Comparative Economic Studies, 2013, 55, (557–581)
© 2013 ACES. All rights reserved. 0888-7233/13
www.palgrave-journals.com/ces/

Regular Article

Asymmetry in the Unemployment–Output Relationship Over the Business Cycle: Evidence from Transition Economies

EMRAH ISMAIL CEVIK[1], SEL DIBOOGLU[2] & SALIH BARIŞIK[3]

[1]Department of Econometrics, Bulent Ecevit University, Zonguldak 67100, Turkey.
[2]Department of Economics, University of Missouri St Louis, 408 SSB, One University Blvd., St Louis, MO 63121, USA.
[3]Department of Economics, Gaziosmanpaşa University, Tokat 60150, Turkey.

This study examines the presence of asymmetry in Okun's law for nine transition economies by means of a Markov regime-switching model. We examine the relationship between unemployment and real GDP to ascertain whether such changes are substantially different in downswing *versus* upswing regimes. The nonlinear model outperforms the linear model in all transition economies in the sample except for Slovenia. There is evidence that the Okun coefficients vary across regimes and countries. In most countries, cyclical unemployment is more sensitive to cyclical output in downswing regimzes than upswing regimes. We also find recoveries entail poor job growth in most transition economies.
Comparative Economic Studies (2013) **55,** 557–581. doi:10.1057/ces.2013.7; published online 25 April 2013

Keywords: Okun's law, asymmetric adjustment, Markov regime switching, transition economies, business cycles

JEL Classifications: E24, E32, C22

INTRODUCTION

Okun's law relates changes in unemployment to changes in output or the output gap. It is an important empirical concept in macroeconomics as it gauges the output–unemployment trade-offs, which makes it useful in

policymaking and forecasting. Combined with the Phillips curve, Okun's law provides a short-run aggregate supply curve. Moreover, the relationship is important for policy makers as it can be used to ascertain whether the growth rate is sustainable.

Okun (1962) found a negative relationship between unemployment and output in the United States. Specifically, Okun's empirical results showed a 3% increase in output that is associated with a 1% decrease in the unemployment rate. Since then, a large number of studies examined the unemployment–output relationship and generally confirmed its empirical validity; however, estimates of Okun's coefficients seem to vary substantially across countries and over time.

There are several reasons why Okun's coefficients are not robust over time and across countries. Model specifications where the relationship between unemployment and output is specified in terms of differences (the differences model) *versus* deviations from a trend (the gap model), various econometric methods, static *versus* dynamic specifications all have a role, although Weber (1995) found that the latter is not as important as the model specification. Finally, using different decomposition methods to estimate cyclical components of output and unemployment may lead to different estimates of Okun's coefficients.

Moosa (1997) tested the validity of Okun's law for G7 countries and found the highest Okun coefficient was in North America and the lowest was in Japan. This was in part because of labor market flexibility in North America as labor market rigidities tend to influence Okun coefficients across countries. Lee (2000) examined the robustness of the Okun relationship for 16 OECD countries and found supportive evidence for Okun's law for most countries. However, quantitatively the Okun coefficients were found to diverge across countries.

Perman and Tavera (2005) investigated the convergence of Okun coefficients among several alternative groupings of European economies. Empirical results provided evidence in favor of convergence of Okun coefficients among Northern and Central European countries. Villaverde and Maza (2009) analyzed Okun's law for the Spanish regions and found different estimates of Okun's coefficients for the regions because of regional disparities in productivity growth.

There have been numerous studies examining nonlinear behavior in the output–unemployment relationship and the empirical results question the validity of the hypothesis that expansions and contractions in output have the same effects on unemployment. A linear response of unemployment to output growth over the business cycle is restrictive in macroeconomics, as a large body of literature has confirmed many macroeconomic time series

behave asymmetrically over the business cycle. For instance, Neftci (1984) found the US unemployment rate increases more sharply during downswings than it declines during upswings. Gomme (1999) and Schettkat (1996) showed that the response of unemployment to output shocks is asymmetric in real business cycle models.

Harris and Silverstone (2001) argued that testing for asymmetry in the output–unemployment relationship is important for at least four reasons. First, it could assist in discriminating among alternative theories of joint labor and goods market behavior. Second, it would strengthen the case for an asymmetric Phillips curve if a country's Okun relationship is also asymmetric. Third, knowledge about the extent of asymmetry in the output–unemployment relationship could be useful for both structural policies (eg, labor market reforms) and stabilization policies (eg, appropriate monetary policy responses). Finally, ignoring asymmetry in Okun's law, when it is present, could lead to forecasting errors. Moreover, Holmes and Silverstone (2006) emphasize factor substitution, changes in labor force participation and sectoral growth rates, asymmetric adjustment costs between expanding and contraction firms, and the role of mismatch all contribute to an asymmetric relationship between unemployment and output over the business cycle.

Recently a large number of studies have focused on asymmetry in Okun's law using nonlinear models. Viren (2001) investigated the nonlinear relationship between output and unemployment using a threshold model for the 20 OECD countries. The study provided evidence in favor of nonlinearity in Okun's law. Harris and Silverzstone (2001) confirmed asymmetry in Okun's law for seven OECD countries using a threshold model. Sögner (2001) used a regime-switching model for the Austrian economy and found evidence of asymmetry in Okun's law. Cuaresma (2003) examined the existence of a nonlinear relationship between output and unemployment in the United States. The study confirmed the contemporaneous effect of output growth on unemployment is asymmetric and significantly higher in recessions than in expansions. Silvapulle *et al*. (2004) also corroborated the asymmetric relationship between output and unemployment using data from the US economy. Huang and Chang (2005) examined the empirical validity of Okun's law for Canada using structural break tests and threshold autoregressive models. Their empirical results provided evidence of structural breaks and nonlinear behavior in Okun's law in Canada. Huang and Lin (2006) followed up on nonlinearity in Okun's law for the United States and found evidence in favor of a nonlinear and negative relationship between unemployment and output. Holmes and Silverstone (2006) tested the presence of asymmetry in Okun's law within and across regimes for the US economy using a Markov regime-switching model and found asymmetry within and across regimes.

