Spring 5-11-2014

# A STATE-LEVEL ANALYSIS OF THE PHILLIPS CURVE

Margarita V. Osadcha
osadcha.mv@gmail.com

TITLE: A STATE-LEVEL ANALYSIS OF THE PHILLIPS CURVE

by

Margarita V. Osadcha

B.A., FLIT, Southern Illinois University, 2011
B.A., Spanish, Southern Illinois University, 2011

A Research Paper
Submitted in Partial Fulfillment of the Requirements for the
Master of Science

Department of Economics
in the Graduate School
Southern Illinois University Carbondale
May 2014

RESEARCH PAPER APPROVAL

A STATE-LEVEL ANALYSIS OF THE PHILLIPS CURVE

by

Margarita V. Osadcha

A Research Paper Submitted in Partial

Fulfillment of the Requirements

for the Degree of Master of

Science in the field of Economics

Approved by:

Dr. Zsolt Becsi

Graduate School
Southern Illinois University Carbondale
April 11, 2014

AN ABSTRACT OF THE RESEARCH PAPER OF

MARGARITA V. OSADCHA, for the Master of Science degree in ECONOMICS, at Southern Illinois University Carbondale.

TITLE: A STATE-LEVEL ANALYSIS OF THE PHILLIPS CURVE

MAJOR PROFESSOR: Dr. Zsolt Becsi

This research gives an overview of the history of the Phillips Curve, as well as the results of studies done in the recent years. In contrast to previous research that uses national-level data, this research uses state-level data for inflation and unemployment over the years 1976-2007. Using a graphical and statistical analysis of the relationship between the inflation and unemployment in the Unites States, we were able to find a relationship exists between lagged unemployment and current inflation in most of the states and most of the years. Panel data analysis with fixed effects and random effects results are highly significant and support Phillips Curve theory. While the analysis supports a national Phillips Curve, our results do not support a significant relationship for all states individually, though 28 states were significant.

TABLE OF CONTENTS

LIST OF TABLES

## Introduction

Central banks play an important role in a country's economic development and stability. During the housing market crash of 2008, which led to the Great Recession, the Federal Reserve gave billions of dollars to the banks in order to avoid their bankruptcy. It is remarkable the power that central banks have not only during economic downturn, but also on a day-to-day basis. There are two main goals that the Federal Reserve is most concerned about today; they are to keep unemployment near its natural rate and to keep inflation low. There has been much research done on the relationship of these two goals, and there is still uncertainty whether it is possible to pursue both of them at the same time. This paper, aims to find whether the relationship between inflation and unemployment is structural, and whether the Phillips Curve holds in the United States using state-level data.

Phillips Curve has played a central role in modern monetary economics. Central banks have attempted to exploit this relationship by influencing unemployment through their inflation policy. However, in recent years this relationship appeared to breakdown and the Phillips Curve is considered less useful for policy makers. Previously, the statistical relationship has been analyzed solely at the national level. We show that using state-level data that the statistical Phillips Curve relationship is restored.

This research gives an overview of the history of the Phillips Curve, as well as the results of studies done in the recent years. In contrast to previous research that uses national-level data, the current research uses state-level data for inflation and unemployment over the years 1976-2007. Using a graphical and statistical analysis of the relationship between the inflation and unemployment in the Unites States, we were able to find from the plots of lagged unemployment and current inflation that the relationship exists in most of the states and most of the years. Panel data analysis with fixed effects and random effects results are highly significant and support Phillips Curve theory. The statistical analysis did not prove the significance of this relationship for all states individually, though 28 states were significant at 90%, 95%, and 99% significance level.

## History of the Phillips Curve

Today, nearly all countries have their own central bank, which is the only bank that has a right to issue the state's currency, manage the money supply, establish reserve requirements, and set interest rates on interbank loans. The goals of monetary policy are high employment, price stability, economic growth, interest rate stability, etc. It is important to note that these goals often cannot be separated from each other and often it creates a conflict. There may exist a negative relationship between the two goals; therefore, the costs must be carefully weighted before the policy implementation.

For example, since central banks have a monopoly over the currency, they can use it to their advantage and control inflation. If there is a structural relationship between inflation and unemployment, then it could potentially control unemployment as well.

In 1958, William Phillips in his original paper "The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom", examined changes in British economy during the 1861-1957-time period. He observed a historical inverse relationship between the unemployment and inflation rates. In other words, the lower the unemployment rate in an economy, the higher the inflation rate and vice versa. Today, this is known as the Phillips Curve. Phillips' paper was soon followed by many more papers written by economists that tried to check it's validity. This concept is very important and if proven to be true, the inflation and unemployment trade off could be useful for determining an optimal monetary policy.

The Phillips curve has been clearly seen during the Great Depression period in United States shown in Economic Report of the President (2009), and the Japanese stock market crash of the 1990s (Fendel et al 2008). However, this relationship does not always hold. During 1970's, the U.S. economy experienced stagflation, which means that there is both high inflation and unemployment rates. This is contradictory to the Philips curve relationship and adds more fuel to the literature that does not support the inflation-unemployment tradeoff. Thomas Sargent and Robert E. Lucas (1976), Milton Friedman (1968) and others are among the famous critics of the Phillips curve. They believe that the Phillips curve relationship is more of a loose association, but not a permanent relationship. It may hold in the short run, but not in the long run.

There has been much additional research done since William Phillips first the inverse relationship between money wage changes and unemployment in the British economy. In 1960, Paul Samuelson and Robert Solow proposed the idea of using the Phillips curve as a monetary policy tool. From the Phillips' example, it seemed that there would be a permanent tradeoff between inflation and unemployment and it would be a good tool for the central bank to use. However, in examining the U.S. data from the 1960's to present, it looks like it is difficult to identify a single relationship between unemployment and inflation. The relationship looks very unstable and at times it is even looks like a positive one. The Philips Curve is not as easy and simple to identify as once believed. This may be due in part to the fact that since the 1960’s, the Phillips curve relationship has been used in enacting monetary policy. The original relationship was seen in data from before the use of modern central bank policies.

Friedman (1968) explained why it is difficult to identify the Phillips Curve by showing the importance of inflation expectations. He recognized that workers care about their real wage and not their nominal wage. When there is an expected rise in inflation, workers negotiate for an increase in their nominal wage to be able to have the same real wage. As a consequence, nominal wages go up, the real wage stays the same and firms will not change the employment. However, if the inflation increases by more than expected, the real wage of workers will decrease and firms will hire more labor at a lower real wage. So, unemployment decreases and we get a Phillips Curve relationship. On the other hand if the expectations of inflation are correct this relationship breaks down.

The dependency of the Phillips Curve on inflationary expectations makes it vulnerable to the monetary policy. If the monetary policy changes then the correlations in the data will change as well.

We needed a model of the economy that explicitly accounts for how the correlations among economic variables depend on the way that monetary policy is set. The New Keynesian Philips Curve model can help policymakers see how the changes in the economic environment translate into correlations in the data. However, the standard New Keynesian model does not have a well-developed financial sector and therefore has difficulty accounting for economic fluctuations prompted by financial crises (Keith 2011).

Both the New Keynesian Phillips curve and the traditional Phillips curve models provide theories of how inflation is determined. However, the two theories differ in the role they assign to expected inflation as a determinant of current inflation and in the non-monetary economic variables that are the important drivers of inflation and economic activity.

## Review of Current Articles on Phillips Curve

Previous tests for the New Keynesian Phillips Curve that assumed rational expectations did not produce a clear result. Klaus and Padula (2011) estimated the New Keynesian Phillips

Curve using U.S. expected inflation data from the Survey of Professional forecasters. Their main finding was that New Keynesian Phillips Curve performs equally well with measures of marginal cost, output, and unit labor cost. This is different from the findings of Gali and Gertler (1999) where they conclude that sticky-price models perform well once marginal costs are approximated by average unit labor costs. This could possibly be explained if Gali and Gertler's findings were distorted by potential irrationalities in the expectations estimates used.

The data gave considerable support for the parameter restrictions implied by the standard forward-looking New Keynesian Phillips Curve. In particular, the discount factor was found to be close to one, inflation was positively affected by real marginal costs, and the degree of price stickiness implied by the estimates suggested that about one-fifth of firms reset price every quarter. These results were found to be independent of whether unit labor cost or detrended output were used as a measure for real marginal costs. Although uncertainty remains about the role of lagged inflation, the results presented in this paper seem to suggest that the New Keynesian Phillips Curve offers an empirically plausible explanation of inflation dynamics as a function of output dynamics or unit labor costs once inflation expectations are approximated with survey data.

Bernanke (2010) defended the Phillips curve and accounted for its imperfections. He said that the Central Bank would strongly resist deviations from price stability in the downward direction. Falling into deflation is not a significant risk for the United States because the public understands that the Federal Reserve will be proactive in addressing further disinflation. Moreover, he described that a combination of anchored expectations and credible central banks has made inflation move more slowly. These two factors together explain why there was no disinflation or decline in the inflation.

Daly, Hobijn, and Lucking (2012) suggested another explanation. Missing disinflation in prices should be accompanied by missing disinflation in wages. However, “Despite a severe recession and modest recovery, real wage growth has stayed relatively solid. A key reason seems to be downward nominal wage rigidities, that is, the tendency of employers to avoid cutting the dollar value of wages” (Daly, Hobijn, and Lucking, 2012). This phenomenon means that, in nominal terms, wages tend not to adjust downward when economic conditions are poor. With inflation relatively low in recent years, these rigidities have limited reductions in the real wages of a large fraction of U.S. workers. Hobijn and Daly suggest that there’s a high demand for wage cuts that will probably push inflation lower even if the economy is recovering.
IMF (2013) provides another explanation- Flattening of the Phillips Curve. Their data analysis shows that the Phillips curve is considerably flatter today than in the past, and the inflation consequences of changes in the economy are therefore much smaller. Another conclusion is that inflation expectations are much better anchored now than in the past. These two factors together explain why there was no disinflation (or decline in the inflation). It follows that these small declines are consistent with a flattening of the Philips curve.

A flatter Philips curve and strongly anchored inflation expectations imply that any temporary overstimulation of the economy is likely to have only small effects on inflation.
The muted relationship between inflation and output raises particular challenges for monetary policy-making for which there are no solutions. Although a flatter Philips curve can mitigate the disinflation effect of a recession, if appropriate money tightening does not occur; it could result in the un-anchoring of inflation expectations and lead to stagflation.

Fitzgerald, Holtemeyer and Nicolini (2013) check the stability of the Phillips curve by looking at the U.S. data both on national and city level. They show that national data is likely to provide little information about the existence of a stable relationship between inflation and unemployment. In fact, the relationship will appear unstable as policy goals change, even if a structural relationship exists. On the other hand, less-aggregated data allows the analysis to address complications raised by changes in monetary policy. In absence of a central bank response to local conditions, a regional shock that affects unemployment in just a single region can help identify the existence and size of a structural relationship between current labor market conditions and future inflation. The article assumes that regions are the same for the most part, but each faces different local disturbances, or shocks. Regional shocks make inflation rates and unemployment rates vary across regions.

The authors show that the estimates of Phillips curves based on regional data are remarkably stable, while estimates using national U.S. data are highly unstable, as predicted. Their results suggest that a one-percentage point lower unemployment rate is associated with higher inflation of 0.3 percentage points over the next year. The stability of this relationship on a regional level suggests that it might provide a viable tool for policymakers.

Olivier Coibion and Yuriy Gorodnichenko (2013) provide a new explanation that accounts for the recent “missing disinflation”, and more importantly stays within the Phillips curve framework. Their results suggest that the Phillips curve still remains useful for understanding the relationship between prices and macroeconomic conditions. There study builds on the expectations augmented Philips curve like in Friedman (1968) and addresses issues such as the possibility of asymmetries due to downward wage rigidities (Akerlof et al. 1996), importance of using real time expectations (Roberts 1998), sensitivity of inflation to marginal costs (Gali and Gertler 1999), and sensitivity to trend inflation (Ascari and Ropele 2007).

