13	16.10
OVER65	11.54	2.10	2.83	18.27
POP	14.92	0.99	12.91	17.24
POPCH	1.59	1.93	-1.07	10.57
DENS	170.41	239.95	0.71	1050.85
N	145			

DURATION, analyzed above in the nonparametric analysis, is again the length of time, measured in quarters, over which a state recession lasts.

Our industrial diversity measures (DIV and DIVCH - discussed below) use industry-level employment data. Problems arise, then, due to the fact that industry data based on the Standard Industrial Classification (SIC) runs through to 1997. For the periods 1998 to 2002, industry classifications are based

<sup>7</sup> Censored observations are those that have either an unknown beginning time prior to the observation period or an unknown ending time after the observation period.

<sup>8</sup> See Kiefer (1988) and Greene (1993) for details as to the implementation of each maximum likelihood estimation, including how explanatory variables are introduced for parameter estimation.

<sup>9</sup> For the sake of robustness, we estimated our model using both the exponential and log-logistic functions and got qualitatively similar results. These results are available upon request from the authors.

on the newly implemented North American Industrial Classification system. Since this will significantly disrupt the DIVCH time series, we will estimate our model covering the recessions recorded between 1979 and 1997.

DIV is the level of industrial diversity in a state in the year prior to the start of the recession. Industrial diversity is measured by the Herfindahl index (discussed above) calculated from the employment shares for each industry by state over time. These data come from the *County Business Patterns*, the Census Bureau's annual report on business activity. Table A1 in the appendix lists the full Web site addresses of all sources. A higher Herfindahl index indicates a less industrially diverse state while a lower index indicates greater industrial diversity. A priori, it is expected that states with greater industrially diversity can better weather an economic downturn and therefore experience shorter recessions.<sup>10</sup>

DIVCH is the percent change in industrial diversity from the year prior to the start of the recession to the year in which the recession occurred.<sup>11</sup> Both the change in diversity as well as the level of diversity is included in the estimating equation because the two variables capture different effects and both could have important influences on recession duration. We hypothesize that increases in industrial diversity should have a negative effect on the duration of recessions. Since the Herfindahl index decreases when diversity increases, a state that experiences a decrease in its Herfindahl index will experience shorter recessions. Thus, a positive sign on DIVCH is expected.

There are several compelling reasons for considering the change in industrial diversity as a possible determinant of recessionary length. Evidence is mounting that job growth and decline patterns differ significantly between recessionary periods and expansionary periods. For instance, Davis et al. (1996, p. 83) have found that job destruction (the elimination of jobs) rates rise by 2.5 percent per quarter during recessionary periods relative to expansionary periods. By contrast, job creation rates (the addition of employment) fall by only 0.7 percent per quarter during recessionary periods relative to expansionary ones. This coun-

ters prevailing wisdom regarding business-cycle behavior, which presumes that the rate of increase in job destruction matches the rate of decline in job creation. Moreover, Davis et al. (1996, p. 39) have found that employment re-allocation flow rates vary significantly between industries and, importantly, job creation varies substantially from industry to industry. Some industries tend to be very well insulated from recessionary downturns such that job creation can offset, and in some cases more than offset, job destruction, whereas other industries are not so well insulated. These cyclical and sectoral changes in job flows that will quite likely alter the diversification (or concentration) of industry within a state may then lead to significant impacts on the duration of a recessionary spell. For instance, if the rate of job destruction in "slow to re-allocate" industries is relatively high for a given state and, in turn, those industries represent a significant share of total employment, we would observe increasing employment concentration (i.e. an increase in DIVCH). This might then make it more difficult for that state to recover. Moreover, if a state is diversifying, job creation in a state's non-traditional sectors that are "high job creation" industries may shorten the duration of a state's recession. Hence, job creation may help offset some job destruction in other sectors in the economy.

U is the state unemployment rate in the year prior to the start of the recession and comes from the Bureau of Labor Statistics. The one-year lagged value for unemployment is necessary because recession duration, the dependent variable, is constructed using the current unemployment rate. The effect on duration here is actually ambiguous. On the one hand, a higher state unemployment rate may prompt longer recessions as a larger portion of the labor force is seeking fewer work opportunities. Hence, many people may be out of work longer. Due to the immediate costs of migrating in the short run, unemployed workers are more likely to stay where they are rather than to move to find employment. This keeps the unemployment rate higher and contributes to longer recessions. On the other hand, it's possible that the deeper a recession is, the quicker an economy can "snap back." Therefore, higher unemployment rates may be associated with shorter recession events. Empirical verification is thus necessary.

