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Abstract

The substantial increase in unemployment during the Great Recession, coupled with the possibility of a breakdown in Okun's law, gave rise to concerns of a structural increase in the natural rate of unemployment. We estimate asymmetries in Okun's law using quarterly data from 1948:01-2012:04 across the business cycle as defined by exogenous breaks for the period after the peak of the business cycle to the trough. We further allow for endogenous break points by estimating a markov switching model. The estimated asymmetries rely on adequate specification of the dynamics of the relationship. The non-linearities in Okun's law provide strong support for an understanding of deviations in Okun's law during the Great Recession as a natural by-product of a stronger relationship between GDP growth during contractions than recoveries, although this fails to explain the entirety of the weak labor market conditions during the tepid recovery in economic activity. This similarly contributes towards an understanding of the phenomena of jobless recoveries which are a product of weak economic growth in recent decades coupled with a weaker relationship between GDP growth and unemployment during expansions. In this respect, the Great Recession, despite the relatively larger contraction in economic activity, was no different from previous recessions.

Keywords: Okun's law, the Great Recession, Business Cycle, Auto-regressive distributed lag, Markov Switching.
JEL Classification: C22, E32

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1 Introduction

In the wake of the Great Recession, unemployment persists as a significant problem despite moderate growth in economic activity. This apparent disconnect between economic growth and unemployment is particularly troubling, especially in formulating and evaluating policies to promote economic growth to address labor market concerns.

The purpose of this paper is to determine the extent to which the increase in unemployment over the Great Recession and labor market conditions since can be attributed to fluctuations in aggregate demand. We further ask whether this time things were different? That is, was the increase in unemployment during the Great Recession different from that observed in other recessions? Can the weak labor markets in the aftermath of the Great Recession be explained by cyclical factors alone?

The possible breakdown in the relationship between aggregate demand and unemployment – in Okun's law – has raised concerns of a structural increase in the natural rate of unemployment rate following the Great Recession. We evaluate the extent to which fluctuations in aggregate demand can explain the sharp increase in the unemployment rate observed during the Great Recession and the weak labor market conditions since. This is an important question because the extent to which cyclical fluctuations in aggregate demand are responsible for the lackluster labor market performance of the past several years suggests that the appropriate policy response would be to encourage fiscal and monetary policies to stimulate demand. In contrast, if labor market frictions have increased the natural rate of unemployment more targeted labor market policies may be in order.

Okun's (1962) estimate of the relationship between economic growth and the unemployment rate is often employed by policy makers and in forecasting. The stability of Okun's law through time has been the source of some debate [see Weber (1995), Moosa (1997),

Silvapulle et al, (2004), and Knotek (2007)]. This concern is particularly acute in the context of the weak labor market performance since the onset of the Great Recession and other jobless recoveries [see Holmes and Silverstone (2005), Ball and Koenig (2009) and Owyang and Sekhposyan (2012)].

The relationship between unemployment and output growth for the U.S. economy appears to vary across the business cycle and is stronger during periods of economic contraction that during expansions [see Gilbert (1973), Cuaresma (2003), Silvapulle et al. (2004), Holmes and Silverstone (2006), Knotek, (2007) and Owyang and Sekhposyan (2012)]. The greater than expected increase in unemployment during the Great Recession may stem from nonlinearities in Okun's law rather than from a structural increase in the natural rate of unemployment. Asymmetries in Okun's law may result from weak expectations for growth and pessimism among employers regarding the strength of the recovery (Silvapulle et al. 2004), changes in labor force participation, sectoral growth rates, asymmetric adjustment costs and job mismatch (Harris and Silverstone 2001).

These potential sources of asymmetries in Okun's law are consistent with defining asymmetries in Okun's law from the peak to the trough of the business cycle [as Owyang and Sekhposyan (2012)], rather than for positive and negative output gaps as is typical in the literature [see, for example, Silvapulle et al. (2004), Knotek (2007) and Ball et al. (2013)]. This definition allows for a weaker relationship between output and unemployment during periods of positive economic growth during which output is below trend, a characteristic of jobless recoveries noted over the past decades.