Huang and Lin (2008) investigated Okun's coefficient for the United States by means of a smooth-time-varying parameter approach and found evidence of a smooth-time-varying Okun's coefficient.

Even though the literature is replete with work on Okun's law in advanced economies, few studies focused on transition economies. Izyumov and Vahaly (2002) examined relationship between output and unemployment in 25 transition economies. They divided the countries into groups of reform leaders and reform laggards and examined the validity of Okun's law for reform leaders. Gabrisch and Buscher (2006) investigated the relationship between unemployment and output for eight Central and East European countries, which joined European Union (EU) in 2004. Using country and panel regressions, they found a limited role for labor market rigidities and that GDP growth is dominated by productivity growth in these countries. However, in spite of the evidence supportive of an asymmetric output–unemployment relationship over the business cycle and time-varying Okun coefficients, the existing literature has paid scant attention to a nonlinear and possibly time-varying relationship between output and unemployment in transition economies.

Testing for asymmetry in Okun's law for the transition economies is important for several reasons. It is well known that, at the beginning of the transition period, unemployment levels in transition economies were quite low and continued to be low in the first stage of transition. After the transition to a market economy, unemployment rates increased sharply. Moreover, Gabrisch and Buscher (2006) show that because of fluctuations in unemployment rates, output evolved in the form of a *J*-curve in most of the transition economies between 1990 and 1994. Therefore, these fluctuations in unemployment rates may lead to a relationship between unemployment and output that varies over time. Second, economic crises in transition economies (such as the Czech Republic crisis in 1997, the Russian crisis in 1998) and developing economies (the Asian crisis in 1997) caused a significant decrease in output in the transition economies so that unemployment rates increased during the 1997–2000 period. Consequently, the relationship between unemployment and output may not be stable in the medium term, and, therefore, regime-varying Okun coefficients may be more appropriate and realistic for transition economies. Finally, it is important to understand the precise nature of Okun's law particularly if it entails jobless recoveries.

To this end, we examine the relationship between output and unemployment by means of a Markov regime-switching model in nine transition economies as regime-dependent Okun coefficients are more appropriate for transition economies. Our focus on the former transition economies is motivated by several factors. First, for these countries, the nature of the

business cycle and its empirical regularities are important to document. Are labor markets 'flexible' in transition economies? Do recoveries imply 'jobless growth' in post transition? Except for the Slovak Republic and Slovenia, which are part of the Eurozone, and Russia, which is outside the EU, these countries are aspiring to adopt the Euro. As a result, understanding output–employment trade-offs is particularly important in the absence of monetary policy instruments that would disappear if these countries were to join the Eurozone. Moreover, closer integration with the EU in the form of a common currency for some countries would likely subject these countries to additional shocks emanating from an enlarged Eurozone. Hence, understanding the behavior of unemployment and output over the business cycle would provide valuable information to policymakers in these countries.

In order to introduce the Markov regime-switching model, the section 'Okun's law and econometric methodology' contains an empirical formulation of Okun's law and discusses our modeling strategy. We apply the strategy to nine transition economies, namely, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Russia, Slovenia and Slovak Republic in the section 'Data and empirical results'. Our selection of sample countries is motivated by data availability. To preview our results, we find a statistically robust Okun's law for all countries. We also find support for a regime-dependent relationship between output and unemployment changes in all countries except Estonia. Our results imply a limited flexibility of labor markets in transition economies and mostly larger unemployment response in downswing than upswing regimes implying poor job growth in recoveries in all countries except for Latvia, Poland, Slovak Republic and Slovenia. We check the robustness of our results with an alternative specification of Okun's law in the section 'Alternative specifications'. Conclusions follow in the last section.

OKUN'S LAW AND ECONOMETRIC METHODOLOGY

Okun's law can be formulated in terms of 'differences' and deviations from a trend (the so-called 'gap' model) to characterize the relation between unemployment and output over the business cycle. Although the gap model is the most common approach in the literature, it has an important drawback as there is no unique method of determining potential output and cyclical unemployment. Empirical results show that the estimation of Okun coefficient is sensitive to the detrending techniques used to derive potential output and unemployment. Moreover, Izyumov and Vahaly (2002) and Gabrisch and Buscher (2006) concluded that estimates of potential

unemployment and output are not reliable for the transition economies. On the other hand, it is well known that on the eve of the transition employment rates were very high in the transition countries, and many people in fact dropped out of the labor force during the transition period. These facts may suggest the presence of a secular trend in unemployment in the transition countries,[1] and hence the gap model specification seems more appropriate for accounting for any secular trends. We consider the gap model specification in our work and follow up with the difference model as an alternative specification in the section 'Alternative specifications'.