RPICH is the percent change in real per capita income at the state level from the year prior to the start of the recession to the year in which the recession occurred. The data for this variable come from the Regional Economic Information System (REIS), a subdivision of the Bureau of Economic Analysis. The change in state income is expected to be negatively related to

<sup>10</sup> Izraeli and Murphy (2003) and Simon and Nardinelli (1992) both use this approach. Izraeli and Murphy (2003) find that a higher Herfindahl index (indicating higher industry concentration) is associated with higher unemployment, supporting their thesis that diversification can reduce unemployment. Similarly, Simon and Nardinelli (1992) find that in all years studied, except during the depression years of 1930 and 1931, industrially more diversified cities experienced lower unemployment.

<sup>11</sup> For recessions that spanned more than one year, the values for those variables are averages of all years during which the recession lasted.



recession duration as increasing incomes would be more likely to lead to shorter recessions while decreasing incomes would likely lengthen recessions. The change in income rather than the income level is used because it is more consistent with how recessions are defined. At any given point in time, the income level varies greatly among states, but this does not necessarily determine which states are experiencing recessions versus expansions. The measure that matters more is whether income is increasing or decreasing.

Following Izraeli and Murphy (2003), three demographic variables are included in the model to account for different population characteristics among states. All three are calculated from U.S. Census data. NWT is the percentage of the working age population that is non-white. More specifically, this is calculated as the percentage of 15- to 64-year-olds who are of any race other than white. This variable is expected to be positively associated with recession duration since this group tends to experience higher unemployment rates (Izraeli and Murphy, 2003).

TEEN is calculated as the percentage of 15- to 64-year-olds who are 15 to 19 years of age. The expected effect of TEEN on recession duration is unclear. Like non-white workers, teenage workers tend to experience higher unemployment rates than the general population, so TEEN could be positively related to duration. On the other hand, a larger proportion of teenage workers mean a smaller labor force, which should lead to a lower unemployment rate and thus a shorter recession.

The third demographic variable, OVER65, is included to represent the proportion of the total population that is 65 years of age or older. The a priori expectation for its effect on duration is also unclear. The per capita income and consumption level of this population group is relatively low, so this could contribute to longer recessions given the weaker demand. On the contrary, a higher proportion of retired individuals means a smaller labor force, which would likely cause lower unemployment and shorter recessions.

Finally, measures of state population (POP), population change (POPCH), and population density (DENS) are added to the model. POP is the log of total population in each state in the year prior to the start of the recession. The data for total population are reported by REIS, and this variable could affect the length of recessions in different ways. A higher population could be an indicator of economies of scale, making a state's businesses more competitive and thus its recessions shorter in duration. In contrast, population could be associated with a higher cost of living and/or more generous welfare payments, which would contribute to longer recessions.

POPCH is simply the percent change in a state's total population from the year prior to the start of the recession to the year in which the recession occurred. It is expected to be negatively associated with recession duration because the in-migration of people tends to increase the proportion of a state's labor force that is likely to be employed.

DENS represents population density or the average number of persons per square mile in a state. It indirectly reflects production costs because a higher population density can lower transportation, communication, and labor costs, for example. If production costs are lower, then state's industries can be more competitive and contribute to shorter recessions. Conversely, areas with sparse populations are more likely to have higher production costs as well as fewer businesses to absorb laid-off workers. So a priori, the sign on DENS is expected to be negative, meaning a higher population density is associated with shorter recessions.<sup>12</sup>

Before proceeding, we investigated a scatterplot of duration against diversity (one of our key variables). From this analysis, three observations (all associated with the state of Nevada), in addition to the two censored ones discussed above, appeared to be well outside the prevailing trends exhibited by the rest of the data. Nevada's industry is very highly concentrated and thus has a much higher Herfindahl index relative to the other 49 states. While Nevada's Herfindahl index values were very high, their recession durations were relatively short and it was clear that these three observations were outliers. Therefore, Nevada's three recessions were dropped from the dataset for the full parametric analysis. These observations represent, then, state-level recessions that occurred between 1979:1 and 1997:4, again as published by Owyang et al. (2005), regardless of the state.<sup>13</sup> In other words, there is no set number of recessions per state. For example, one state may have had only one recession during this time period while another state may have had five.