The potential ambiguity in the timing of asymmetries in Okun's law suggests that an endogenous determination of these breaks is appropriate. Very few papers have addressed the

issue of the adequate definition for asymmetries through endogenously determined breakpoints. Cuaresma (2003) estimated endogenous thresholds for asymmetries in Okun's law. Holmes and Silverstone (2006) estimate a Markov Switching model allowing for variations within each regime for periods of positive and negative output gaps. This model follows this line while estimating the relationship on a far more expansive data period than Holmes and Silverstone (2006). Also, given the absence of evidence of asymmetries within expansionary regimes reported in Holmes and Silverstone, we consider only two regimes with a switch in the coefficient vector alone.

This paper contributes to the debate by addressing these issues. First, we examine the stability of Okun's law across the business cycle using exogenously determined breaks based on NBER recession dates through the Great Recession. Second, we allow for endogenously determined breakpoints through the estimation of a Markov switching model. Finally, we determine the extent to which Okun's law in the Great Recession differs from other recessions and whether fluctuations in aggregate demand are sufficient to explain the substantial increase in unemployment in 2008 and 2009 and the persistently high unemployment rate in the years since.

2 Data Description and Preliminary Data Analysis

2.1. Data Sources and Summary Statistics

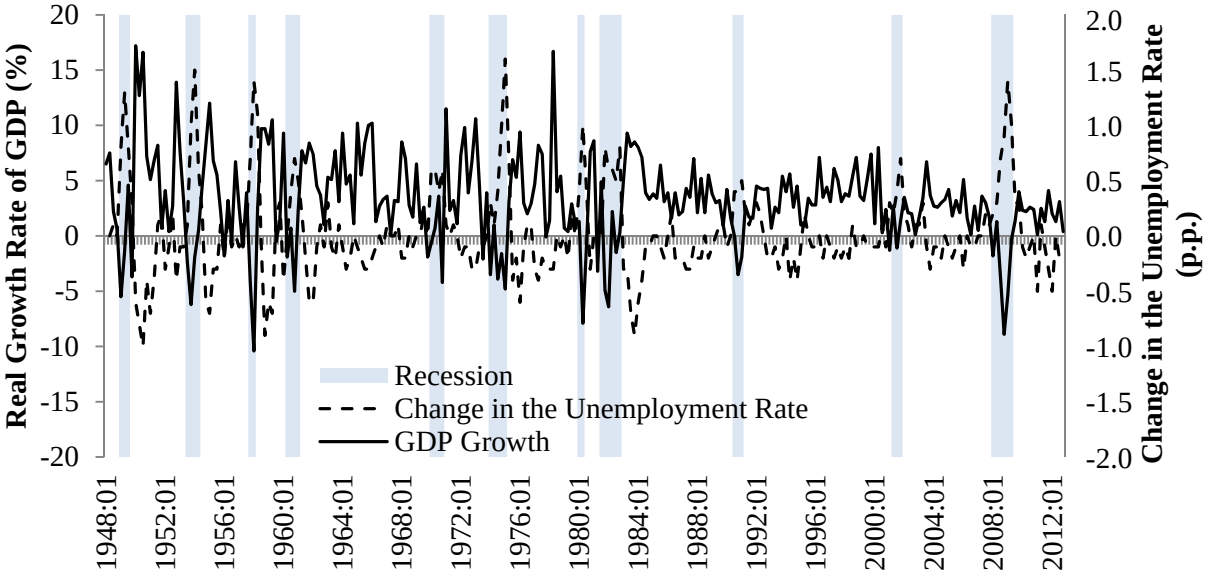
We use quarterly data for the period between the first quarter of 1948 and the fourth quarter of 2012. Data for the unemployment rate are from the Bureau of Labor Statistics. Quarterly data for the growth rate of GDP are from the Bureau of Economic Analysis. Recession dates are taken from the Federal Reserve Economic Data based on the National Bureau of Economic Research recession dating from the period following the peak through the trough of

the business cycle. Following Owyang and Sekhposyan (2012), for the exogenous definition of potential breakpoints, we define asymmetries in Okun's law during periods of contraction from the period following the peak to the trough of the business cycle. Figure 1 presents a time series plot of the real growth rate of GDP and the change in the unemployment rate in the United States between 1948:01 and 2012:04.