The gap model specification can be formulated as follows:

$$u_t - u^* = \alpha + \beta(y_t - y^*) + \varepsilon_t \tag{1}$$

where y^* represents potential or trend level of output, u^* is the natural rate of unemployment and ε_t is a white-noise disturbance term. In the gap model specification, $u_t - u^*$ captures cyclical unemployment (called unemployment gap) and $y_t - y^*$ captures cyclical output (called output gap). In other words, the left and right hand side terms indicate the difference between the observed and potential values of real output and unemployment. The dynamic linear gap model specification of Okun's law proposed by Moosa (1997) can be written as:

$$u_t^c = \alpha + \beta y_t^c + \sum_{i=1}^{k} \rho_i u_{t-i}^c + \varepsilon_t \tag{2}$$

where u_t^c is cyclical unemployment, y_t^c is cyclical output and ε_t is a white-noise disturbance term. The lags of cyclical unemployment are required in equation 2 to remove serial correlation in the residuals. The most important drawback of the gap model is to determine potential or trend output and the natural level of unemployment. Although there have been many detrending procedures in the literature, the Hodrick and Prescott (1997) (HP) filter is commonly used for determining potential output. For instance, Lee (2000), Cuerasma (2003), Huang and Chang (2005), Perman and Tavera (2005), Adanu (2005) and Villaverde and Maza (2009) used the HP method to derive the cyclical unemployment and output series. Hence, we use the HP filter to derive cyclical unemployment and output with the following modifications:

[1] We thank Josef Brada for pointing out the possibility of a secular trend in unemployment during transition.

Originally, Hodrick and Prescott (1997) suggested 1,600 for the smoothing parameter in detrending quarterly series. On the other hand, the HP filter has been criticized in the literature for causing spurious cycles in the filtered series. Pedersen (2001) proposed an iterative method to determine the optimal value for the smoothing parameter in the HP filter. Moreover, following Pederson (2001), Rand and Tarp (2002) found that the smoothness parameter is significantly lower than 1,600 for developing countries. Therefore, we use the iterative procedure suggested by Pedersen (2001) and find that the optimal value of λ to be between 353 and 358 for unemployment and output series. Another problem with the use of HP filter is the end-point problem. Mise *et al.* (2005) suggested the use of additional forecasts of the series to overcome the end-point problem. Hence, we use an AR(n) model (with n set at 4 to eliminate serial correlation) to forecast eight additional quarters of the series and then we add the forecasts to the series before applying the HP filter.

However, given the literature we cited above regarding the evidence in favor of a nonlinear relationship between unemployment and output, we consider nonlinearity in Okun's law using a two-state Markov regime-switching model. A regime-dependent version of equation 2 can be reformulated in terms of a Markov regime-switching model as follows:

$$u_t^c = \alpha(s_t) + \beta(s_t) y_t^c + \sum_{i=1}^{k} \rho_i(s_t) u_{t-i}^c + \varepsilon_t \tag{3}$$

where s_t is the unobservable regime parameter, $\alpha(s_t)$ is regime-varying intercept, $\beta(s_t)$ is regime-varying Okun coefficient and ε_t is the innovation process. We assume that the unemployment rate follows a two-regime Markov process: $s_t = 1$ can be considered as an upswing regime in the economy and $s_t = 2$ is a downswing regime.[2] As the unemployment rate is countercyclical, in general one would expect the mean change in unemployment unrelated to output to decrease in the upswing and increase in

[2] The identification of regimes is an important issue within a Markov regime-switching framework. Studies on Okun's law generally identify the regimes as 'expansion' and 'contraction' (Harris and Silverstone, 2001; Huang and Chang, 2005; Holmes and Silverstone, 2006). Malley and Molana (2008) identify the regimes as 'high effort' in which the unemployment rate is above the natural rate and 'low effort' in which unemployment rate is under the natural rate. Harris and Silverstone (2001) label the regimes as 'upturn in business cycle' and 'downturn in business cycle'. While examining the asymmetric nature of the output–unemployment relationship, Silvapulle *et al.* (2004) use the upswing /downswing terminology. We follow suit and identify the regimes as 'upswing in the economy' and 'downswing in the economy', respectively.

the downswing regime (ie, $\alpha_1 < 0$, $\alpha_2 > 0$). However, as the transition economies underwent substantial structural change during transition, changes in structural unemployment would make it difficult to sign α_i *a priori*. The unobserved state variable, s_t, evolves according to a first order Markov-switching process described in Hamilton (1994):

$$\begin{aligned} &P[s_t = 1|s_{t-1} = 1] = p_{11} \\ &P[s_t = 1|s_{t-1} = 2] = 1 - p_{11} \\ &P[s_t = 2|s_{t-1} = 2] = p_{22} \\ &P[s_t = 2|s_{t-1} = 1] = 1 - p_{22} \\ &0 < p_{11} < 1 \quad 0 < p_{22} < 1 \end{aligned} \tag{4}$$

where p_{ij} are the fixed transition probabilities of being in an upswing or downswing regime, respectively. Note that the mean duration of staying in an upswing or downswing regime can also be calculated as $d = 1/(1-p_{ii})$.

There is a number of estimation issues that need to be addressed. Equation 3 can be estimated by using the maximum likelihood (ML) method based on the Expectation-Maximization (EM) algorithm discussed in Hamilton (1994) and Krolzig (1997). This iterative technique obtains the estimates of the parameters and the transition probabilities governing the Markov chain of the unobserved states. Let us denote this parameter vector by λ, so that for equation 3, $\lambda = [\alpha(s_t), \beta(s_t), \rho_k(s_t), \sum(s_t), p_{ii}]$ and λ is chosen to maximize the likelihood for given observations of the changes in the unemployment rate.