Before discussing the full parametric results, it is advisable to address the potential for collinearity between independent variables as the presence of this

<sup>12</sup> More detailed descriptions of the data sources for each variable are listed in Table A1 of the Appendix.

<sup>13</sup> Since we employ Owyang et al.'s (2005) data to the greatest extent possible, one might reasonably presume that we in fact have a population of recession data by state. However, in principle, we do not. Recessions occurred in other states in other countries over this 1979:1 to 1997:4 period and states within the United States experienced recessions in periods prior to 1979 as well. Moreover, any given recessionary observation represents one realization of a recession event presumably drawn from a population of possible recessionary events. Hence, we are in all likelihood better off treating the available data from Owyang et al. (2005) as a sample of recessionary data.

would result in a downward bias in estimated standard errors. Hence, we run the risk of concluding a statistically meaningful variable is statistically insignificant. To address this, a correlation matrix is presented in Table 3 below. For the most part, there appears to be very little correlation between independent variables. In fact, the highest degree of correlation appears to be between DIV and POP at 28 percent which is relatively small and not likely to pose much difficulty in the resulting estimations presented below.

### 6. Estimation results

Estimation results are presented in Table 4.<sup>14</sup> The table lists each coefficient with its t-statistic in parentheses as well as the marginal effect of a given independent variable's impact on the duration of a recession.<sup>15</sup> Specifically, these marginal effects are elasticities, a common and convenient measure of quantitative impact, associated with a given independent variable. In effect, elasticity measures the percent change in the duration of a recession resulting from a percentage change in a given independent variable. Mathematically, this effect is derived as follows. Following standard implementation, a full parametric duration analysis employing the Weibull distribution results in the following expression for the expected duration of a given event, denoted E(T):

$$E(T) = \frac{1}{\rho t^{\rho-1} [\exp(-\mathbf{x}'\boldsymbol{\beta})]^\rho} \tag{7}$$

where  $\rho > 0$  is a "shape parameter" measuring the degree of duration dependence in the Weibull formulation,  $\mathbf{x}$  is a vector of independent variables (discussed above) and  $\boldsymbol{\beta}$  is a vector of coefficients determined through maximum likelihood estimation.<sup>16</sup> Taking the natural log of (7) we get:

$$\ln E(T) = -\ln(\rho) - (\rho - 1)\ln(t) + \rho\mathbf{x}'\boldsymbol{\beta} \tag{8}$$

Differentiating (8) with respect to a given independent variable  $x_i$  yields:

$$\frac{1}{E(T)} \frac{\partial E(T)}{\partial x_i} = \rho\beta_i \tag{9}$$

The left-hand side of (9) is by definition a semi-elasticity. Therefore, measuring the percent change in recession duration that results from a unit increase in a given independent variable  $x_i$  involves multiplying the estimated shape parameter by the estimated coefficient on  $x_i$ . To calculate an elasticity, one need only multiply (9) by  $x_i$ . The most common way of doing so is to multiply by the mean value of  $x_i$ <sup>17</sup>:

$$\frac{\bar{x}_i}{E(T)} \frac{\partial E(T)}{\partial x_i} = \rho\beta_i \bar{x}_i \tag{10}$$

Turning attention to the estimated results, first note that the joint hypothesis that all coefficients are jointly equal to zero can be rejected because the Wald  $\chi^2$  statistic, indicating goodness of fit, is statistically significant. A significant Wald  $\chi^2$  statistic indicates that the coefficients on the independent variables are *not* all jointly equal to zero. In addition, the estimated "shape" parameter,  $\rho > 0$ , which measures the degree of duration dependence in the Weibull formulation, of 1.86 is statistically significantly different from one, indicating that the series exhibits positive duration dependence.

Interestingly, and contrary to much of the literature, the level of diversity (DIV) was not a significant factor in determining recession length. This result is robust in that even if the change in diversity variable (DIVCH) is removed from the model, the level of diversity does not turn out to be significant. However, the change in diversity (DIVCH) is positively associated with recession length. Recall that the Herfindahl index is higher when industrial concentration is higher. These results indicate that when industrial concentration is increasing over the year prior to the start of a recession, the duration of the recession is longer. When industrial diversity is increasing, recession durations are shorter. So according to these results, it is not the initial level of industrial diversity

<sup>14</sup> The regressions have been corrected for heteroskedasticity using White's correction. STATA 8.0 was used to perform the analyses.