As a rule of thumb, Okun's law is generally defined with respect to the real growth rate of GDP and changes in the unemployment rate. Since 2007, however, labor market performance appeared to have disconnected from economic growth in a significant way. The growth rate of GDP contracted by 3.1 percent in 2009 while the unemployment rate increased by 3.5 percentage points, nearly seven tenths of a percentage point more than would be predicted by Okun's law. During the recovery, the apparent break in Okun's law appeared to occur in the opposite direction. That is, while real GDP growth over 2011 was 1.8 percent, below the 2-2.5 percent generally defined as the long term growth rate of the economy, the unemployment rate fell 0.7 percentage points. In this situation, Okun's law would have predicted a 0.4 percent increase in the unemployment rate as real GDP growth was below trend. Indeed, this latter disconnect was noted by Federal Reserve Chairman Ben Bernanke in a speech on March 25, 2012.

Part of the initial concerns regarding the stability of Okun's law in 2009 resulted from BEA GDP growth data that required later revision. Barnes et al. (2012), highlighting the stability of Okun's law, note that indeed prediction errors for Okun's law using real time data can often be used to predict subsequent revisions to the BEA data and revisions to estimates for potential GDP. They show, however, that the subsequent revisions in BEA GDP data are insufficient to explain the forecast errors observed in Okun's law during the recession.

Figure 1 Time Series Plot of the Real Growth Rate of GDP and the Change in the Unemployment Rate in the United States, 1948:01-2012:04



Source: Bureau of Labor Statistics, Bureau of Economic Analysis, and Author's Calculations

2.2. Cyclical Components of the Time Series

The cyclical component of GDP and unemployment are extracted using two approaches. First, following Weber (1995), we obtain obtain the gap series for the unemployment rate by regressing the unemployment rate (ur) on a constant and a break in the third quarter of 1973. For GDP, we regress the natural log of GDP ($lgdp$) on a constant, trend and a quadratic trend, allowing for a break in all three in the third quarter of 1973.

(1) $$ur_t = \beta_0 + \beta_1 d_{1973:3} + u_t$$

(2) $$lgdp_t = \beta_0 + \beta_1 d_{1973:3} + \beta_2 t + \beta_3 d_{1973:3} t + \beta_2 t^2 + \beta_3 d_{1973:3} t^2 + u_t$$

The residuals from these regressions describe the deviations of the unemployment rate from the natural rate and the deviation of GDP from its trend.

Second, we use the Hodrick-Prescott filter to obtain the cyclical components of the two series. The Hodrick-Prescott filter extracts the trend component τ_t by minimizing the following objective function

$$\min_{\{\tau_t\}} \sum_{t=1}^{T}(y_t - \tau_t)^2 + \lambda \sum_{t=1}^{T}\left((\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})\right)^2 \quad (3)$$

where λ controls the smoothness of the trend, as λ becomes large without bound the trend becomes linear. The first element of the objective function corresponds to the squared deviations of the series from the trend, measuring the goodness of fit for the regression. The second term defines how smooth the series is my imposing a penalty for variations from one time period to the next. We use $\lambda = 1600$ which is typical of analyses using quarterly data.

2.3. Hysteresis and Unit Roots in Unemployment

A presence of a unit root in the unemployment rate is important both conceptually and methodologically. If the natural rate of unemployment depends on aggregate demand, that is, if an increase in cyclical unemployment produces a structural increase in the natural rate of unemployment, unemployment hysteresis can contribute towards positive feedbacks that may potentially push up the unemployment rate. Hysteresis in unemployment is defined by the notion that the equilibrium unemployment rate depends on the history of the actual unemployment rate (Blanchard and Summers, 1986). Testing for a linear form of hysteresis in unemployment involves testing for a unit root in the unemployment rate series (Cuestas and Gil-Alana, 2011).

The presence of a unit root is indication of hysteresis in unemployment. This is also important methodologically as it affects the model specification through the potential for a cointegrating relationship. Augmented Dickey Fuller test results suggest that the unemployment rate is stationary around a constant. The BIC selected two lags for the difference of the

unemployment rate and the ADF test statistic of -3.58 is below the 1% critical value of -3.44 and is consistent with results found in the literature (see Nelson and Plosser 1989 and Perron 1989 among many others). Because we have rejected the null of a unit root, the presence of breaks in the series does not constitute a major challenge. The results therefore suggest that a linear form unemployment hysteresis is not consistent with the available data.

3 Methodology

Estimation of Okun's coefficient in the economic literature has been conducted using a variety of model specifications. Okun (1962) estimated the original relationship using the change in the unemployment rate and the growth rate of GDP as well as by using deviation of the unemployment rate from the natural rate of unemployment and deviations of GDP from its trend. Okun (1962) favored the latter and indeed suggests the potential benefits from alternative methods for separating the trend and cyclical components from the two series. As such, we focus primarily on estimating the Okun relationship based on the cyclical components of each of the time series extracted using a break and a quadratic trend and using the Hodrick-Prescott Filter.