The EM algorithm consists of two steps. First, the expectation step involves filtering and smoothing algorithms and using the estimated parameter vector $\lambda^{(j-1)}$ of the last maximization step for the unknown true parameter vector. This provides an estimate of the smoothed probabilities $\Pr(S|Y, \lambda^{(j-1)})$ of the unobserved states s_t, where Y denotes the observed variables and S records the history of the Markov chain. In the maximization step, an estimate of the parameter vector λ is derived as a solution $\tilde{\lambda}$ of the first-order conditions associated with the likelihood function, where the conditional regime probabilities $\Pr(S|Y, \lambda)$ are replaced with the smoothed probabilities $\Pr(S|Y, \lambda^{(j-1)})$ derived in the previous expectation step. Having the new parameter vector λ, one can update the filtered and smoothed probabilities in the next expectation step. Continuing in this fashion guarantees an increase in the value of likelihood function (Clements and Krolzig, 1998).

We also use an LR test to determine whether a Markov regime-switching model describes Okun's law better than a linear model. In the LR test, the null hypothesis is no regime switching in Okun's law, whereas the alternative hypothesis is the presence of regime switching. The LR test statistic can be expressed as $\mathrm{LR} = 2[\ln L(\lambda) - \ln L(\lambda_r)]$ where $L(\lambda)$ is the log-likelihood value for the Markov regime-switching model and $L(\lambda_r)$ is the log-likelihood value for the linear model. The LR test has a χ^2 distribution with r degrees of freedom, where r is the number of restrictions. Nevertheless, a problem arises in testing regime-switching models against linear models. This is because the transition probabilities in regime-switching models are not identified in the linear model, and thus the LR test does not follow the standard χ^2 distribution.[3] To overcome this problem, Davies (1987) suggests the calculation of upper bound p-values which are given by:

$$M : \Pr[\sup LR(\gamma) > K] \leq \Pr\left[\chi_r^2 > M\right] + VM^{\frac{1}{2}(r-1)} e^{-\frac{1}{2}M} \frac{2^{-\frac{1}{2}r}}{\Gamma\left(\frac{1}{2}r\right)} \tag{5}$$

where $M = 2[\ln L(\lambda) - \ln L(\lambda_r)]$, $\Gamma(.)$ is the gamma distribution function, r is the number of restrictions, and $V = 2K^{1/2}$.

DATA AND EMPIRICAL RESULTS

The aim of this study is to investigate the unemployment – output relationship over the business cycle and any asymmetry thereof for the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Russia, Slovenia and Slovak Republic. Quarterly data are used for the unemployment rate and real GDP over the 1995Q1–2012Q2 period. All data are obtained from the OECD database, the IMF International Financial Statistics CD-ROOM and the World Bank Global Economic Monitor database. Owing to data availability, the data set starts from 1996Q1 for Slovenia. In order to account for any seasonal effects, the data are seasonally adjusted using the Tramo/Seats method.

Cyclical unemployment and output series are illustrated in Figure 1. The figure shows that the behavior of unemployment and output is consistent with Okun's law in that cyclical unemployment and output are negatively correlated for all countries. Moreover, the impact of the 2007–2009 global

[3] Although a large number of studies examines linearity in the literature, these studies have computational difficulties; see, for example, Hansen (1992), Garcia (1998) and Cho and White (2007). Therefore, several studies in the literature use the LR test to compare results of the linear and the regime-switching model.

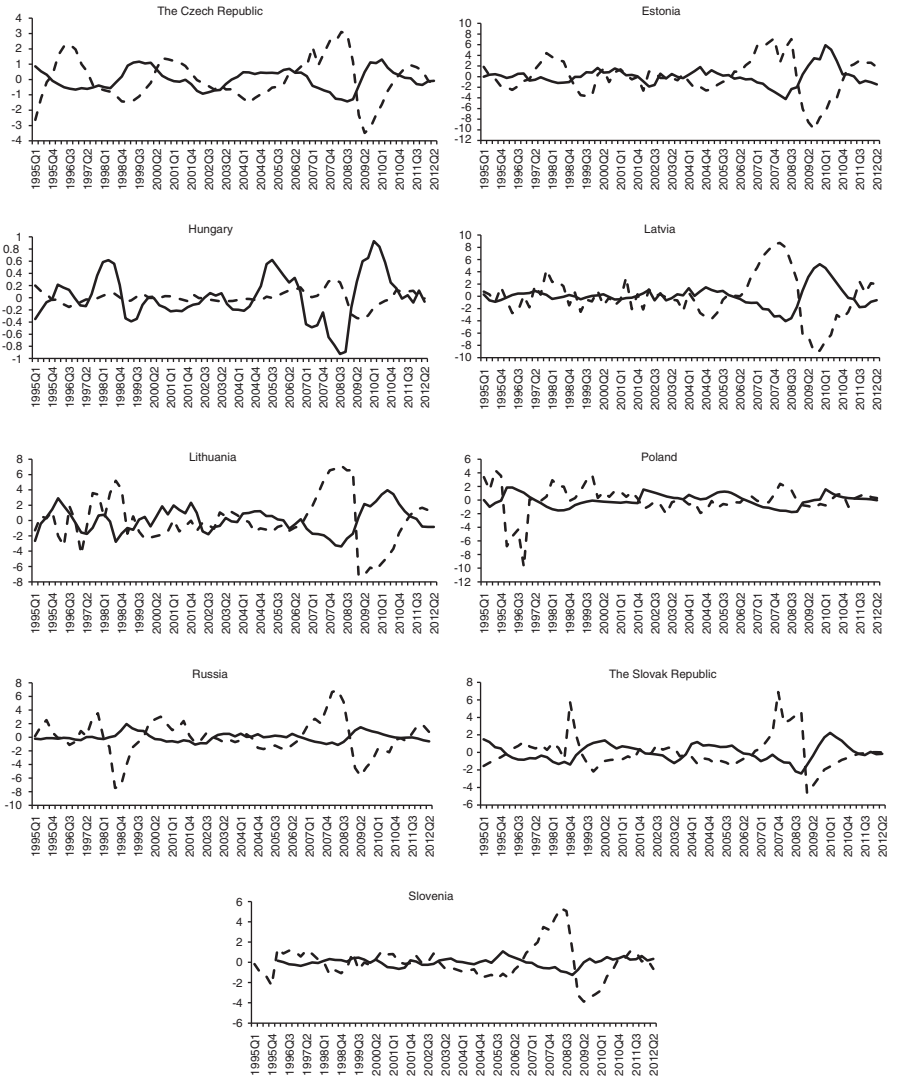

Figure 1: Cyclical unemployment and output in transition economies
Note: The dashed line is cyclical output and the solid line is cyclical unemployment.