<sup>15</sup> For comparison, ordinary least squares regression analysis was performed on these data also and the results regarding diversity were the same. That is, DIVCH was positive and significant while DIV was not statistically significant. These results, too, are available upon request.

<sup>16</sup> Note that the expected duration, E(T) of an event is in effect the inverse of the Weibull hazard function:  $\lambda(t) = \lambda(t) = \rho t^{\rho-1} \lambda_0^\rho$  where  $\lambda_0^\rho$  is the baseline hazard function. The independent variables are introduced through the baseline hazard. The most common means of doing so is to define  $\lambda_0^\rho = \exp(-\mathbf{x}'\boldsymbol{\beta})$ . Moreover, it can be shown that if  $\rho = 1$ , the resulting hazard function exhibits no duration dependence, suggesting the exponential function is a reasonable density to employ. If  $(\rho \neq 1)$ , then the function exhibits positive (negative) duration dependence. See Kiefer (1988), Greene (1993), and Nadeau

(1997) for a more complete discussion of duration techniques and empirical implementation.

<sup>17</sup> Note that if an independent variable is already measured in natural logs, as is POP,  $\rho\beta_i$  measures an elasticity.

**Table 3.** Correlation matrix for independent variables

	DIV	DIVCH	U	RPICH	NWT	TEEN	OVER65	POP	POPCH	DENS
DIV	1.00									
DIVCH	-0.18	1.00								
U	-0.06	-0.16	1.00							
RPICH	-0.15	0.19	0.08	1.00						
NWT	-0.10	0.00	0.12	0.05	1.00					
TEEN	-0.15	-0.31	0.23	-0.20	-0.10	1.00				
OVER65	0.12	0.12	-0.28	0.15	-0.23	-0.23	1.00			
POP	-0.28	0.00	0.05	0.13	0.24	-0.09	0.18	1.00		
POPCH	-0.01	0.07	-0.13	-0.08	0.19	-0.19	-0.19	-0.08	1.00	
DENS	-0.19	0.11	-0.08	0.18	0.08	-0.16	0.24	0.25	-0.22	1.00

**Table 4.** Full parametric maximum-likelihood estimation results (t-statistics in parentheses.)

Parameter	Weibull	Elasticity (evaluated at variable's mean)
DIV	0.01 (0.79)	5.91
DIVCH	0.036** (2.17)	0.17
U	0.05 (-1.48)	0.55
RPICH	-0.043** (-2.15)	0.08
NWT	0.01** (2.26)	0.24
TEEN	0.01 (0.37)	0.24
OVER65	0.05 (1.53)	1.07
POP	-0.15*** (-2.53)	-0.28
POPCH	0.13*** (4.81)	0.50
DENS	0.0001 (1.22)	0.03
Wald $\lambda^2$	64.45***	
shape parameter	$p = 1.86$	

\*\*\* indicates significance at the 1% level  
 \*\* indicates significance at the 5% level  
 \* indicates significance at the 10% level

that matters but whether industrial diversity is increasing or decreasing.<sup>18</sup> This result, indicating a type of “accelerator effect,” appears to be an economically meaningful effect as well. According to Table 4, when evaluated at DIVCH’s mean, a relatively small 10 percent increase (decrease) in the rate of DIVCH growth alone (akin to increasing from a 3.0 percent growth to 3.3 percent growth) results in a 1.7 percent increase (decrease) in the length of a state’s recession. Hence, an acceleration in employment concentration will therefore result in longer recessions. Conversely, efforts to promote diversity (reduce DIVCH) will result in shorter recessions. In light of what we know about job creation and destruction then, it would appear that our results suggest that state economies that are more diversified are able to absorb jobs into those higher job creation sectors by virtue of the fact that a more diverse economy will likely have such sectors present.

At first glance, the results with respect to the level of diversity may appear to be inconsistent with previous research. For example, Izraeli and Murphy (2003) report that the level of diversity reduces unemployment. With unemployment being a key ingredient of a recession, one might expect that the level of diversity should reduce the duration of recessions, but our results find an insignificant influence.

<sup>18</sup> It should be pointed out at this juncture that there are two common means of estimating duration models. One method is to estimate the hazard function directly. When this is done, the resulting coefficients reflect the marginal impact each one has on the conditional probability of an event occurring given that it has not occurred as of yet. Had we done so, we would have gotten a negative coefficient on DIVCH, for instance. That is, reduced diversity reduces the likelihood of a recession ending in period t given that it lasted until t. Alternatively, one could estimate the survivor function directly – which is more closely akin to the notion of duration. Given our specific interest in duration, and given that the resulting marginal effects are essentially the reciprocal of the first method, we chose to model the survivor function directly.