3.1. Static and Dynamic Models

Analyses have also considered not only a contemporaneous relationship between unemployment and GDP, but also a dynamic relationship in which unemployment responds to lagged changes in GDP. We estimate two basic models. The first describes the contemporaneous relationship between the unemployment rate and the output gap as formulated by Okun (1962). The latter allows for dynamics in the relationship between the two variables by estimating an autoregressive distributed lag (ARDL) model. Following Weber (1995), we consider up to four lags for the autoregressive and distributed lag terms.

For the static model we estimate, in which Okun's law is defined by the parameter β_1,

(4) $$ur_t^c = \beta_0 + \beta_1 lgdp_t^c + v_t$$

The ARDL model allows for a dynamic relationship between unemployment and GDP.

(5) $$ur_t^c = \beta_0 + \sum_{i=1}^{k} \beta_{i,ur} ur_{t-i}^c + \sum_{i=0}^{k} \beta_{i,lgdp} lgdp_{t-i}^c + v_t$$

Okun's law coefficient is then estimated as

(6) $$\beta_{Okun} = \frac{\sum_{i=0}^{k} \beta_{i,lgdp}}{1-\sum_{i=1}^{k} \beta_{i,ur}}$$

Note that if the additional lags and the auto-regressive terms can be excluded, the model collapses to the static model defined in (5). Okun's law in the dynamic model is a nonlinear combination of the model parameters. Confidence intervals for the Okun's law coefficient defined by the ARDL model are obtained using a moving overlapping block bootstrap. The block length is selected by inspecting the correlogram for the unemployment rate and defined as two times the number of periods required for the correlations to dampen. We use the percentiles defined from 9,999 samples with replacement to construct the confidence intervals.

3.2. Asymmetries across the Business Cycle: Exogenous Breaks

Variation in the Okun relationship may stem from behavior over the business cycle. We allow for an exogenous break in the constant and the slope parameters during recessions using the static model and the autoregressive distributed lag models,

(7) $$ur_t^c = \beta_0 + \delta_0 d_t + \beta_1 lgdp_t^c + \delta_1 d_t lgdp_t^c + v_t$$

(8) $$ur_t^c = \beta_0 + \delta_0 d_t + \sum_{i=1}^{k} \beta_{i,ur} ur_{t-i}^c + \sum_{i=0}^{k} \beta_{i,lgdp} lgdp_{t-i}^c + \sum_{i=0}^{k} \delta_i d_{t-i} lgdp_{t-i}^c + v_t$$

where d_t is an indicator variable denoting a period of economic contraction. This indicator variable is constructed in a deterministic fashion and reflects the recession dates defined by the National Bureau of Economic Research. Evidence for asymmetries across the business cycle stem from finding that the δ_i are jointly significant. We further augment this model with an additional indicator for the Great Recession to determine whether any differences between the Great Recession and other recessions are significant.

The static model, using both de-trending approaches, suffers from serial correlation suggesting that the dynamics of the process are not adequately specified. As our objective is to examine the significance of changes in the relationship across the business cycle we employ Newey-West standard errors, with four lags, in assessing the significance of the results and in constructing confidence intervals. The presence of serially correlated errors is evidence of dynamic misspecification in the static model. Two lags were selected by both the BIC and the AIC for the ARDL model which is free of up to fourth order serial correlation.

3.3. Asymmetries in Okun's Law: Endogenous Breaks with a Markov Switching Model

We further allow for endogenously determined regimes using a two-state first-order markov switching model. The model is defined by the likelihood function

$$L = \prod_{t=1}^{T}\left(p_1 f(\boldsymbol{y}|\boldsymbol{x};\theta) + p_2 f(\boldsymbol{y}|\boldsymbol{x};\theta)\right) \tag{9}$$

The likelihood problems suffers from incomplete information and cannot be solved analytically. Instead, numerical methods for maximizing the likelihood or, more commonly, the expectations-maximization (EM) algorithm are used to obtain estimates across the two regimes.