financial crisis on unemployment and output is evident in transition economies. As output started to decrease at the beginning of the 2008, the unemployment rate increased significantly in all countries.

In order to properly model the unemployment – output relationship, we pretest for the stationarity of data *via* Augmented Dickey–Fuller and

Table 1: Unit root test results

Countries	u_t^c		y_t^c	
	ADF	PP	ADF	PP
Czech Republic	−3.895***	−2.987***	−4.142***	−3.392***
Estonia	−3.482***	−2.930***	−4.448***	−3.040***
Hungary	−4.165***	−3.089***	−4.686***	−3.324***
Latvia	−5.047***	−2.926***	−3.548***	−3.015***
Lithuania	−3.471***	−3.405***	−3.354***	−3.425***
Poland	−2.470**	−2.812***	−4.926***	−4.946***
Russia	−3.375***	−2.977***	−4.651***	−2.734***
Slovak Republic	−4.170***	−3.144***	−4.421***	−4.241***
Slovenia	−2.780***	−2.919***	−3.538***	−3.128***

*, ** and *** indicate the rejection of a unit root at the 10%, 5% and 1% significance level, respectively.
Note: The optimal number of lags selected according to the Schwarz Bayesian Information Criterion (BIC) in the Augmented Dickey-Fuller Statistic (ADF) test.
PP = Phillips-Perron Statistic.

Phillips–Perron unit root tests; the results are presented in Table 1. Unit root test results indicate that the null hypothesis of unit root can be rejected at the 5% significance level for cyclical output and unemployment in all countries.

We estimate a two-state Markov regime-switching model to determine the nature of the output – unemployment relationship and Okun coefficients in transition economies. The lag length of the autoregressive component of the unemployment rate is chosen by the Akaike information criterion (AIC) considering up to four lags. The AIC selects one lag for the Czech Republic and Slovak Republic, two lags for Estonia and Russia, three lags for Slovenia and four lags for Hungary and Latvia.

Next, using the LR test statistic explained above, we test whether a Markov regime-switching model or the linear model are more appropriate for Okun's law. In Table 2, the H_0 column indicates the value of the log likelihood under the linear model specification; the H_A column shows the log likelihood under the Markov regime-switching model specification; the χ^2 column displays the *p*-value of the LR test under the standard χ^2 distribution; and the 'Davies *p*-value' column presents the results obtained from Davies' (1987) upper-bound *p*-value calculations. The LR test results presented in Table 2 soundly reject the null hypothesis of no regime switching in Okun's law for all countries except for Slovenia. These results lend support to a nonlinear (regime switching) relationship between unemployment and output. Thus, a linear model would be misspecified; as such, it is necessary to use nonlinear models to examine the relationship between output and unemployment (Okun's law) in transition economies.

Table 2: Tests of linearity *versus* Markov regime switching

Countries	Log likelihood (H_0)	Log likelihood (H_A)	LR test statistic	χ^2 *p*-value	Davies *p*-value
Czech Republic	16.655	26.290	19.269	(0.000)	(0.012)
Estonia	−74.707	−65.760	17.894	(0.003)	(0.049)
Hungary	30.283	44.543	28.519	(0.000)	(0.004)
Latvia	−45.620	−33.612	24.031	(0.001)	(0.023)
Lithuania	−111.795	−100.286	23.019	(0.000)	(0.000)
Poland	−77.029	−57.060	39.937	(0.000)	(0.000)
Russia	−9.823	−0.579	18.489	(0.002)	(0.040)
Slovak Republic	−30.064	−19.594	20.941	(0.000)	(0.006)
Slovenia	3.756	11.428	15.343	(0.017)	(0.228)

Maximum likelihood estimates of the Markov regime-switching model implied by Okun's law are reported in Table 3. The estimates of Okun coefficients are negative for all countries in the upswing and downswing regimes and these results are in line with *a priori* expectations. Even though Okun coefficients are quite different across regimes and countries, we can make the following observations: Okun coefficients are statistically significant at the 5% level for all countries in the upswing regime except for the Czech Republic. The statistically insignificant Okun coefficients imply poor job creation in recoveries for the Czech Republic. On the other hand, the values of Okun coefficients are statistically significant at 5% level for all countries in the downswing regime-implying substantial job losses in contractions in all countries except for Hungary and Latvia.

The estimated Okun coefficients are statistically different in the upswing and downswing regimes for the Czech Republic, Hungary, Latvia and Russia. For these countries there is significant asymmetry in Okun's law.[4] In an upswing regime, Okun coefficients range from −0.021 for the Czech Republic to −1.647 for Hungary. However, most countries (eg, Estonia, Latvia, Lithuania, Poland and Slovak Republic) have Okun coefficients in the (−0.157, −0.263) range for the upswing regime. These coefficients indicate similar job creation in upswing regimes as compared with the US based on similar studies in the literature. For example, Cuaresma (2003) and Silvapulle *et al.* (2004) found point estimates of −0.20 and −0.25 for the quarterly response of unemployment with respect to output in an increasing output regime. As for

[4] We use a Wald test to determine whether Okun coefficients are statistically different across regimes for all countries. We can reject the null hypothesis that Okun coefficients are statistically equal across regimes at the 5% level for the Czech Republic, Hungary, Latvia and Russia. The test results are available upon request.