However, there is an important difference between this study and previous research, including Izraeli and Murphy. Most previous research examine one continuous time period of business cycles while this paper isolates the recessionary periods only. There is evidence that economic agents behave differently during recessions than during expansions. For instance, unemployment during expansions is dominated by new entrants and reentrants into the labor market while unemployment during recessions is dominated by layoffs (for this and other examples, see Chapters 5 and 6 of Davis et al., 1996). In addition, Owyang et al. (2005) find that industrial mix affects growth rates differently depending on whether they examine recessions or expansions. Thus, the finding that diversity level is an insignificant influence may stem from which time periods are included in the analysis. The result may be different for expansionary time periods.

Other variables were also found to be significant determinants of recession duration. The change in real per capita income (RPICH) is statistically significant and is negatively associated with duration. In other words, when real income is increasing, recessions are shorter in length. Indeed, a relatively small 10 percent increase in per capita income growth shortens the duration of a recession by 1 percent. This result is expected since the change in income is an indicator commonly used to define and date changes in the business cycle. If incomes are increasing, then an economy has most likely reached its turning point in a recession.

A variable found to have a significant determinant of recession length is the percentage of the working-age population that is non-white (NWT). As expected, it is positively associated with longer recessions, although the quantitative effect is quite small. The non-white population tends to experience higher levels of unemployment, as Izraeli and Murphy (2003) find in their study also, and this contributes to longer recessions.

Finally, both population (POP) and population change (POPCH) are statistically significant factors, but their coefficients have opposite signs. The opposite direction of their signs is an interesting result. A large total population in the year prior to the start of a recession is associated with shorter recessions, but when the state's population is increasing, recessions are longer. The sign on total population was expected since a larger population may be an indication of economies of scale in a state, making its businesses more competitive. The sign on population change was not expected since a growing population is sometimes seen as a sign of a thriving economy. It is possible though that a state might not have enough jobs to ac-

commodate in-migration and thus increases in population contribute to longer recessions. The signs on total population and population change are opposite of what Izraeli and Murphy (2003) report, but again, this can likely be attributed to the fact that recessions are isolated here, while all recessions and expansions were used in their study. Furthermore, when one continuous time period is examined, expansions comprise a larger proportion of time than do recessions.

In general, these results follow the a priori expectations. The sign on population change is one exception. The results also generally support the idea that diversification is a reasonable goal because increasing diversification (and/or slowing concentration) appears to be associated with shorter recessions.

An important issue arises as a result of the manner in which we have currently constructed DIVCH. Recall that this variable measures the change in industrial diversity from the year prior to the start of the recession to the year in which the recession occurred. However, there are a couple of potential problems with this that need to be addressed.

First, it is quite possible that just prior to, or at the beginning, of a given recession, a state might experience a substantial shock to its economy if a major industry within that state experiences large employment lay-offs. Hence, the recession period itself may in effect be causing DIVCH to change, clouding the causality as implied by our current model. Indeed, the data suggesting how job flow patterns change during recessions relative to expansions suggests this possibility.

Second, as a more extreme example, it is possible that if a major industry in an economy were to exit in the year just prior to the start of a recession, one could see *more* industrial diversity during the recessionary period as employment in the remaining smaller industries may be more evenly distributed. Hence, we might have a result which says that massive lay-offs in a sector just prior to a recession, resulting in an improvement in industrial diversity, might shorten a recession. Such an outcome is not very likely given that 1) we are dealing with state-level data and for the most part, US states are fairly diversified, and 2) we do control for state-level unemployment rates anyway. However, it is nonetheless beneficial to address this point, as well as the first point. By focusing on a calculated measure of DIVCH that 1) was sufficiently distanced (in time) from the beginning of the recessionary event and 2) represented primarily expansionary periods where the diversity index was changing largely as a result of improving business conditions (i.e. where job creations was out-pacing job destruction), we can lessen the concern over endogeneity as well as

lessen the concern that a major sector will exit a state's economy.