They introduce household inflation expectation in the Phillips curve model, and show that it plays a significant role in accounting for the absence of disinflation since 2009. There are three reason that household inflation expectations can successfully explain the missing disinflation even better than other methods used previously. 1) There are no quantitative measure of firm inflation expectations available in the U.S. 2) Regressions that include both household and professional forecasts show that households are better proxies for inflation expectations. 3) They show a survey of inflation expectations of firms in New Zealand is very similar to household inflation expectations, but strongly at odds with professional forecasts. Although, the Phillips curve is meant to capture the pricing decisions and expectation of the firm, they could not find comparable data for firms whose price-setting decisions determine inflation dynamics in the economy. Consequently, the data they used was from forecasts of households (U. of Michigan Survey of Consumers) and professional forecasters (Survey of Professional Forecasters, Livingston Survey). They estimated several versions of nested Philips curves that includes both household and professional forecasts. For example, including and excluding the Great Recession, using the unemployment gap, unrestricted and restricted coefficients on forecasts, and then controlling for contemporaneous oil price changes.

Based on their data and regressions, household inflation expectations rose sharply from 2.3% in 2009 to 4% in 2013, but professional forecasters had stayed around 2% over the same period. The main historical difference in inflation forecasts between households and professionals is identified as being the level of oil prices. Since gasoline prices are very visible to the consumers, households adjust their inflation expectation accordingly, which means their expectations have not been fully anchored. The oil price coefficient is found to be significant and could explain the missing disinflation during the Great Recession time period. Household's inflation expectations are found to play a significant role in accounting for the absence of disinflation since 2009. However, while Coibion and Gorodnichenko suggest that this can explain the missing disinflation since the Great Recession. Their work is based on a unique set of factors, and policymakers should not necessarily expect it to repeated in the future.

Palley, Thomas (2012) reviews the history of the Phillips curve theory, focusing on the critical distinction between "formation of inflation expectations" and "incorporation of inflation expectations". A review of history shows that Phillips curve theory has focused on the former and neglected the latter. That has had profound and little appreciated implications for the Phillips curve theory and macroeconomics. The explanations of Friedman, Phelps, and Lucas of the Phillips curve fundamentally changed the direction of Phillips curve research. Making formation of inflation expectations the critical question. That change truncated interest in an alternative approach to explaining the Phillips curve that identified the incorporation of inflation expectations into nominal wage settings as the critical factor. Near-rational expectation formation can explain the existence of a negatively sloped Phillips curve, but it cannot provide a welfare economics rationale for exploiting the trade-off.

Mulligan and Robert (2011) state that the Phillips curve need not be abandoned either as a theoretical construct or as a tool for policy formulation. However, in reality, the true relationship between unemployment and inflation is exactly the opposite of what has been widely believed. It is essential that both policy and theory be guided by improved and accurate estimates of appropriate and theoretically better-motivated specifications. Austrian business cycle theory should inform public policy— in clear and loud tones—that in the long-run there is a positive relationship between inflation and unemployment, as documented in this article. The sooner policymakers embrace a goal of zero inflation as the road to lower unemployment, the better.

Lee, et al (2005) explains the existing empirical irregularity about the slope of the Phillips curve. This article provides a model of imperfect competition to show that the slope of a Phillips curve is shock-dependent. They empirically apply a stale-space, Markov-switching model to examine the impact of inflation surprises on the unemployment gap, resulting in the state-dependent Phillips curve fitting quite well. The empirical evidence indicates that an unexpected monetary expansion does produce effects in reducing unemployment rates and that supply shocks should not be ignored in estimating the Phillips curve because they dominate demand shocks in several nonoil shock periods.

## Methodology

For this analysis I selected data for the annual unemployment rate from the Bureau of Labor Statistics for each state for the years 1976 through 2007. The CPI data came from the revised 2009 version of the Berry-Fording-Hanson yearly state cost of living index for the 50 states, for years 1976 through 2007. I used the first difference of the CPI in order to derive the inflation rate per year for each state.

I then performed a visual analysis of the graphs of the inflation rate and unemployment rate by state and by year in order to identify the Phillips Curve. We placed inflation on the “y” axis and unemployment on the “x” axis and graphed the data according to state and then according to year. We ran the same procedure twice. First using inflation and unemployment without lags, and second time we used a one lag on unemployment in order to see if current unemployment has an effect on next period’s inflation. The plots of inflation and unemployment rate without lag were randomly scattered in most states and years without showing any particular pattern; therefore, we did not include them in this analysis. Instead, we followed the paper of Fitzgerald, Holtemeyer and Nicolini (2013), where they used the current unemployment rate and the future inflation rate to construct a Phillips Curve. The graphs of lagged unemployment and current inflation sorted by state are shown in Appendix A, and the graphs of lagged unemployment and current inflation sorted by year are shown in Appendix B. The results in Appendix A are sorted by U.S. region.

The next step was to write a linear regression model of Phillips Curve using current inflation and unemployment from the previous period sorted by state and by year. For this I used the traditional Phillips Curve equation (equation (1) below). This form has not been augmented using the expectations of future inflation as was explained earlier in the literature review. This paper looks at the relationship between inflation and unemployment for two reasons. First, this study looks if the relationship exhibited in the state level data is permanent, which means that changes in the current unemployment cause changes in future inflation. If this is the case and if it is statistically significant then unemployment may be used to predict the future inflation. This would give households and firms an improved ability to predict the future prices they will face. Secondly, from a policy analysis point-of-view, inflation can be potentially used to control economic activity and the unemployment rate if there is a stable relationship. This gives us some basis for understanding and analyzing the effectiveness of monetary policy.

The following are the Phillips Curve equations used for the linear regression analysis:

The Phillips Curve sorted by state and by year: $\pi_t = \beta_1 + \beta_2 unem_{t-1} + u_t$ (1)

We run the first equation twice, first sorting by state and then sorting by year. In total we have fifty regressions for each state and then thirty regressions for each year, 1977-2007. The results for state-sorted regressions are shown in Table 1 and the results for year-sorted regressions are shown in Table 2.

For the second equation we combine all the states and look at the national Phillips Curve using panel regression techniques to analyze the state level data at a national level. The purpose for doing this is to see in which case the relationship shows more prominence. The results of equation (2) are shown in Table 3.

National Phillips Curve: $$\pi_{it} = \beta_1 + \beta_2 unem_{it-1} + u_{it} \qquad (2)$$

After estimating a pooled time series model, we also estimate Fixed and Random effects of equation (2).

Fixed effects: $$\pi_{it} = \beta_i + \beta_1 unem_{it-1} + u_{it} \qquad (3)$$

Random effects: $$\pi_{it} = \beta_1 + \beta_2 unem_{it-1} + u_{it} + \epsilon_{it} \qquad (4)$$

In equation (4) $u_{it}$ denotes the within group variation and $\in_{\mathrm{it}}$ is the between group variations. The results of equation (3) and (4) are shown in Table 4 and Table 5 respectively.

Fixed effect explores the relationship between predictor and outcome variables, in our case unemployment (predictor) and inflation (outcome). This technique removes the effect of the uncontrolled variables that my influence the predictor, which allows us to see the results more clearly and less biased. Random-effects on the other hand, assume the variation to be random and uncorrelated with the predictor. (Torres-Reyna, 2007)

## Results

From Appendix A, we can observe the majority of the states in all regions show a clear negative relationship between the current unemployment rate and the future inflation rate. In the regions 1 through 4, 6 and 7, the Phillips Curve is easily identifiable, while regions 5 and 8 are less clear. In Appendix B, we can see that the years 1977-1980 show a flat Phillips curve, which means that unemployment does not seem to influence the inflation during that time period. From 1981-1989 and from 1991-1998, we can observe a negative relationship between inflation and lagged unemployment. This means that unemployment could have possibly influenced future inflation during the 80's and 90's. Nevertheless, from 2000-2007 the plots look more scattered and the Phillips Curve relationship is hard to identify.

The results of the regression of Phillips Curve per state are listed in Table 1. There were 28 out of 50 states, which displayed a Phillips Curve and were accepted at 90%, 95%and 99% significance levels. They were California (CA), Illinois (IL), Kansas (KS), Montana (MT), Nevada (NV), New Mexico (NM), Oklahoma (OK), West Virginia (WV), Wyoming (WY) at 99% level of significance, and Idaho (ID), Louisiana (LA), Massachusetts (MA), New Hampshire (NH), New York (NY), Texas (TX), Washington (WA) at a 95% level of significance, and Rhode Island (RI), Vermont (VT), New Jersey (NJ), Pennsylvania (PA), Illinois (IL), Wisconsin (WI), Iowa (IA), Florida (FL), Kentucky (KY), Alaska (AK), Arizona (AZ), Utah (UT) at a 90% level of significance.

The majority of the states' results in Regions 1-2, and 6-8 were significant while states in the Regions 3-5, which are Midwestern and southern states, were mostly insignificant.

The results from the regression of the Phillips Curve per year are listed in Table 2 and there were 13 out of 30 significant years at 90%, 95%and 99% significance levels. They were

1992-1993 at a 90% significance level; followed by 1984, 1990, 1994, and 1995 at a 95% significance level, and 1985-89, 1996, and 1997 were significant at a 99% level of significance.

Panel results shown in Table 3 are highly significant, meaning that there is a Phillips Curve relationship in the national-level data. The results also improved under random-effects and fixed-effects model shown in Tables 4 and Table 5 respectively.

We also performed a Hausman test to see whether the fixed-effects or random-effects model was more efficient. In Hausman test, under the null hypothesis (Ho) the regression errors are correlated and in alternative hypothesis (Ha) they are not. The results of this test are shown in Table 6. In this case, random effects is consistent under the null hypothesis due to higher efficiency, but inconsistent under (Ha), while fixed-effects is consistent under both (Ho) and (Ha) and thus the latter technique is preferred.

.