Table 3: The Markov regime-switching model results

	Regime 1: Upswing in the Economy		Regime 2: Downswing in the Economy		Regime 1: Upswing in the Economy		Regime 2: Downswing in the Economy		Regime 1: Upswing in the Economy		Regime 2: Downswing in the Economy	
	Czech Republic				*Estonia*				*Hungary*			
αst	−0.173***	(0.031)	0.062**	(0.024)	−0.061	(0.127)	0.094	(0.128)	−0.209***	(0.038)	0.014	(0.014)
βst	−0.021	(0.028)	−0.194***	(0.016)	−0.165***	(0.047)	−0.205***	(0.044)	−1.647***	(0.128)	−0.199	(0.160)
ρ_1	0.753***	(0.031)	0.739***	(0.039)	0.574**	(0.020)	0.662***	(0.126)	0.689***	(0.167)	1.191***	(0.014)
ρ_2					−0.201	(0.195)	0.262**	(0.113)	0.387	(0.293)	−0.155	(0.150)
ρ_3									0.126	(0.419)	−0.460***	(0.143)
ρ_4									−1.051***	(0.217)	0.250***	(0.089)
σ_{st}	0.119		0.150		0.556		0.531		0.049		0.104	
p_{ij}	0.865		0.946		0.345		0.372		0.086		0.864	
d	7.43		18.61		1.53		1.59		1.09		7.36	
P-χ^2	6.250 (0.510)				5.996 (0.423)				11.129 (0.194)			
N-χ^2	3.225 (0.199)				2.811 (0.245)				3.341 (0.188)			
H-χ^2	1.633 (0.802)				3.883 (0.692)				4.556 (0.918)			
	Latvia				*Lithuania*				*Poland*			
αst	−0.145	(0.143)	0.057	(0.049)	−0.795***	(0.200)	0.963***	(0.206)	−0.996***	(0.180)	0.310***	(0.076)
βst	−0.223***	(0.061)	−0.031	(0.028)	−0.263***	(0.049)	−0.389***	(0.114)	−0.234**	(0.099)	−0.185***	(0.031)
ρ_1	0.070	(0.184)	1.334***	(0.135)								
ρ_2	0.623***	(0.174)	−0.717***	(0.173)								
ρ_3	0.101	(0.212)	0.308***	(0.129)								
ρ_4	−0.472***	(0.150)	−0.361***	(0.087)								
σst	0.440		0.267		0.823		0.735		0.338		0.506	
pij	0.803		0.884		0.854		0.828		0.858		0.960	
d	5.09		8.63		6.88		5.84		7.09		23.56	
P-χ^2	11.512 (0.174)				7.559 (0.477)				14.068 (0.080)			
N-χ^2	1.566 (0.457)				5.843 (0.053)				0.323 (0.850)			
H-χ^2	8.502 (0.579)				2.858 (0.239)				6.295 (0.042)			

Table 3: (continued)

	Regime 1: Upswing in the Economy		Regime 2: Downswing in the Economy		Regime 1: Upswing in the Economy		Regime 2: Downswing in the Economy		Regime 1: Upswing in the Economy		Regime 2: Downswing in the Economy	
	Russia				*Slovak Republic*				*Slovenia*			
αst	−0.174***	(0.032)	0.186***	(0.068)	−0.172***	(0.040)	0.467***	(0.115)	−0.104***	(0.025)	0.070*	(0.037)
βst	−0.046***	(0.013)	−0.098***	(0.024)	−0.157***	(0.032)	−0.173***	(0.045)	−0.076***	(0.012)	−0.089***	(0.024)
ρ_1	0.655***	(0.089)	0.804***	(0.196)	0.743***	(0.042)	0.639***	(0.166)	0.370***	(0.089)	0.724***	(0.157)
ρ_2	0.136***	(0.094)	−0.370**	(0.162)					0.872***	(0.121)	−0.508***	(0.166)
ρ_3									−0.445***	(0.097)	0.450***	(0.139)
σst	0.142		0.228		0.239		0.302		0.062		0.210	
pij	0.615		0.494		0.907		0.700		0.487		0.788	
d	2.60		1.98		10.84		3.32		1.95		4.72	
P-χ^2	11.920 (0.068)				11.440 (0.120)				3.719 (0.590)			
N-χ^2	53.809 (0.000)				0.358 (0.835)				0.596 (0.742)			
H-χ^2	1.360 (0.968)				2.652 (0.617)				3.779 (0.876)			

*, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Notes: The figures in parentheses give the standard errors of coefficients. σ_1 gives the standard error of regression for the upswing regime, and σ_2 shows the standard error of regression for the downswing regime. p_{ii} indicate regime transition probabilities. P-χ^2 indicates the Portmanteau serial correlation test, N-χ^2 indicates the normality test and H-χ^2 indicates the heteroskedasticity test of the residuals (for more details on these tests, see Krolzig (1997)).