To address these issues then, we constructed two alternative measures of DIVCH. The first, DIVCH\_AVG, measures the average change in DIV over the three years prior to the start of a given recession. This measure gives an indication of how DIVCH has behaved on average over time. While mitigating the issues raised above, this measure may not completely remove the endogeneity as a state's economy may experience some industrial re-structuring within a year of the start of a formal recession as some industries may have different cyclical behaviors. To address this, we calculated DIVCH\_LAG3, which measures the change in industrial diversity three years prior to the start of the recession relative to the level of diversity two years prior to the start of a recession.<sup>19</sup> These results are presented in Table 5. With respect to the change in diversity's impact on recession duration, the results are qualitatively in line with earlier results. In both cases, DIVCH\_AVG and DIVCH\_LAG3 indicate that increasing (decreasing) industrial concentration lengthens (shortens) the duration of recessions. Indeed, focusing on DIVCH\_LAG3, a 10 percent acceleration (deceleration) in the concentration two years prior to the start of a recession increases (decreases) the duration event by 1.7 percent.

## 7. Conclusion

The objectives of this paper were 1) to test whether state-level recessions are more likely or less likely to persist as they increase in duration, and 2) to discover what factors and characteristics of state economies influence the duration of recessions, testing the influence of industrial diversity in particular. Regarding the first goal, the main finding is that most recessions are *more* likely to end as their duration increases given that they have not ended already. With respect to the second objective, our empirical results indicate that numerous factors have statistically significant influences on the duration of recessions. These factors in-

clude the percent growth in industrial diversity, unemployment, real income per capita income growth, the proportion of non-white workers, total population, and the change in total population.

The most interesting and noteworthy finding of this study is that the initial level of industrial diversity in a state is not what significantly influences recession duration. Rather it is whether or not industrial diversity is increasing. In states where diversity is increasing, recessions are shorter in duration. In states where diversity is decreasing, recessions are longer in duration. This research finding is a hopeful message for states that are relatively more concentrated since it seems to indicate that their initial level of diversity is not as important as their change in diversity. Therefore, this could mean that as long as a state can accelerate its industrial diversification, they may be able to reduce the duration of their recessions.

Precisely how to increase diversity, though, is a challenging policy dilemma. Aiming to decrease a state's most prominent industry in order to even out industry proportions is of course, not very logical. Nor is it logical to attempt to foster industries for which a state does not already have some related potential and capabilities. As a simplistic example, a state should not try to increase its mining industry if it does not already have minerals abundantly available. There may be a good reason why some industries are very small in proportion. Each state should assess its strengths and capabilities when deciding which industries to target for expansion. Similarly, each state should identify which industries are most likely to contract, assuming that not all of the new employment in the expanding industries will come from in-migration. Then, in order to ease the reallocation of labor, policy initiatives such as job training could be pursued.

Before promoting active policy intervention, however, it is important to recall the results of the nonparametric analysis in context with the classical argument against the use of policy. The nonparametric analysis suggests that a recession is more likely to end the longer it persists. Therefore, a state should evaluate how long their recession has already lasted and consider whether policy intervention is necessary.

Targeting diversification though, does not appear to have a downside in terms of real per capita income tradeoffs, according to Izraeli and Murphy (2003). This finding, in addition to the general view that diversification reduces instability (Wundt, 1992), suggests that a policy aimed at diversifying a state's industrial base is not likely to have negative repercussions even if the recession should happen to end before the policy takes effect. This cannot be said with certainty however, unless expansionary periods are researched as well.

<sup>19</sup> The selection of the three-year limit in the construction of these alternative variables is largely a pragmatic one. Ideally, a larger lag may be desirable however data limitations tend to restrict such a strategy. Our state level industrial employment data is only available back to 1977 (as is our available recession data). Hence, when we construct DIVCH based on lags of employment data, we are in effect losing some recession observations. In fact, our three year lag results in the loss of 27 recession observations, or about 19 percent of our available data. While this is a substantial percentage it is necessary given the importance of the potential endogeneity issue. However, further restrictions on the data that would result from using additional lags would substantially reduce the power of the maximum likelihood estimates generated here.