The probability of being in regime i is simply

(10) $$p_{t|t}(i) = \frac{p_{t|t-1}(i) f(\boldsymbol{y}|\boldsymbol{x};\theta)}{p_{t|t-1}(i) f(\boldsymbol{y}|\boldsymbol{x};\theta) + p_{t|t-1}(i) f(\boldsymbol{y}|\boldsymbol{x};\theta)}$$

The average across t for each of the probabilities for each regime respectively provide an estimate for the expected probability of being in each regime. With these in hand we can solve the normal equations for each of the respective parameters in the auto-regressive distributed lag and update the expected probabilities. When the values converge with a given tolerance level the algorithm terminates.

4 Okun's Law and the Business Cycle

4.1. Linear Static and Dynamic Estimates

The estimated relationship between the unemployment rate and GDP is consistent with that outlined by Okun (1962), who originally estimated a value of -0.36 based on the output gap, and with the consensus in the literature, between -0.4 and -0.5, that the coefficient is somewhat larger than estimated by Okun (1962). The estimated relationship is sensitive to the model specification and to the dynamics of the process, although it varies within a relatively tight range. Similarly, the results are also sensitive to the particular procedure used to obtain the cyclical components of unemployment and GDP. The presence of serial correlation in the static models, together with empirical observations regarding the persistence and temporal responses in unemployment, suggests that appropriately modeling the dynamics of the process is paramount, particularly for quarterly data. This observation stems from model misspecification issues in the static model. The model results suggest that the autoregressive terms are particularly important in conjunction with the distributed lags. We obtain an estimate of -0.48 for our desired specification in the ARDL with two lags.

4.2. Asymmetries across the Business Cycle: Exogenous Breakpoints

Table 1 presents estimates for Okun's law over different phases of the business cycle as defined by the NBER. The dynamic models support an asymmetric relationship between unemployment and GDP. Both of the static models fail to reject the null of no difference across periods of expansion and contraction. The dynamic specification of the model is important in examining asymmetries in Okun's law. Ball et al. (2013) fail to identify asymmetries across the business cycle in the static model using annual data based on the HP filter. Our results with the static model are very similar to those presented in Ball et al. (2013). The presence of serial correlation in the error term, however, suggests that the dynamics of the model are misspecified. For the autoregressive distributed lag model, tests for the presence of a break in the slope coefficients indicate a significant difference in the long run multiplier for periods of expansion and contractions which supports the hypothesis of asymmetries in Okun's law.

The interpretation of these estimates is that once the direct and indirect elements associated with the relationship are accounted for a one percent increase in GDP growth above trend is associated with a -0.48 percentage point reduction in unemployment. During periods of expansion the relationship is marginally weaker, -0.44, and during periods of contraction the relationship is stronger, -0.65. It is interesting to note that Okun (1962) first derived his estimates of -0.36 during a period characterized by fewer, albeit relatively, strong recessions.

The estimates from the dynamic model are more negative during contractions, indicating a stronger relationship between unemployment and GDP during recessions than expansions. The Great Recession fits neatly into this framework, as does the general concept of jobless recoveries. With asymmetries in Okun's law across the business cycle, weak economic growth following the 1991, 2001 and 2008 recessions, relative to the periods following the recessions in

Table 1 Asymmetry in Okun's Law Across Business Cycles

	Model	Okun's Law Coefficient	Expansions	Contractions	p-value
Quadratic Trend	**Static OLS**	-0.3818 (-0.4403,-0.3233)	-0.3793 (-0.4462,-0.3124)	-0.3998 (-0.4810,-0.3186)	0.6616
	ARDL k=2	-0.3086 (-0.3110,-0.3061)	-0.2842 (-0.3190,-0.2493)	-0.3689 (-0.5155,-0.2224)	0.1072
HP Filter	**Static OLS**	-0.4351 (-0.4757,-0.3945)	-0.4635 (-0.5136,-0.4134)	-0.4865 (-0.5437,-0.4293)	0.5332
	ARDL k=2	-0.4799 (-0.5002,-0.4595)	-0.4389 (-0.4735,-0.4042)	-0.6488 (-0.7669,-0.5308)	0.0000

Source: Author's Calculations

Notes: P-value is for significance of change in the slope coefficient during recessions. p-value and confidence intervals for OLS model reflect Newey-West standard errors. In addition, 95% confidence intervals given in parenthesis. Confidence intervals for the ARDL k=2 model derived from moving block bootstrap.

the 1970s and 1980s, may produce weak labor markets following the downturns. The phenomena of jobless recoveries is therefore a byproduct of a moderation in economic growth and a weaker relationship in Okun's law during periods of expansion. As Owyang and Sekhposyan (2012), using the gap specification, we find that the asymmetries estimated over the Great Recession are not significantly different from those observed during past recessions.