the downswing regime, the Okun coefficients range from −0.031 for Latvia to −0.389 for Lithuania. Specifically, job losses for the Slovak Republic, Poland, Lithuania, Latvia, Estonia and the Czech Republic during downswings are comparable with those found by Cuaresma (2003) and Silvapulle *et al*. (2004) for the United States. Note that point estimates in Table 3 imply that downswing regimes induce significant job losses that exceed job gains in expansions for the Czech Republic, Estonia, Lithuania, Russia, the Slovak Republic and Slovenia. This result is in contrast with the so-called labor-hoarding hypothesis as the latter implies job preservation during contractions. There is some evidence that labor hoarding was prevalent during the early stages of transition, which prevented widespread restructuring in labor markets (Svejnar, 1999; Boeri, 2000) but this seems to have disappeared in the second half of 1990s as contractions induced significant employment losses afterwards (Basu *et al*., 2005; Boeri and Garibaldi, 2006). While so-called jobless growth, the low job creation during expansions in Central and Eastern Europe, has been documented (eg, Boeri and Garibaldi, 2006, Onaran, 2008, Lehmann and Muravyev, 2011),[5] there is no consensus on the sources of poor job content of growth.[6] A plausible explanation of jobless growth is labor market rigidities. For example, Babecky *et al*. (2010) find non-Euro member states of the EU to be more likely to experience wage freezes compared with Euro member states. This is particularly true for the Czech Republic and Estonia. Moreover, labor market outcomes depend on the business climate in general, and a difficult business climate seems to have limited the ability of small- and medium-sized enterprises to create jobs in some Eastern European countries; Schiff *et al*. (2006). However, Boeri and Garibaldi (2006) argue that rather than being a by-product of structural/institutional rigidities, poor job growth in Central and Eastern Europe is the result of productivity enhancing job destruction.

Regardless of its sources, poor job growth in Central and Eastern Europe during expansions, persistently high unemployment and high incidence of long-term unemployment remain a serious problem. Except for Russia, the countries in our sample are part of the EU. The Czech Republic, Hungary,

[5] Onaran (2008) finds positive but low output elasticity of labor demand in Central and Eastern Europe with a number of cases where employment is completely detached from output. Boeri and Garibaldi (2006) found that the elasticity of employment with respect to output growth is 0.1 in Eastern European members of the EU, way below the Eurozone.

[6] Strictly speaking, the unemployment rate might be falling when the economy experiences job losses. Moreover, unemployment can remain high when the economy adds jobs as labor market adjustments can take other forms such as migration, changes in labor force participation and transitions between the 'grey economy' and the 'formal economy' where workers are afforded legal protections.

Latvia, Lithuania and Poland are required to adopt the Euro in the future per their accession agreements to the EU (Slovenia, Slovakia and Estonia are already in the Eurozone). If non-Eurozone countries were to adopt the Euro, they would face significant costs of losing monetary policy instruments. Even if labor markets in emerging European economies are flexible as compared with the Eurozone, flexible exchange rates provide fast and efficient adjustment mechanisms and hence retaining exchange rate flexibility is important as adopting the Euro for some countries would likely subject these countries to additional shocks emanating from an enlarged Eurozone. In face of the current sovereign debt crisis and the constraints on fiscal policy, retaining monetary policy would help in mitigating the effects of external shocks. In addition, there is evidence that labor mobility to prosperous areas in Central and Eastern European economies is low, which would exacerbate labor market outcomes in the absence of exchange rate flexibility. This is partly a function of inadequate infrastructure/transportation networks and housing (Schiff *et al.*, 2006).

Note that Okun coefficients indicate a different type of asymmetry in Hungary, Latvia and Poland: job losses in downswing regimes are lower than job gains in upswing regimes in these countries. Moreover, the Okun coefficient is not statistically significant in upswing regimes for the Czech Republic. The transition probabilities in Table 3 indicate that regimes are persistent in the Czech Republic, Latvia, Lithuania and Poland. The probability of remaining in a downswing regime at time t when the series is also in a downswing regime at time $t-1$ is above 70% for all countries except for Estonia and Russia. On the other hand, the probability of remaining in an upswing regime at time t when the series is also in an upswing regime at time $t-1$ is above 70% for all countries except for Estonia, Hungary, Russia and Slovenia. In addition, the mean duration of a downswing regime varies between 1.5 (in Estonia) and 18.6 (in Czech Republic) quarters. Especially, the mean duration of downswing regime is above 2 years for the Czech Republic, Hungary, Latvia and Poland. On the other hand, the upswing regime duration is generally longer than four quarters (except for Estonia, Hungary, Russia and Slovenia) with a range between 5.09 (in Latvia) and 10.84 (in Slovak Republic). Finally, normality, serial correlation and heteroskedasticity tests of the residuals obtained from the Markov regime-switching model are also reported in Table 3. The tests results in Table 3 indicate that the Markov regime-switching model passes all diagnostic tests.

The smoothed regime probabilities for the downswing regime are illustrated in Figures 2–10. The smoothed probabilities in Figures 2–10 show that the Markov-regime switching model is quite successful in characterizing the upswing and downswing regimes in transition economies. Specifically,

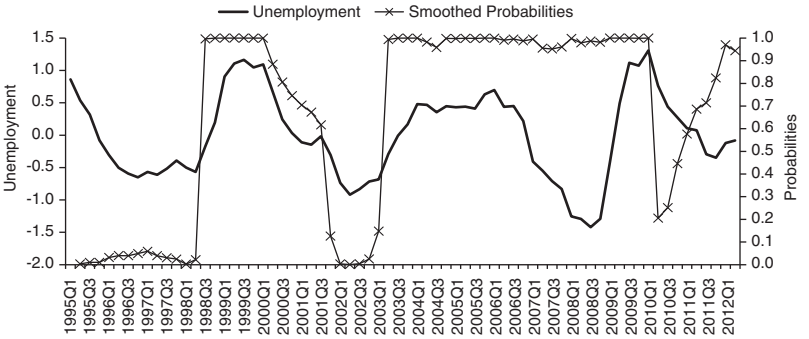

Figure 2: Smoothed transition probabilities for the downswing regime: The Czech Republic