**Table 1 –Regression Results of equation (1), sorted by state.**

Region 1

| State | Constant | Slope | Standard error | Adj. $R^2$ |
|---|---|---|---|---|
| **CT** | *3.767* | *-0.160* | *0.156* | *0.0016* |
| **ME** | *3.393* | *-0.139* | *0.112* | *0.0175* |
| **MA** | *4.744* | *-0.295*** | *0.123* | *0.1369* |
| **NH** | *4.054* | *-0.290*** | *0.121* | *0.1376* |
| **RI** | *4.001* | *-0.204** | *0.114* | *0.0691* |
| **VT** | *3.700* | *-0.215** | *0.123* | *0.0639* |

Region 2

| State | Constant | Slope | Standard error | Adj. $R^2$ |
|---|---|---|---|---|
| **DE** | *2.229* | *0.020* | *0.089* | *-0.0328* |
| **MD** | *2.981* | *-0.112* | *0.134* | *-0.0102* |
| **NJ** | *4.459* | *-0.240** | *0.123* | *0.0857* |
| **NY** | *4.793* | *-0.290*** | *0.133* | *0.1105* |
| **PA** | *3.777* | *-0.183** | *0.099* | *0.0746* |

Region 3

| State | Constant | Slope | Standard error | Adj. $R^2$ |
|---|---|---|---|---|
| **IL** | *3.334* | *-0.137** | *0.070* | *0.0863* |
| **IN** | *2.408* | *-0.023* | *0.057* | *-0.0288* |
| **MI** | *2.651* | *-0.038* | *0.041* | *-0.0061* |
| **OH** | *2.883* | *-0.087* | *0.060* | *0.0361* |
| **WI** | *3.004* | *-0.126** | *0.072* | *0.0647* |

Region 4

| State | Constant | Slope | Standard error | Adj. $R^2$ |
|---|---|---|---|---|
| **IA** | *2.912* | *-0.145** | *0.080* | *0.0711* |
| **KS** | *4.324* | *-0.455**** | *0.160* | *0.1907* |
| **MN** | *3.143* | *-0.158* | *0.103* | *0.0431* |
| **MO** | *2.732* | *-0.082* | *0.091* | *-0.0062* |
| **NE** | *2.942* | *-0.196* | *0.137* | *0.0335* |
| **ND** | *2.675* | *-0.115* | *0.155* | *-0.0153* |
| **SD** | *3.021* | *-0.207* | *0.179* | *0.0109* |

** at 90% level of significance*
*** at 95% level of significance*
**** at 99% level of significance*

Region 5

| State | Constant | Slope | Standard error | Adj. $R^2$ |
|---|---|---|---|---|
| **AL** | *2.634* | *-0.075* | *0.053* | *0.0317* |
| **AR** | *2.724* | *-0.100* | *0.083* | *0.0146* |
| **FL** | *3.187* | *-0.163** | *0.093* | *0.0642* |
| **GA** | *2.762* | *-0.094* | *0.122* | *-0.0138* |
| **KY** | *2.955* | *-0.123** | *0.071* | *0.0706* |
| **LA** | *3.158* | *-0.138*** | *0.064* | *0.1084* |
| **MS** | *2.668* | *-0.082* | *0.062* | *0.0249* |
| **NC** | *2.657* | *-0.077* | *0.094* | *-0.0112* |
| **SC** | *2.390* | *-0.036* | *0.088* | *-0.0287* |
| **TN** | *2.746* | *-0.091* | *0.067* | *0.0261* |
| **VA** | *3.081* | *-0.167* | *0.124* | *0.0262* |
| **WV** | *3.064* | *-0.115**** | *0.036* | *0.2313* |

Region 6

| State | Constant | Slope | Standard error | Adj. $R^2$ |
|---|---|---|---|---|
| **AZ** | *3.701* | *-0.208** | *0.120* | *0.0623* |
| **NM** | *5.413* | *-0.432**** | *0.111* | *0.3214* |
| **OK** | *3.477* | *-0.268**** | *0.088* | *0.2164* |
| **TX** | *3.941* | *-0.300*** | *0.112* | *0.1697* |

Region 7

| State | Constant | Slope | Standard error | Adj. $R^2$ |
|---|---|---|---|---|
| **CO** | *4.166* | *-0.264* | *0.175* | *0.0403* |
| **ID** | *4.763* | *-0.406**** | *0.104* | *0.3236* |
| **MT** | *5.409* | *-0.526**** | *0.096* | *0.4889* |
| **UT** | *4.058* | *-0.288** | *0.143* | *0.0933* |
| **WY** | *4.629* | *-0.455**** | *0.089* | *0.4562* |

** at 90% level of significance*
*** at 95% level of significance*
**** at 99% level of significance*

Region 8

| State | Constant | Slope | Standard error | Adj. $R^2$ |
|---|---|---|---|---|
| **AK** | *4.792* | *-0.281** | *0.150* | *0.0773* |
| **CA** | *7.129* | *-0.586**** | *0.177* | *0.2503* |
| **HI** | *5.740* | *-0.503*** | *0.226* | *0.1163* |
| **NV** | *4.990* | *-0.409**** | *0.118* | *0.2671* |
| **OR** | *4.036* | *-0.195* | *0.119* | *0.0536* |
| **WA** | *4.946* | *-0.311*** | *0.121* | *0.1587* |

* at 90% level of significance
** at 95% level of significance
*** at 99% level of significance

**Table 2 – Regression Results of equation (2), sorted by year.**

| Year | Constant | Slope | Standard error | Adj $R^2$ |
|---|---|---|---|---|
| **1977** | *1.973* | *0.034* | *0.026* | *0.0325* |
| **1978** | *2.656* | *-0.013* | *0.023* | *-0.0202* |
| **1979** | *3.578* | *-0.010* | *0.025* | *-0.0197* |
| **1980** | *4.045* | *0.020* | *0.058* | *-0.0146* |
| **1981** | *4.185* | *-0.058* | *0.036* | *0.0313* |
| **1982** | *2.513* | *-0.020* | *0.022* | *0.0015* |
| **1983** | *1.535* | *-0.005* | *0.017* | *-0.0149* |
| **1984** | *2.199* | *-0.0503*** | *0.022* | *0.0772* |
| **1985** | *2.150* | *-0.068**** | *0.025* | *0.1196* |
| **1986** | *2.334* | *-0.160**** | *0.037* | *0.2739* |
| **1987** | *3.235* | *-0.181**** | *0.032* | *0.0324* |
| **1988** | *3.394* | *-0.176**** | *0.035* | *0.3267* |
| **1989** | *3.798* | *-0.192**** | *0.037* | *0.3467* |
| **1990** | *3.638* | *-0.148*** | *0.071* | *0.0629* |
| **1991** | *2.171* | *-0.038* | *0.046* | *-0.0008* |
| **1992** | *1.906* | *-0.022** | *0.040* | *0.0393* |
| **1993** | *1.765* | *-0.015** | *0.011* | *0.0403* |
| **1994** | *1.874* | *-0.026*** | *0.018* | *0.0177* |
| **1995** | *1.879* | *0.001*** | *0.018* | *0.0893* |
| **1996** | *2.306* | *-0.064**** | *0.034* | *0.2816* |
| **1997** | *1.676* | *-0.010**** | *0.036* | *0.1226* |
| **1998** | *1.674* | *-0.034* | *-0.006* | *-0.0058* |
| **1999** | *1.792* | *0.026* | *0.067* | *-0.0058* |
| **2000** | *3.032* | *-0.001* | *0.080* | *-0.0190* |
| **2001** | *2.224* | *0.040* | *0.063* | *-0.0040* |
| **2002** | *1.900* | *0.011* | *0.107* | *-0.0206* |
| **2003** | *2.429* | *0.020* | *0.094* | *-0.0194* |
| **2004** | *2.605* | *0.139* | *0.160* | *0.0023* |
| **2005** | *4.035* | *-0.007* | *0.170* | *-0.0207* |
| **2006** | *4.615* | *-0.152* | *0.143* | *0.0004* |
| **2007** | *4.194* | *-0.116* | *0.146* | *-0.0078* |

** at 90% level of significance*
*** at 95% level of significance*
**** at 99% level of significance*

Table 3 – Pooled Regression

| Pooled Regression | | | | |
|---|---|---|---|---|
| R-squared | = | 0.0678 | | |
| Adj. R-squared | = | 0.0672 | | |
| F(1, 1548) | = | 112.65 | | |
| infl | Coef. | Std. Err. | t | P>\|t\| |
| Lunem | -0.133 | 0.013 | -10.61 | 0 |
| _cons | 3.219 | 0.078 | 41.27 | 0 |

Table 4 – Random-Effects Regression

| Random-Effects | | | | | |
|---|---|---|---|---|---|
| R-sq: | within | = | 0.0929 | | |
| | between | = | 0.0132 | | |
| | overall | = | 0.0678 | | |
| | Wald chi2(1) | = | 140.92 | | |
| infl | Coef. | Std.Err. | z | P>\|z\| | |
| Lunem | -0.162 | 0.014 | -11.87 | 0 | |
| _cons | 3.388 | 0.092 | 36.97 | 0 | |
| sigma_u | 0.262 | | | | |
| sigma_e | 0.942 | | | | |
| rho | 0.072 | | | | |

Table 5 – Fixed-Effects Regression

| Fixed-Effects | | | | |
|---|---|---|---|---|
| R-sq: | within = | | 0.0929 | |
| | between = | | 0.0132 | |
| | overall = | | 0.0678 | |
| | F(1,1499) = | | 153.56 | |
| infl | Coef. | Std. Err. | t | P>\|t\| |
| Lunem | -0.18 | 0.014 | -12.39 | 0 |
| _cons | 3.49 | 0.088 | 39.47 | 0 |
| sigma_u | 0.350 | | | |
| sigma_e | 0.942 | | | |
| rho | 0.121 | | | |

Table 6 – Hausman Test

| Hausman Test (Comparing FE and RE models) | | | | |
|---|---|---|---|---|
| | ***FE*** | ***RE*** | ***(FE-RE)Difference*** | ***S.E.*** |
| ***L.unem*** | -0.18 | -0.162 | -0.017 | 0.005 |

*FE = consistent under Ho and Ha.*
*RE= inconsistent under Ha, efficient under Ho.*

## Conclusion

Visually examining the graphs of inflation and unemployment a relationship exists for most of the states and years. Furthermore, after performing the regression analysis for individual states and years, the relationship proved to be statistically significant in 28 out of 50 states and 11 out of 30 years. When we analyze the full sample using panel techniques, we find a highly significant relationship, strongly suggesting that there is a Phillips Curve relationship in the national data.

It is possible that expectations augmented Phillips Curve could improve the significance of all states, by accounting for inflation expectations. In our analysis, it appears that the inverse relationship between inflation and unemployment is not as significant for the individual states as it is when the full sample of the states is analyzed. There could be several reasons for this. A possible reason that the relationship does not hold is the difference in the effects of monetary policy experienced in the different states. Expected inflation and the natural rate of unemployment could have been further integrated into the regression as it was done previously.

The results are surprising considering the results of Fitzgerald, et al 2013. In their paper, national level data should not show the significance of the Phillips Curve as well as disaggregate state data. The current research shows just the opposite. It might be the case that the state level data is still too large scale for the regression to show the effects of monetary policy, as it is in the case of national level data. For future research it is possible that the use of city level data would be less biased.

Nevertheless, it is important to note that in looking at the plots of current period inflation and lagged unemployment there exists a visible trend in the plot of the data. In addition, the negative slope coefficients that are found in the regression results in Tables 1 and 2 also show this fact. The panel regression is highly significant, unlike the regression by state where the Phillips curve relationship is obviously existent in graphs, but not significant. This indicates the possibility of a third variable linking these. This research shows a potential of the Phillips Curve relationship in the individual states and gives us incentive for the future work and improvement of the analysis of the inflation and unemployment trade-off.

# BIBLIOGRAPHY


Bernanke, Ben, 2010. "The Economic Outlook and Monetary Policy," speech delivered at the Federal Reserve Bank of Kansas City Economic Symposium, Jackson Hole, Wyoming, August 27, 2010.

Berry, William D., Richard C. Fording and Russell L. Hanson, 2009. "An Annual Cost of Living Index for the American States, 1960-95," (revised 2009 version), *Journal of Politics*, vol.60, no. 2, 550-67.

Capie, Forrest, Fischer, Stanley, Goodhart, Charles and Schnadt, Norbert ,1994. "The future of central banking: the tercentenary symposium of the Bank of England." *Cambridge University Press*. Cambridge, UK.

Coibion, Olivier and Yuriy Gorodnichenko, 2013. "Is The Phillips Curve Alive and Well After All? Inflation Expectations and the Missing Disinflation." NBER Working Paper No. 19598

Daly, Mary, Bart Hobijn, and Brian Lucking, 2012. "Why Has Wage Growth Stayed Strong?" *FRBSF Economic Letter* 2012-10, April 2, 2012.

Fendel, Ralf, Eliza M. Lis and Jan-Christoph Rülke, 2008. "Does the Financial Market Believe in the Phillips Curve? – Evidence from the G7 countries". *Center for European, Governance and Economic Development Research*.

Fitzgerald, Terry; Brian Holtemeyer and Juan Pabio Nicolini, 2013. "Is There a Stable Phillips Curve After All?" Region (10453369), Vol. 27, Issue 4, p4-11.

Friedman, Milton, 1968. "The Role of Monetary Policy," *American Economic Review,* 58. pp.1-17.