The results also underscores the importance of the dynamics of the relationship between unemployment and GDP growth in understanding Okun's law. Elsby, Hobijn and Sahin (2010) note that during the latter half of 2009, labor markets continued to deteriorate, despite a positive output gap, although generally consistent with overall economic slack [see Elsby et al. (2011)]. During the last two quarters of 2009, periods of moderate economic growth, the unemployment rate increased from 9.3 percent to 9.9 percent. This lagged increase is consistent with the

dynamics of the relationship specified here. Furthermore, it is consistent with the weaker relationship we would expect to see during periods following a recession.

Our estimates for Okun's law across the business cycle are consistent with the available literature. Cuaresma (2003) estimates a coefficient of -0.19 for expansions and -0.44 for contractions. Silvapulle et al. (2004) estimates Okun coefficients of -0.25 and -0.61 with respect to increases and decreases in cyclical output. Holmes and Silverstone (2006) find asymmetries within expansionary and recessionary periods with estimates of -0.023 and -0.025 during expansionary regimes and -0.193 and -0.084 in contractionary regimes, for periods of below and above trend growth. Owyang and Sekhposyan (2012) find that the average recession increases the unemployment rate by 0.22 percentage points. Ball et al. (2013) find no asymmetries in Okun's law, although that may result from a misspecification of the dynamics of the relationship.

4.3. Asymmetries across the Business Cycle: Endogenous Breakpoints

The Markov switching regression estimates based on the dynamic model with two lags with gaps obtained by the HP filter are of -0.43 for regime one, the weaker state consistent with periods of relatively stronger economic growth and -0.59 for stronger regime two consistent with periods of contraction. The magnitude of the asymmetries reported are consistent with those obtained by defining exogenous breaks in the slope coefficient across business cycles as defined by the NBER.

Figure 2 presents the change in the unemployment rate between 1949:04 and 2012:01 and the dating for the strong regime identified by the Markov switching model limiting the regime shift to the coefficient vector alone. The weaker regime generally occurs during periods of expansion. The only exception is that the recession from 1970:01 to 1970:04 and that from 1990:03:1991:04 are drawn from regime one with probabilities of 70.4 percent and 76.2 percent,

respectively. Over 90 percent of those quarter that are not identified as recession by the NBER are identified as belonging to the weaker regime.

The three recessions prior to 1960 belong entirely to the stronger regime. Although the unemployment rate was relatively low during this period, in each recession the unemployment rate increased by more than 1.3 percentage points in a single quarter. For the recessions beginning in third quarter of 1953 and in the fourth quarter of 1957, the stronger regime persists two and four quarters, respectively beyond the trough of the business cycle.

The stronger regime associated with the 1974:01-1975:01 recession begins three quarters into the recession and continues two quarters after its trough. During the last two quarter of this recession the unemployment rate increased by 1.0 and 1.6 percentage points, respectively, and the probability of the stronger regime jumped from 60 percent to 91 percent and 99 percent for each quarter, respectively.

Similarly, the stronger regime associated with the 1981:03-1982:04 recession is identified with a lag; the first year of the recession is in the weaker regime while the last two, and several quarters after are in the stronger regime. The same pattern, albeit with greater moderation, occurs during the 2001:02-2001:04 recession.

During the Great Recession, the stronger regime dominates during the first and second quarter of 2009, with probability above 90 percent during the period in which the unemployment rate grew 1.4 percentage points and 1 percentage point in each quarter, respectively. The fourth quarter of 2009 through the end of 2010, however, are strongly in the weaker regime with probability above 80 percent.