**Table 5.** Full parametric results - alternative measures of DIVCH (t-statistics reported in parentheses)

Parameter	Average DIVCH		DIVCH Lagged 3 Years	
	Weibull	Elasticity (evaluated at variable's mean)	Weibull	Elasticity (evaluated at variable's mean)
DIV	0.0020 (1.60)	1.27	0.0018 (1.33)	1.11
DIVCH_AVG	0.052** (2.08)	0.26	----- -----	
DIVCH_LAG3	----- -----		0.034*** (2.79)	0.17
U	0.05 (1.34)	0.54	0.04 (1.22)	0.48
RPICH	-1.15 (-0.55)	2.22	-0.36 (-0.19)	0.72
NWT	0.01 (1.10)	0.13	0.01 (1.34)	0.25
TEEN	-0.07 (-1.62)	-1.78	-0.06 (-1.49)	-1.65
OVER65	-0.02 (-0.48)	-0.35	-0.01 (-0.34)	-0.23
POP	-0.04 (-0.62)	-0.08	0.01 (0.02)	0.02
POPCH	0.13*** (4.02)	0.01	0.14*** (4.57)	0.01
DENS	0.0004 (1.63)	0.12	0.0003 (1.33)	0.10
Wald $\lambda^2$	60.47***		63.13***	
shape parameter	$p = 1.97$	.	$p = 2.00$	.

\*\*\* indicates significance at the 1% level

\*\* indicates significance at the 5% level

\* indicates significance at the 10% level

Thus an important direction for future research would be to perform a similar duration analysis on expansionary time periods rather than recessionary periods. If job creation and destruction vary considerably over the business cycle as Davis et al. (1996, p. 83) suggests, then industrial diversity may have different influences over the business cycle as well. It may be that an entirely different model would be necessary as determinants of expansion duration may differ from

determinants of recession duration. Even so, it would still be interesting to see a comparison between recessions and expansions in terms of how diversity influences the duration of the downturns and upswings in the economy.

An additional avenue for future research would be to differentiate state recessions that appear to be coincident with national recessions and those that are not. Doing so would offer insights as to whether or not

a more diverse economy insulates a state from general macroeconomic shocks versus state-specific economic shocks. This may be of particular interest to those state economies that are more exposed to the national or international economy such as states that import a significant amount of crude oil from abroad, for instance. Doing this with our current dataset would be difficult at best however. Of the 145 recessionary observations here, only 31 appear not to coincide with national recessions and duration models generally require relatively large amounts of data. Doing so, therefore, would require substantial data collection by either generating state recessionary data prior to 1977 or later than 1997 which is beyond the scope of this study. Thus, while this study has improved our understanding of recession duration, additional research here would be valuable.

## References

- Armstrong, H. and J. Taylor. 2000. *Regional Economics and Policy*, Third Edition. Malden, MA: Blackwell Publishers.
- Carlino, G. and K. Sill. 2001. Regional income fluctuations: Common trends and common cycles. *Review of Economics and Statistics* 83(3): 446-456.
- Cebula, R. 2005. Internal migration determinants: Recent evidence. *International Advances in Economic Research* 11(3): 267-274.
- Crone, T. M. 2005. An alternative definition of economic regions in the United States based on similarities of state business cycles. *Review of Economics and Statistics* 87(4): 617-626.
- Crone, T. M. and A. Clayton-Matthews. 2005. Consistent economic indexes for the 50 States. *Review of Economics and Statistics* 87(4): 593-603.
- Davis, S. J., J. C. Haltiwanger, and S. Schuh. 1996. *Job Creation and Destruction*. Cambridge: The MIT Press.
- Garcia-Mila, T. and T. J. McGuire. 1993. Industrial mix as a factor in the growth and variability of states' economies. *Regional Science and Urban Economics*. 23: 731-748.
- Greene, W. 1993. *Econometric Analysis*. New York: MacMillan.
- 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.
- Kiefer, N. M. 1988. Economic duration data and hazard functions. *Journal of Economic Literature* 26: 646-679.
- Nadeau, L. W. 1997. EPA effectiveness at reducing the duration of plant-level noncompliance. *Journal of Environmental Economics and Management* 34: 54-78.
- Owyang, M. T., J. Piger, and H. J. Wall. 2005. Business cycle phases in U.S. States. *Review of Economics and Statistics* 87(4): 617-626.
- Simon, C. J. and C. Nardinelli. 1992. Does industrial diversity always reduce unemployment? Evidence from the great depression and after. *Economic Inquiry* 30(2): 384-397.
- Stock, J. H. and M. W. Watson. 1989. New indexes of coincident and leading economic indicators. *NBER Macroeconomics Annual* 351-394.
- Wagner, J. E. 2000. Regional Economic Diversity: Action, Concept, or State of Confusion. *The Journal of Regional Analysis and Policy* 30(2):1-22.
- Wagner, J.E. and E. M. Elder. 2004. Recession and rainy day funds in the United States: What are the odds your state is saving enough? Duquesne University Working Paper.
- Wundt, B. D. 1992. Reevaluating alternative measures of industrial diversity as indicators of regional cyclical variations. *The Review of Regional Studies* 22(1): 59-73.