International Monetary Fund (IMF), 2013. "The Dog That Didn't Bark: Has Inflation Been Muzzled or Was It Just Sleeping," Chapter 3 in *World Economic Outlook*, April 2013.

Klaus, Adam and Mario Padula, 2011. "Inflation Dynamics And Subjective Expectations In The United States," *Economic Inquiry, Western Economic Association International*, vol. 49(1), pages 13-25, 01

Lee, Hsiu-Yun, Jyh-Lin Wu and Show-Lin Chen, 2005. "A Theory-Based, State-Dependent Phillips Curve and its Estimation".*Economic Inquiry, Vol. 43, Issue 1, pp. 194-205.*

Lazear, Edward P., Donald B. Marron, et al. 2009. "Economic Report of the President, 2009". Tables B-3 and B-42.

Llaudes, Ricardo, 2005. "The Phillips Curve and Long Term Unemployment," ECB Working Paper 441.

Mulligan, Robert, 2011. “An Austrian Rehabilitation of the Phillips Curve”. *Cato Journal*, Vol. 21, No. 1.

Palley, Thomas, 2012. "The economics of the Phillips curve: Formation of inflation expectations versus incorporation of inflation expectations," *Structural Change and Economic Dynamics, Elsevier*, vol. 23(3), pages 221-230.

Phillips, A. W, 1958. "The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom", *Economica*, New Series, Vol. 25, No. 100, 283-299.

Sargent, Thomas, 1979. “After Keynesian Macroeconomics,” *Federal Reserve Bank of Minneapolis Quarterly*. Review, 3:2, Spring, p. 1–16; Reprinted in: After the Phillips Curve: Persistence of High Inflation and High Unemployment, Federal Reserve Bank of Boston Conference Series No. 19, 1979, p. 49–72.

Sill, Keith , 2011. "Inflation dynamics and the New Keynesian Phillips curve," *Business Review, Federal Reserve Bank of Philadelphia*, issue Q1, pages 17-25.

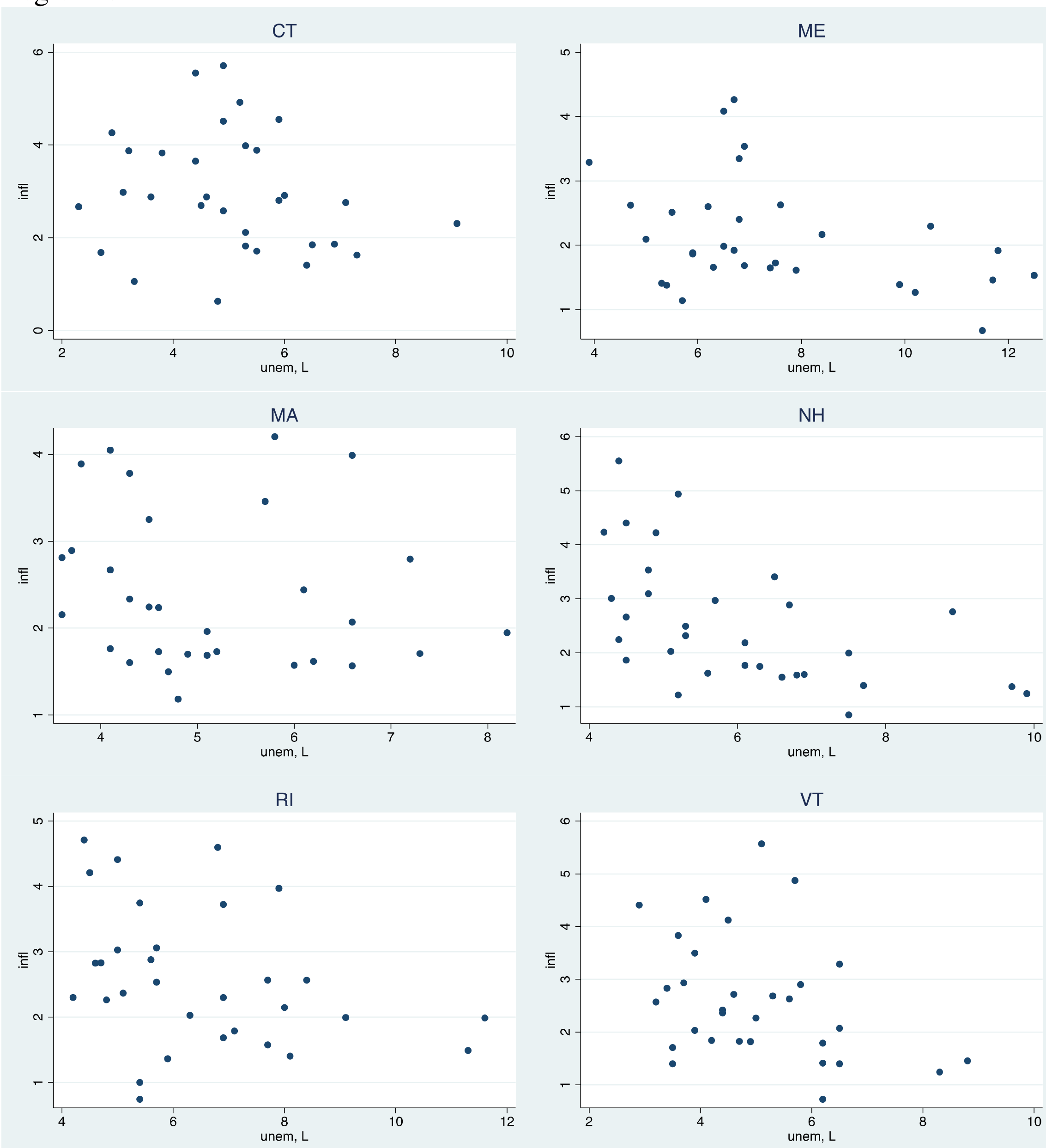
Torres-Reyna, Oscar, 2007. “Panel data analysis, Fixed & Random Effects”. http://dss.princeton.edu/training/Panel101.pdf

"U.S. Bureau of Labor Statistics." *U.S. Bureau of Labor Statistics*. 09 Apr. 2014. http://www.bls.gov/

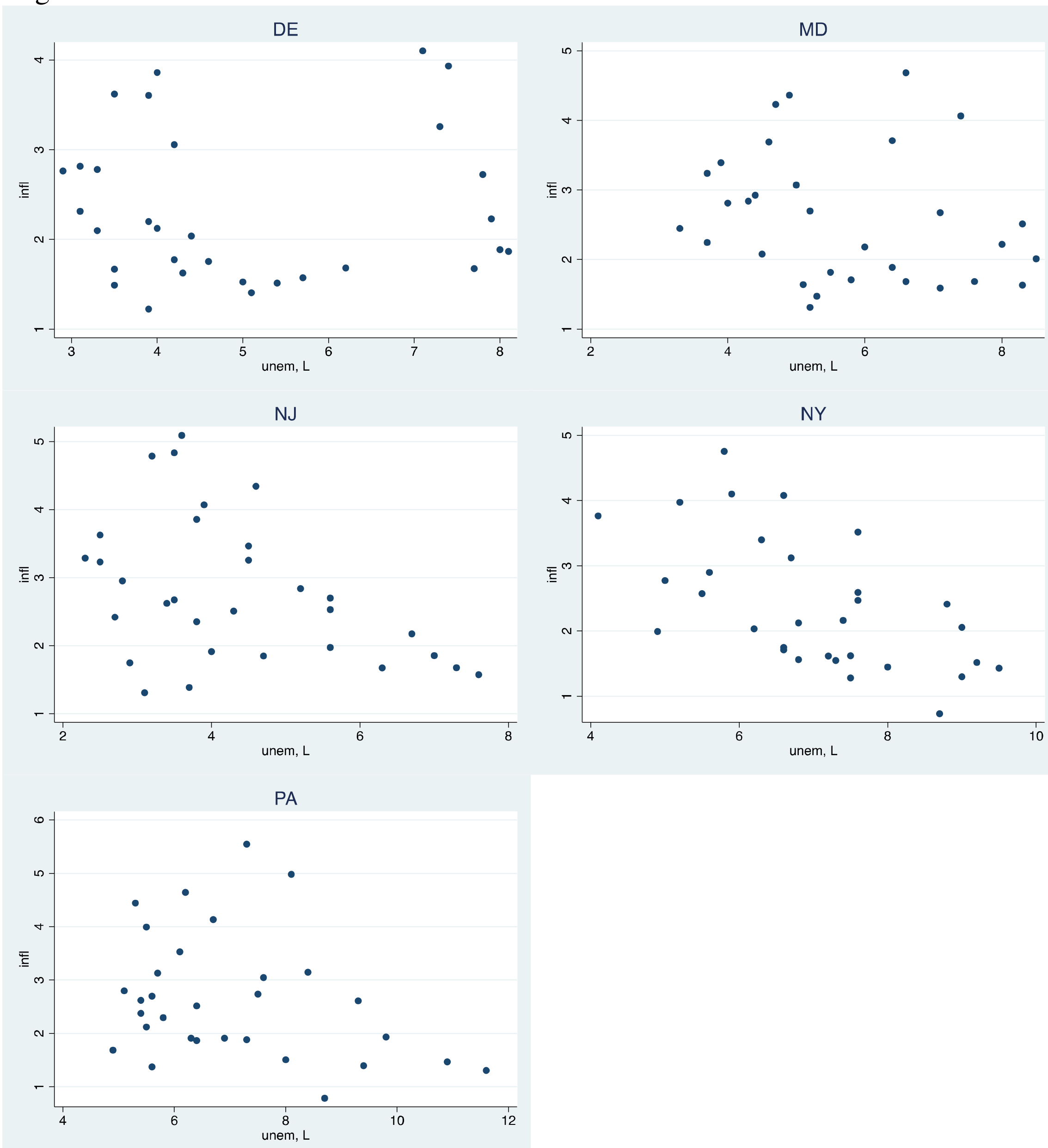
APPENDIX

Appendix A – Graphs of Phillips Curve sorted by U.S. region.