The use of recession dates from peak to trough is a conceptually more appealing approach to defining asymmetries across the business cycle than that based on a zero output gap

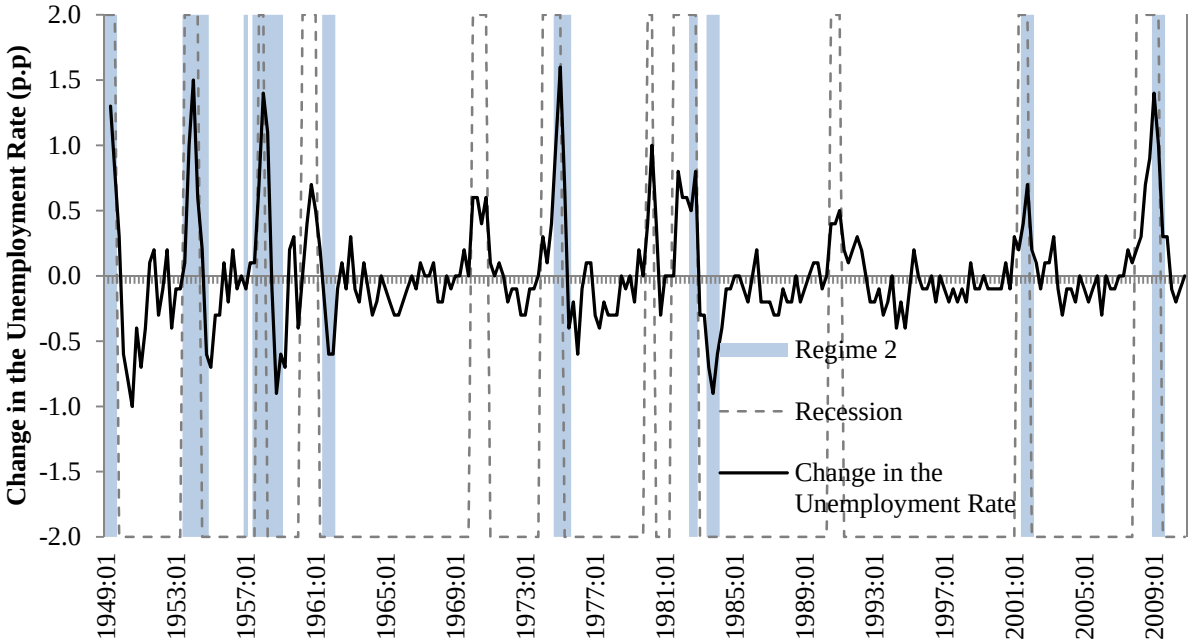
Table 2 ARDL and Markov Switching Model Estimates

	ARDL k=2	Regime 1	Regime 2
Okun's Law Coefficient	-0.48	-0.43	-0.59
ur_{t-1}^{c}	0.9970	0.9563	0.8729
	(0.0593)	(0.1178)	(0.2115)
ur_{t-2}^{c}	-0.3006	-0.2154	-0.2174
	(0.0494)	(0.0846)	(0.0957)
$lgdp_{t}^{c}$	-0.2123	-0.1765	-0.2885
	(0.0154)	(0.0244)	(0.0359)
$lgdp_{t-1}^{c}$	0.0531	0.0788	-0.0027
	(0.0243)	(0.0306)	(0.0806)
$lgdp_{t-2}^{c}$	0.0135	-0.0149	0.0877
	(0.0210)	(0.0266)	(0.0649)

Standard Error in Parenthesis

threshold. The Markov Switching model results support asymmetries in Okun's law that appear consistent with a fairly strong threshold in the unemployment rate These results can be compared to Cuaresma (2004) who estimate a threshold for a regime shift when the output gap falls below -0.39 using HP filtered and -0.14 for the bivariate time series approach taken to extract the cyclical components. The endogenously identified periods reflects the mechanisms underlying weak economic performance and those features that characterize a jobless recovery.

Figure 2 Strong Regime and the Change in the Unemployment Rate 1948:04-2012:01



Source: Author's Calculations

Overall, the endogenous breaks closely mirror those patterns in the instability in Okun's law that are often mentioned in the literature. The analysis is consistent with a threshold effect for movement between regimes. All of the instances of an increase in the unemployment above one percentage point in a quarter are identified as belonging to the stronger regime. Furthermore, in each of the periods identified as belonging to the stronger regime the unemployment rate increased by more than half of a percentage point in a single quarter. In the two quarters during which the unemployment rate grows by more than six tenths of a percentage point that are not identified as belonging to the stronger regime, the onset of the stronger regimes occurs several quarters ahead; in one of the instances, in 1960 this occurs during a period of expansion.

5 Policy Implications

The very sharp increase in unemployment during the Great Recession, coupled with persistently high unemployment its wake, has led to an important discussion regarding the validity of Okun's law in the past few years and concerns that a structural increase in the natural rate of unemployment is responsible for the high rate of unemployment observed over the past several years.