**Appendix Table A1.** Data descriptions and sources

<b>Variable</b>	<b>Description</b>	<b>Source</b>
<b>DURATION</b>	Number of quarters over which a given state is deemed to be in recession.	Owyang et al. (2005)
DIV	Industrial diversity in a state in the year prior to the recession. Calculated using the Herfindahl Index.	County Business Patterns, <a href="http://www.census.gov/epcd/cbp/view/cbpview.html">www.census.gov/epcd/cbp/view/cbpview.html</a>
DIVCH	Change in industrial diversity. Calculated as the change in the Herfindahl index from year prior to recession to year of recession.	County Business Patterns, <a href="http://www.census.gov/epcd/cbp/view/cbpview.html">www.census.gov/epcd/cbp/view/cbpview.html</a>
U	State unemployment rate in the year prior to the recession.	Bureau of Labor Statistics, <a href="http://www.bls.gov/">www.bls.gov/</a>
RPICH	Change in state real per capita personal income. Change calculated as log difference in real income from year prior to recession to year of recession. Real income calculated from nominal income using annual CPI based on All Urban Consumers.	Regional Economic Information System, <a href="http://www.bea.doc.gov/bea/regional/reis/(income)">www.bea.doc.gov/bea/regional/reis/(income)</a> Bureau of Labor Statistics, <a href="http://www.bls.gov/cpi/home.htm">http://www.bls.gov/cpi/home.htm</a> (CPI)
NWT	Percentage of a state's working-age population (15-64 years) that is non-white. Calculated from Census data.	U.S. Census Bureau, <a href="http://www.census.gov/popest/archives">www.census.gov/popest/archives</a>
TEEN	Percentage of a state's working-age population that is 15-19 years of age. Calculated from Census data.	U.S. Census Bureau, <a href="http://www.census.gov/popest/archives">www.census.gov/popest/archives</a>
OVER65	Percentage of a state's total population that is 65 years or older. Calculated from Census data.	U.S. Census Bureau, <a href="http://www.census.gov/popest/archives">www.census.gov/popest/archives</a>
POP	Log of total state population in the year prior to the recession.	Regional Economic Information System, <a href="http://www.bea.doc.gov/bea/regional/reis/">www.bea.doc.gov/bea/regional/reis/</a>
POPCH	Rate of population growth in a state. Change calculated as log difference in annual population from year prior to recession to year of recession.	Regional Economic Information System, <a href="http://www.bea.doc.gov/bea/regional/reis/">www.bea.doc.gov/bea/regional/reis/</a>
DENS	Population density. Calculated as persons per square mile.	Regional Economic Information System, <a href="http://www.bea.doc.gov/bea/regional/reis/">www.bea.doc.gov/bea/regional/reis/</a>



**Appendix Table A2.** Recession duration data and nonparametric hazard, survivor, and integrated hazard estimates

Duration in Quarters	Completed Recessions	Uncompleted Recessions	Hazard Esti- mate	Survivor Es- timate	Integrated Hazard
$t_j$	$j_j$	$n_j$	$\hat{\lambda}(t_j)$	$\hat{S}(t_j)$	$\hat{\Lambda}(t_j)$
2	20	148	0.135	0.865	0.145
3	17	128	0.133	0.750	0.288
4	14	111	0.126	0.655	0.423
5	25	97	0.258	0.486	0.721
6	18	72	0.250	0.365	1.008
7	10	54	0.185	0.297	1.213
8	9	44	0.205	0.236	1.442
9	5	35	0.143	0.203	1.596
10	2	30	0.067	0.189	1.665
11	4	28	0.143	0.162	1.819
12	2	24	0.083	0.149	1.906
13	3	22	0.136	0.128	2.053
14	6	19	0.316	0.088	2.432
15	5	13	0.385	0.054	2.918
16	2	8	0.250	0.041	3.205
17	1	6	0.167	0.034	3.388
18	1	5	0.200	0.027	3.611
19	0	4	0.000	0.027	3.611
20	0	4	0.000	0.027	3.611
21	1	4	0.250	0.020	3.899
30	1	3	0.333	0.014	4.304
52	1	2	0.500	0.007	4.997