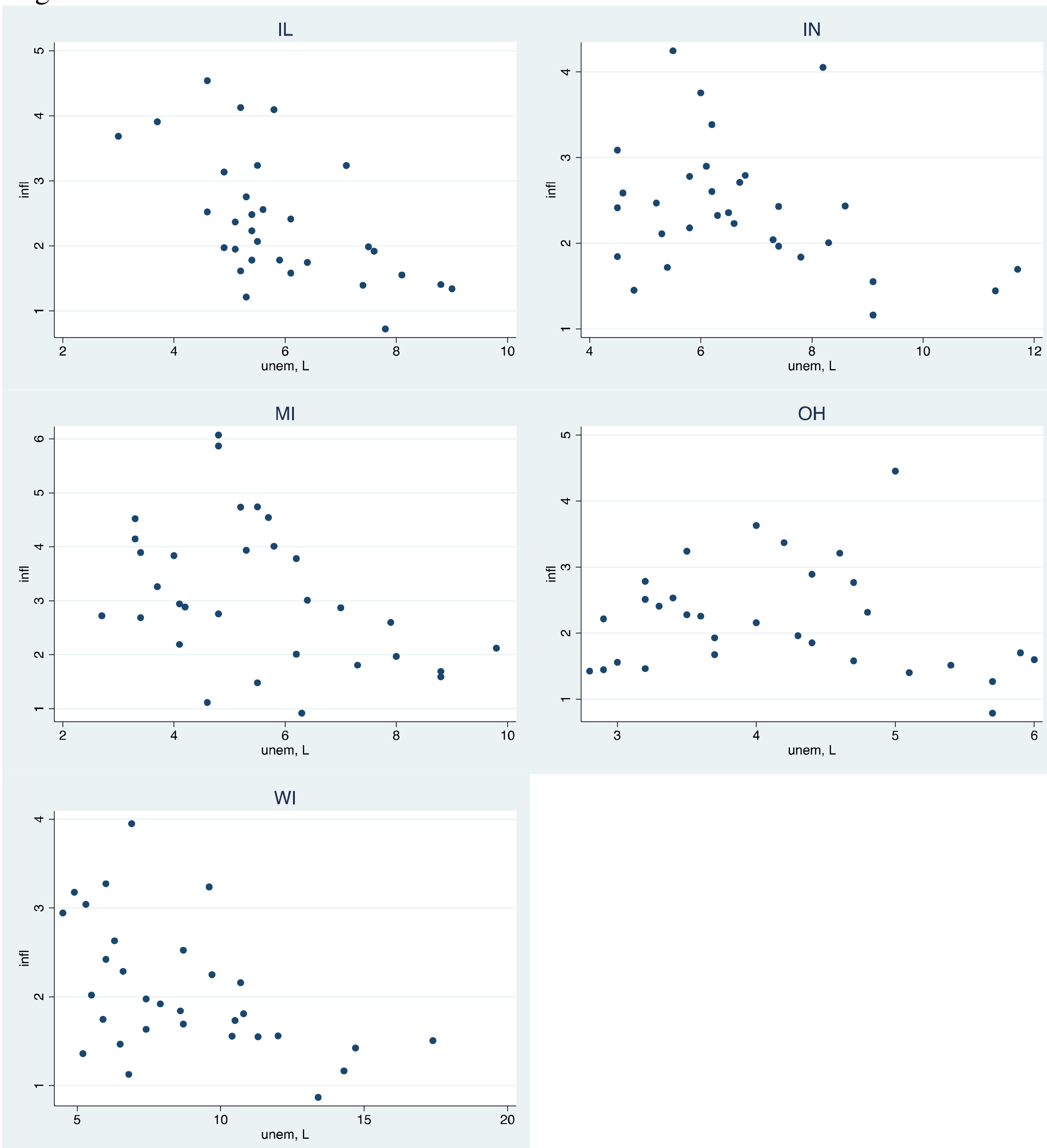
Region 1:



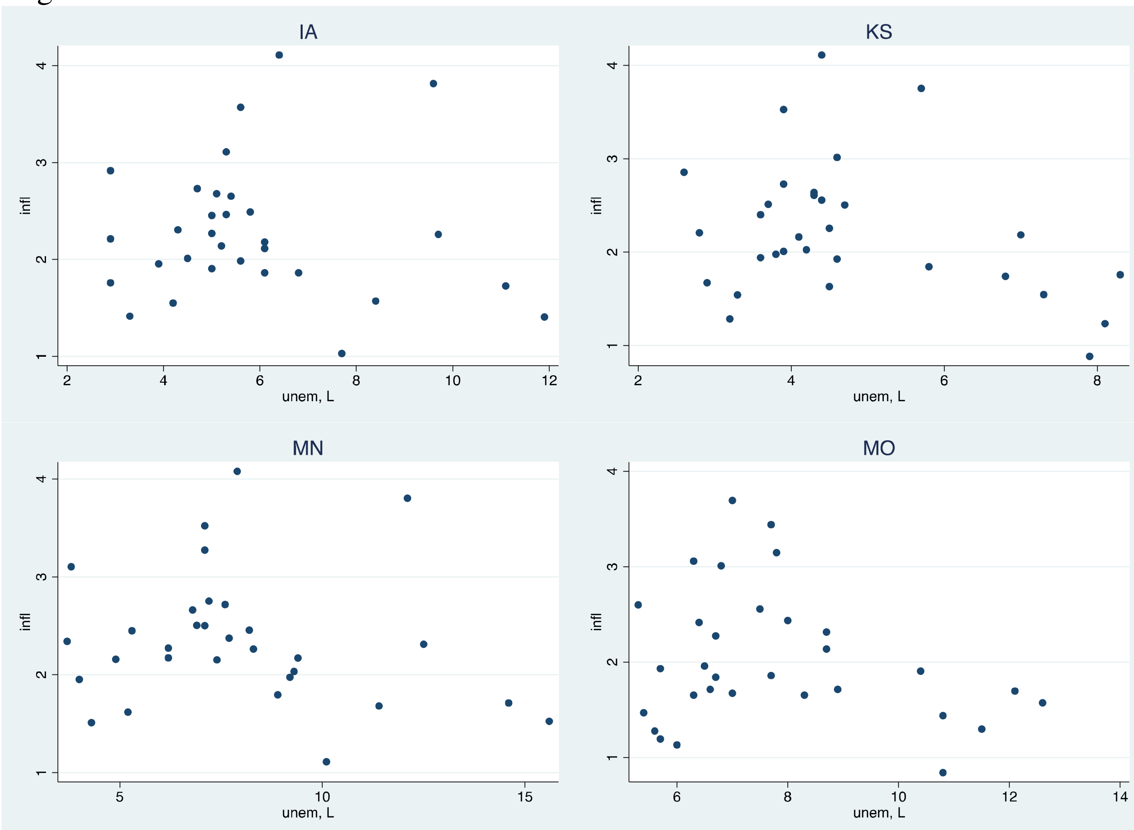
Region 2:

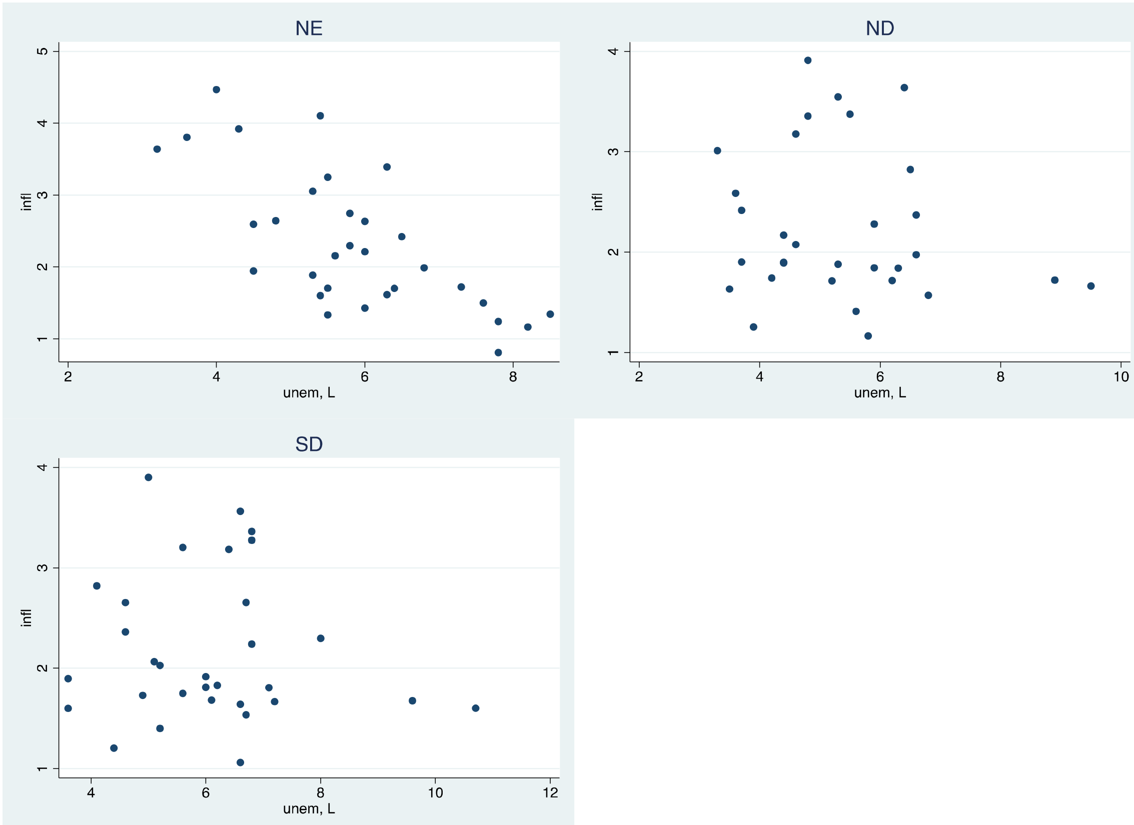

DE
infl
unem, L
MD
infl
unem, L
NJ
infl
unem, L
NY
infl
unem, L
PA
infl
unem, L

Region 3:

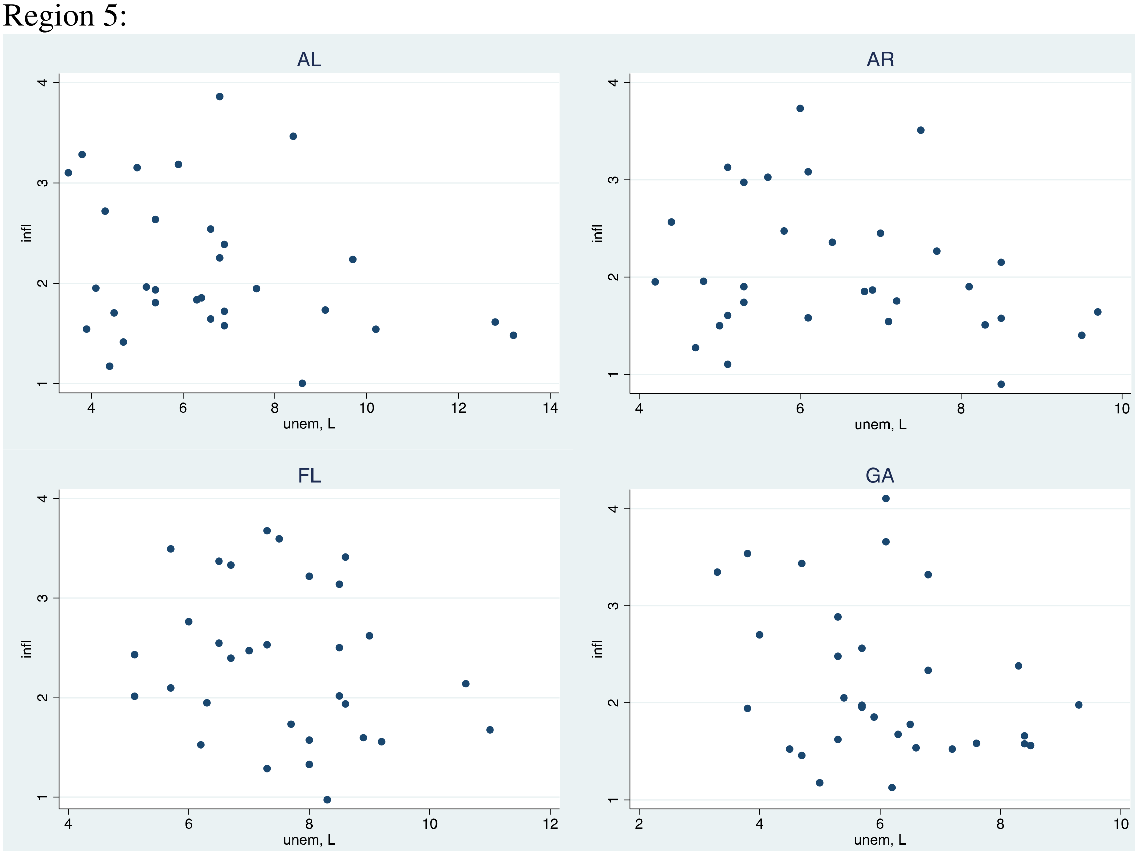


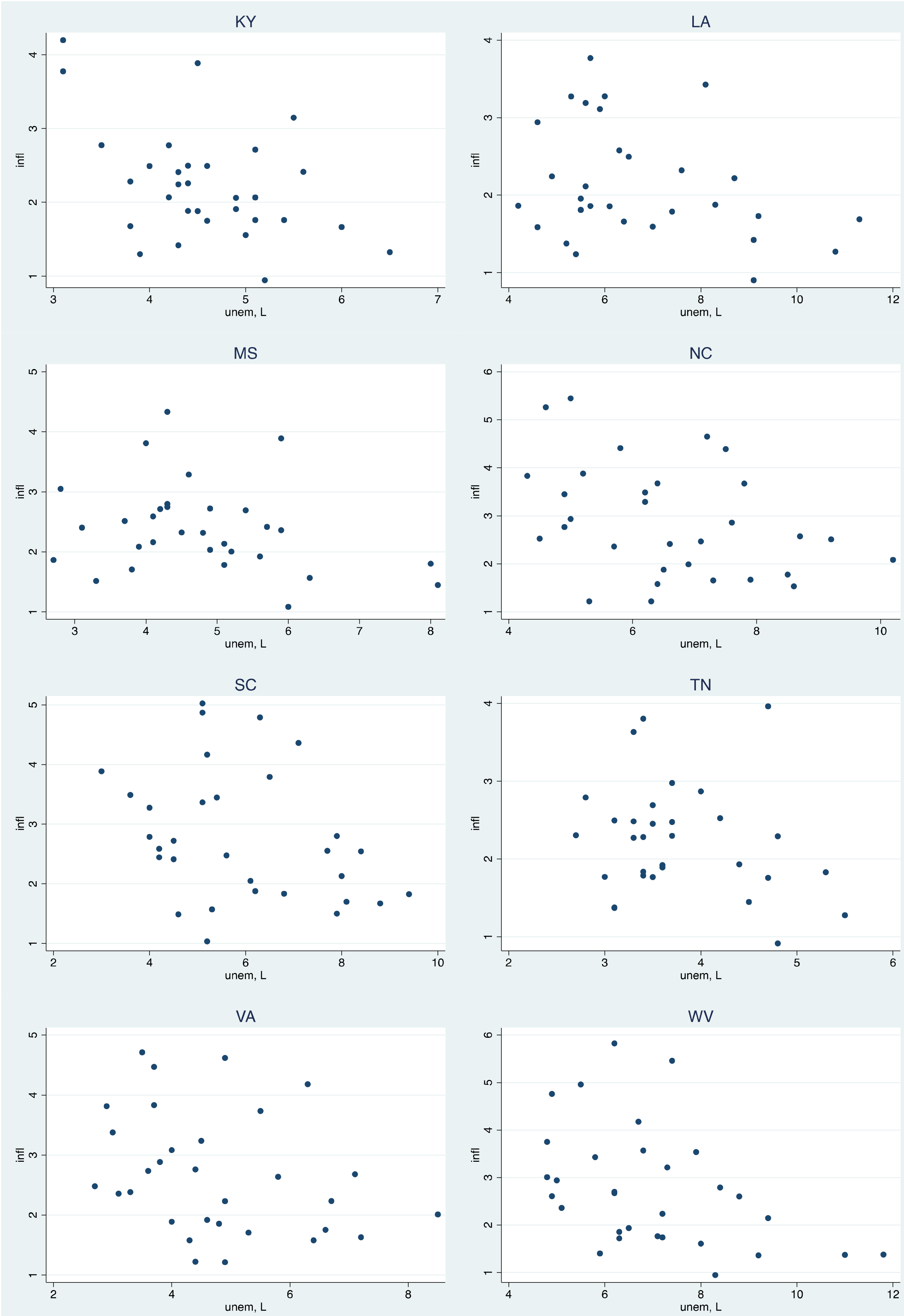
Region 4:



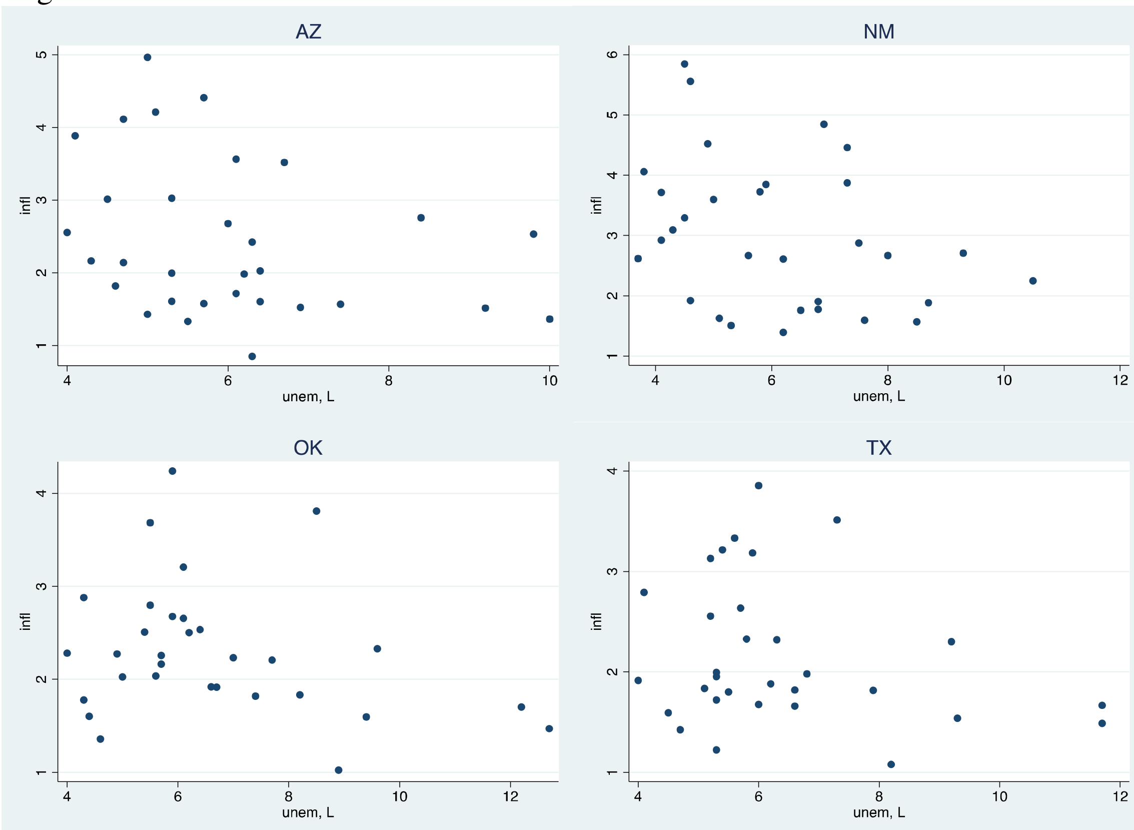



Region 5:

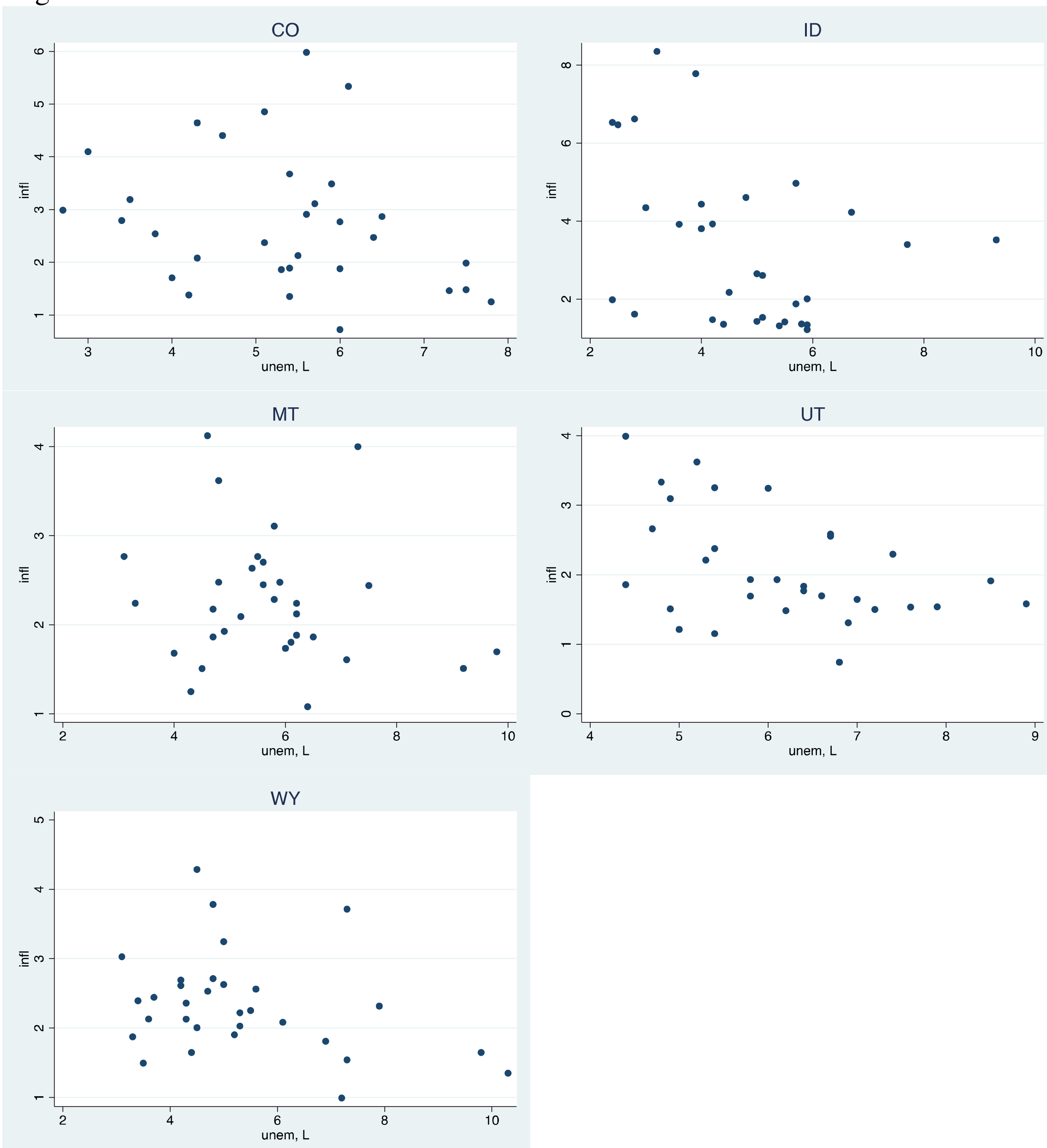



KY
LA
MS
NC
SC
TN
VA
WV
infl
unem, L

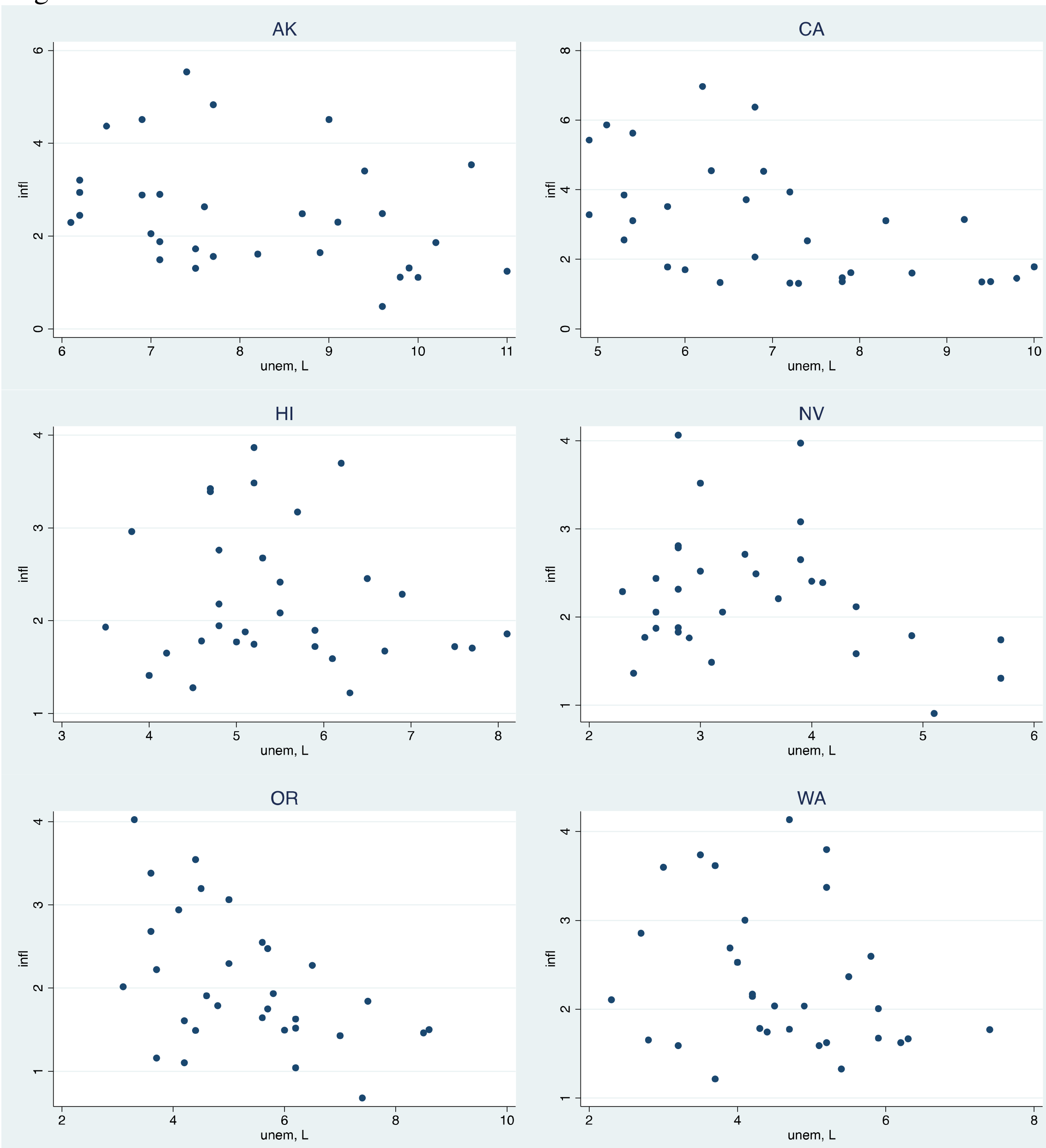
Region 6:



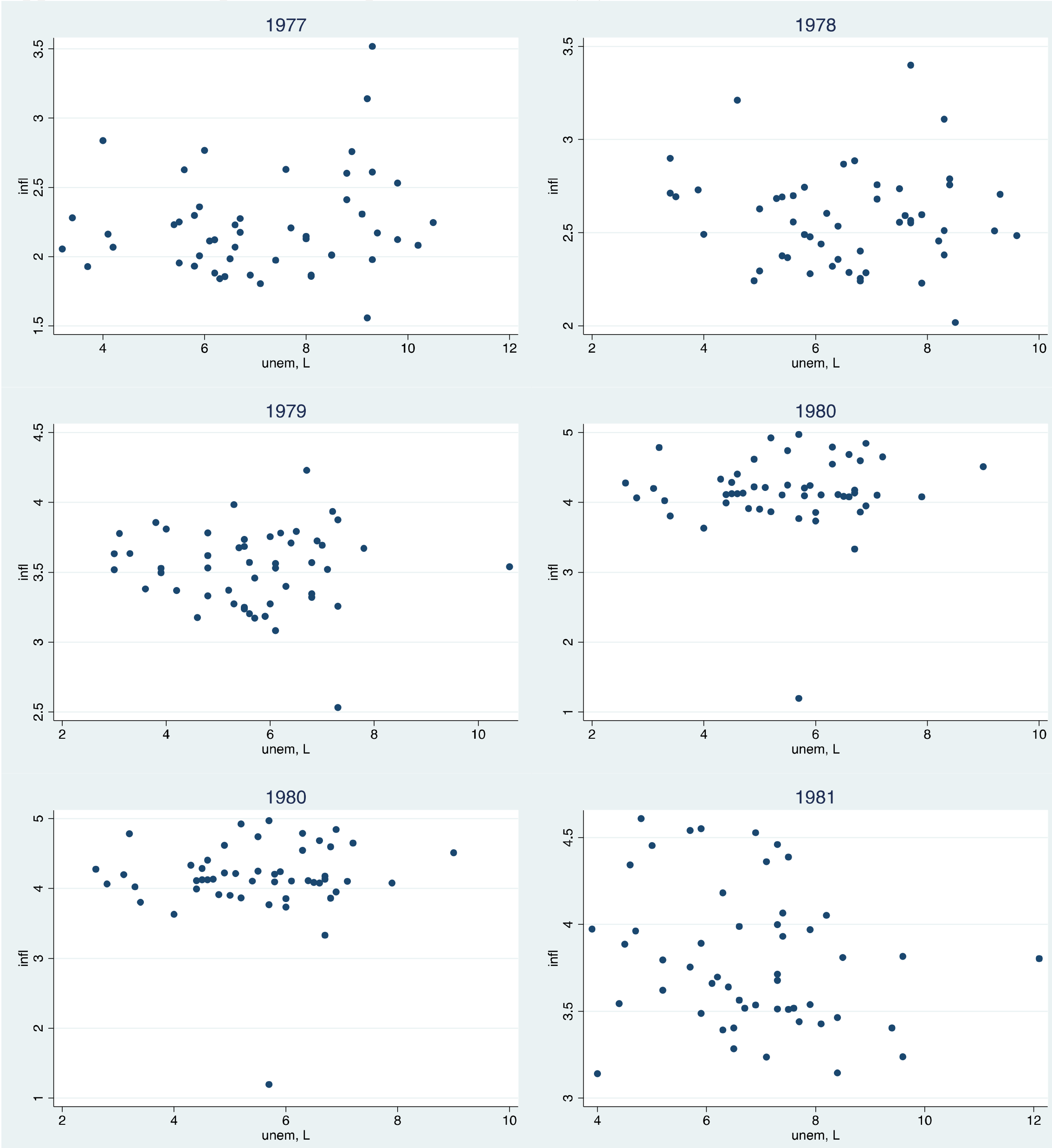
Region 7:

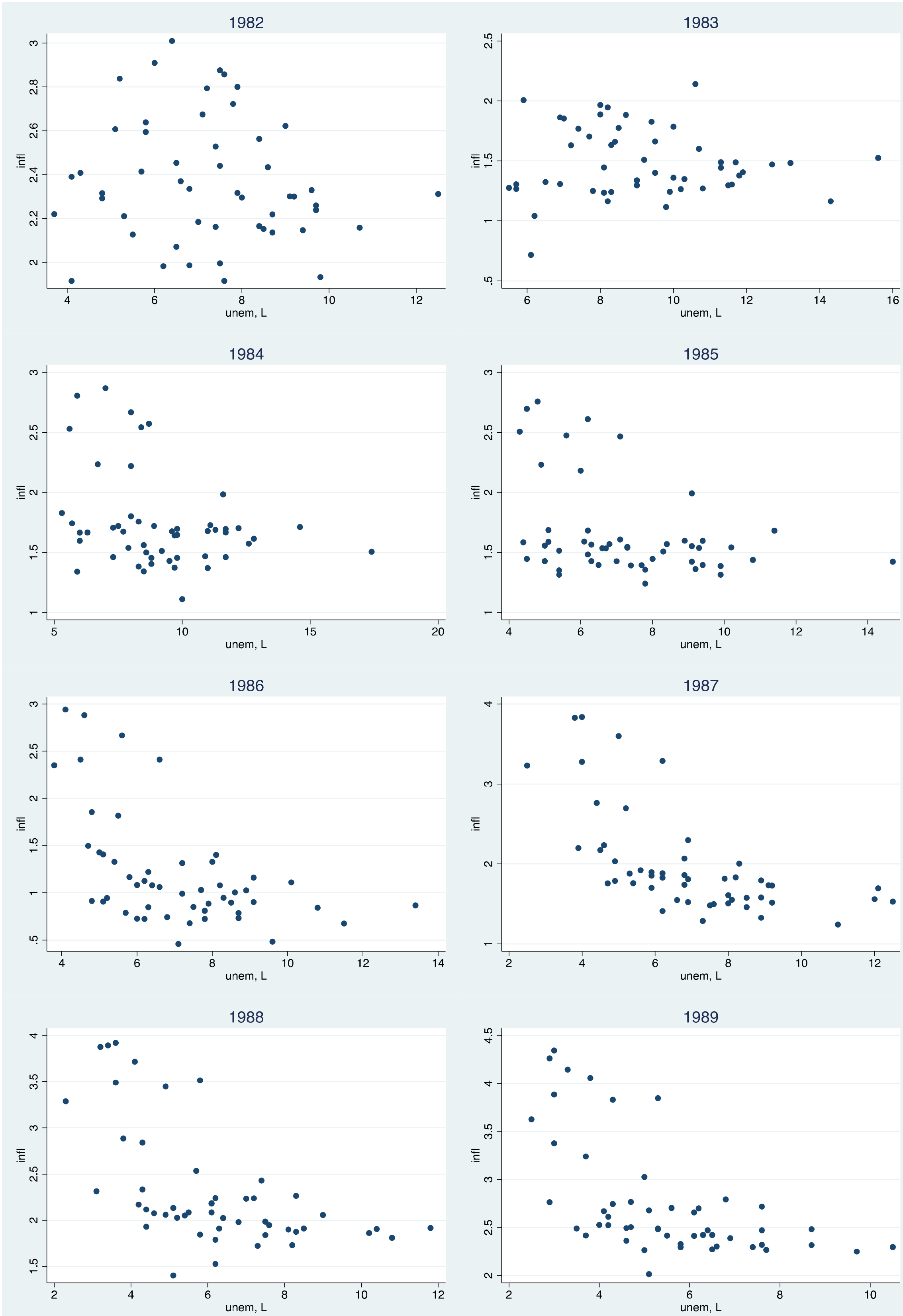


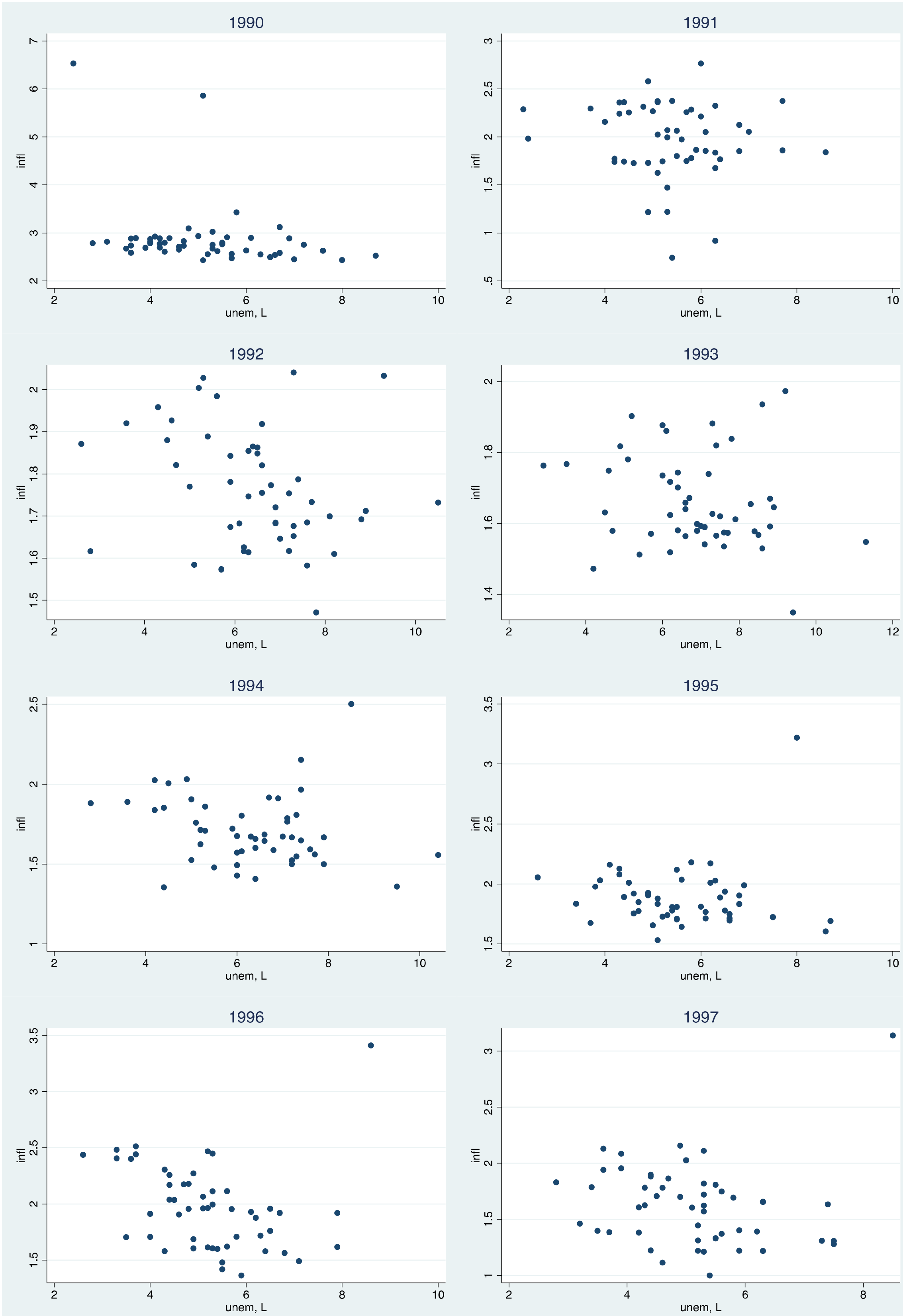
Region 8:

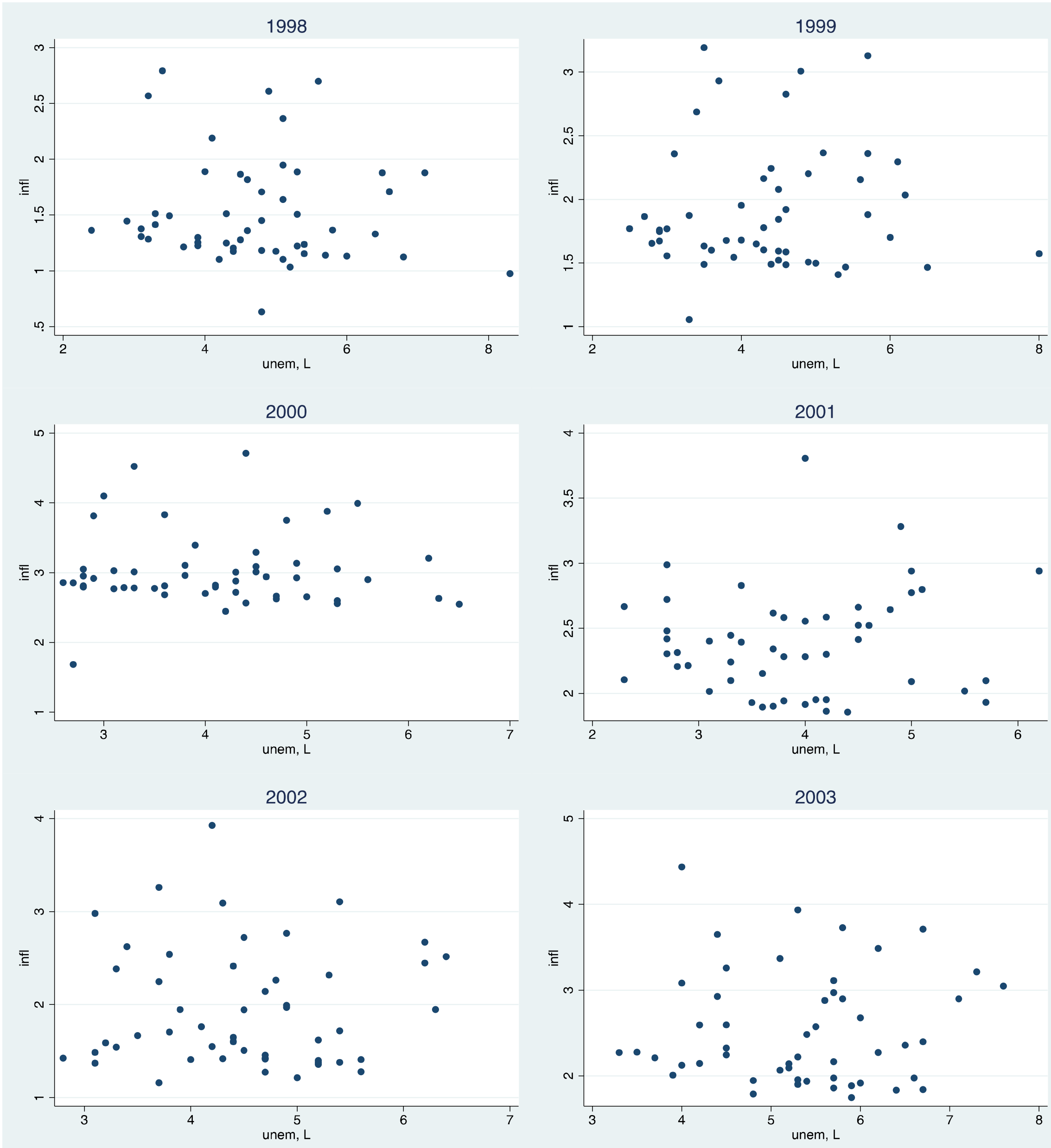


Appendix B – Graphs of Phillips Curve sorted by year, for all states

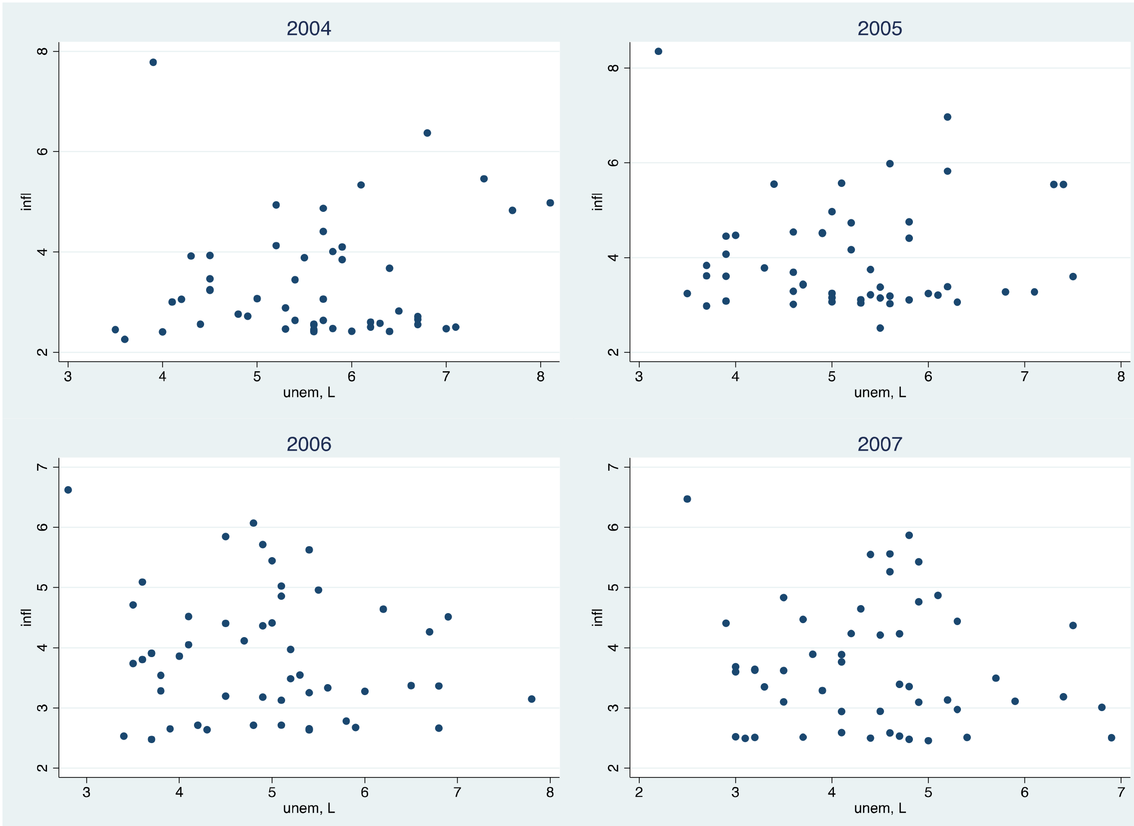



1982
1983
1984
1985
1986
1987
1988
1989
infl
unem, L


1990
1991
1992
1993
1994
1995
1996
1997
infl
unem, L



1998
1999
2000
2001
2002
2003
infl
unem, L


2004
2005
2006
2007
infl
unem, L

Appendix C – Results of the Panal Regression.

| Pooled Regression | | | | |
|---|---|---|---|---|
| R-squared = | 0.0678 | | | |
| Adj. R-squared = | 0.0672 | | | |
| F(1, 1548) = | 112.65 | | | |
| infl | Coef. | Std. Err. | t | P>\|t\| |
| Lunem | -0.133 | 0.013 | -10.61 | 0 |
| _cons | 3.219 | 0.078 | 41.27 | 0 |

| Fixed-Effects | | | | |
|---|---|---|---|---|
| R-sq: | within = | 0.0929 | | |
| | between = | 0.0132 | | |
| | overall = | 0.0678 | | |
| | F(1,1499) = | 153.56 | | |
| infl | Coef. | Std. Err. | t | P>\|t\| |
| Lunem | -0.18 | 0.014 | -12.39 | 0 |
| _cons | 3.49 | 0.088 | 39.47 | 0 |
| sigma_u | 0.350 | | | |
| sigma_e | 0.942 | | | |
| rho | 0.121 | | | |

| Random-Effects | | | | |
|---|---|---|---|---|
| R-sq: | within = | 0.0929 | | |
| | between = | 0.0132 | | |
| | overall = | 0.0678 | | |
| | Wald chi2(1) = | 140.92 | | |
| infl | Coef. | Std.Err. | z | P>\|z\| |
| Lunem | -0.162 | 0.014 | -11.87 | 0 |
| _cons | 3.388 | 0.092 | 36.97 | 0 |
| sigma_u | 0.262 | | | |
| sigma_e | 0.942 | | | |
| rho | 0.072 | | | |

| Hausman Test (Comparing FE and RE models) | | | | |
|---|---|---|---|---|
| | ***FE*** | ***RE*** | ***(FE-RE)Difference*** | ***S.E.*** |
| ***L.unem*** | -0.18 | -0.162 | -0.017 | 0.005 |

*FE = consistent under Ho and Ha.*
*RE= inconsistent under Ha, efficient under Ho.*

VITA

Graduate School
Southern Illinois University Carbondale

Margarita Osadcha

osadcha.mv@gmail.com

Southern Illinois University Carbondale
Bachelor of Arts, Foreign Languages and International Trade, December 2011
Bachelor of Arts, Spanish, December 2011

Research Paper Title:
A state-level analysis of the Phillips Curve

Major Professor: Dr. Zsolt Becsi