This paper contributes towards the mounting evidence that the increase in the unemployment rate during the Great Recession, and part of the puzzling labor market performance since, can be attributed to cyclical fluctuations in aggregate demand. Our results suggest that asymmetries in Okun's law across the business cycle can explain the substantial increase in the unemployment rate during the Great Recession. During periods of contraction, unemployment is more sensitive to fluctuations in output growth from its potential thereby leading to a larger than expected increase in unemployment for a given drop in economic activity. Ball and Koenig (2009) note that data from the Job Openings and Turnover Survey support the hypothesis that cash-flow pressures during the credit crunch may have accelerated layoffs, consistent with a larger Okun's law coefficient during periods of contraction.

Elsby et al (2011) similarly find that the lackluster labor market recovery can be traced in large part to weakness in aggregate demand; only a small part seems attributable to increases in labor market frictions, suggesting that unemployment is unlikely to remain high after aggregate demand recovers. Rothstein (2012) reviews structural explanations for historically weak labor markets in recent years and finds that the evidence is more consistent with the hypothesis that continued poor performance is primarily attributable to shortfalls in the aggregate demand for

labor. Ball, Leigh and Loungani (2013) show that Okun's law is a strong and stable relationship that did not change substantially during the Great Recession.

While shortfalls in aggregate demand can explain the large increase in unemployment and are the driving force in persistently weak labor markets in the past several years, they are insufficient to explain it in its entirety. Daly et al. (2011) show, using a standard job search and matching framework, that the natural rate of unemployment has risen in the past several years, although only a small fraction of this increase is likely to be persistent. This, nonetheless, suggests a combination of policies to stimulate aggregate demand together with policies targeting labor market frictions.

The large relative contribution of cyclical fluctuations in aggregate demand to unemployment during the Great Recession, however, suggests that fiscal and monetary policies are appropriate measures to improve labor market outcomes. The presence of asymmetries in Okun's law further suggests that not only the type but the timing of policies are important. Fiscal and monetary policies that stimulate aggregate demand will be more effective in reducing unemployment during contractions than during recoveries. Fiscal and monetary policies, which stimulate aggregate demand, will have weaker labor market effects during periods of expansion. In contrast, as the policies stimulate aggregate demand during contractions, or dampen the contraction in economic activity, we can expect to see more favorable labor market outcomes, that is, a smaller reduction that would be implied by the larger Okun's coefficient during periods of contraction.

6 Conclusions

Deviations, during the Great Recession, in expectations for unemployment, derived from estimates for Okun's law, are completely explainable through asymmetries in the relationship across the business cycle. Labor markets during the recovery, however, are not. The potential breakdown in Okun's law raised the specter of a potential structural increase in the natural rate of unemployment following the housing bust and the financial crisis. The results presented here reinforce the conclusion that weak labor markets following the Great Recession are typical of asymmetries in Okun's law. In this vein, despite the relative strength of the downturn in economic activity, the Great Recession does not differ in this respect to other post WWII recessions. This alone, however, is not sufficient to explain the persistently high unemployment in the years following the Great Recession.

The weaker relationship between GDP growth and unemployment during periods of economic expansion is a structural feature of Okun's law. In this context, coupled with relatively weak economic performance in the periods following the 1991, 2001 and 2008 recessions, we would expect to see weak labor markets during the recovery. As such, Asymmetries in Okun's law are a chief suspect in producing jobless recovering in the last two decades (Holmes and Silverstone, 2012) .

The non-linearities in Okun's law provide strong support for an understanding of deviations in Okun's law during the Great Recession as a natural by-product of a stronger relationship between GDP growth during contractions than recoveries, although this fails to explain the entirety of the weak labor market conditions during the tepid recovery in economic activity. This similarly contributes towards an understanding of the phenomena of jobless recoveries which are a product of weak economic growth in recent decades coupled with a

weaker relationship between GDP growth and unemployment during expansions. In this respect, the Great Recession, despite the relatively larger contraction in economic activity, was no different from previous recessions.

This research opens some interesting avenues for future research. A full variance decomposition for cyclical fluctuations and structural factors contributing to an increase in the unemployment rate can provide for more detail regarding the nature of the weak labor markets over the past several years. Furthermore, the asymmetries in Okun's law may be a source of nonlinearities in the Phillips curve across the business cycle.

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