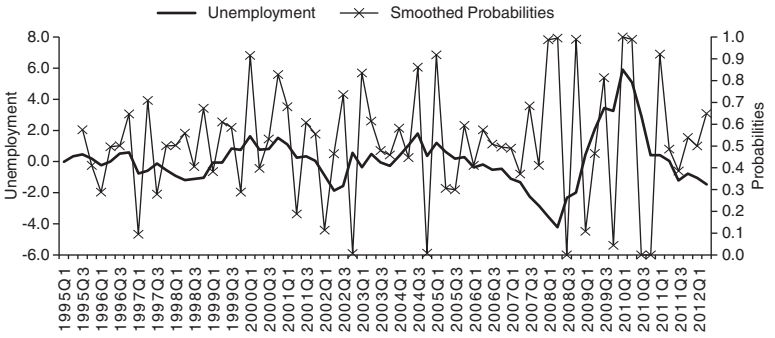

Figure 3: Smoothed transition probabilities for the downswing regime: Estonia

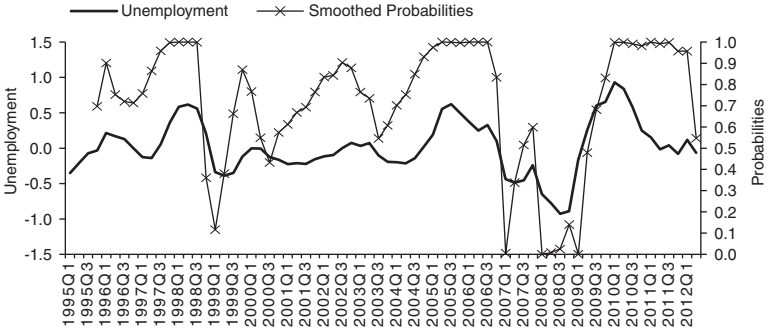

Figure 4: Smoothed transition probabilities for the downswing regime: Hungary

the estimated smoothed probabilities derived from the estimated Markov regime-switching model successfully track phases of the business cycle. For example, the global financial crisis that started in the United States in late



Figure 5: Smoothed transition probabilities for the downswing regime: Latvia

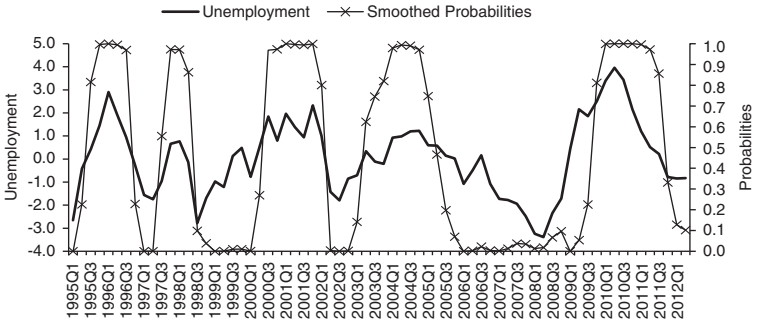

Figure 6: Smoothed transition probabilities for the downswing regime: Lithuania

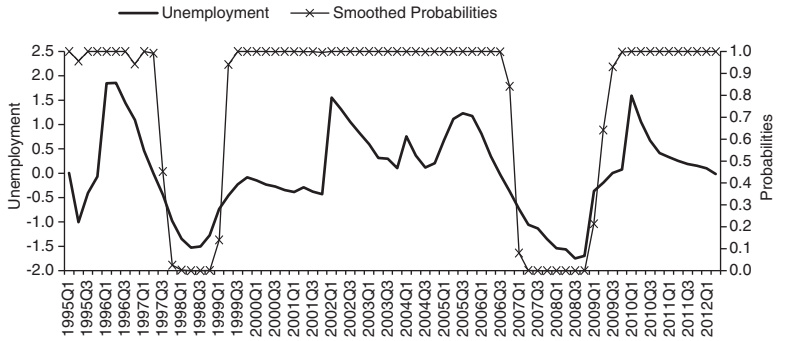

Figure 7: Smoothed transition probabilities for the downswing regime: Poland

2007 increased the unemployment rate all over and this period is characterized by the downswing regime for all countries in our sample. Moreover, most of the transition economies were affected by 1998 Russian

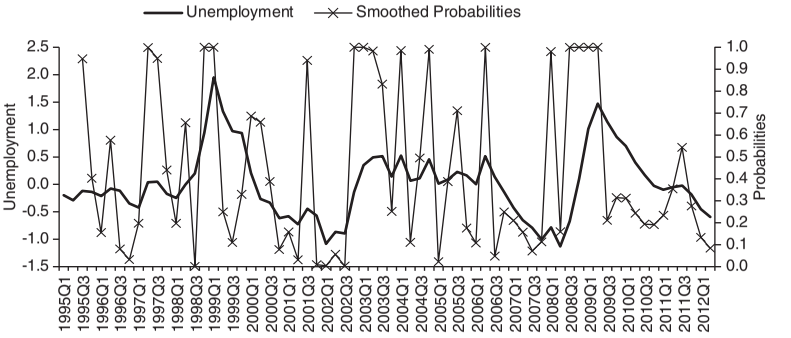

Figure 8: Smoothed transition probabilities for the downswing regime: Russia

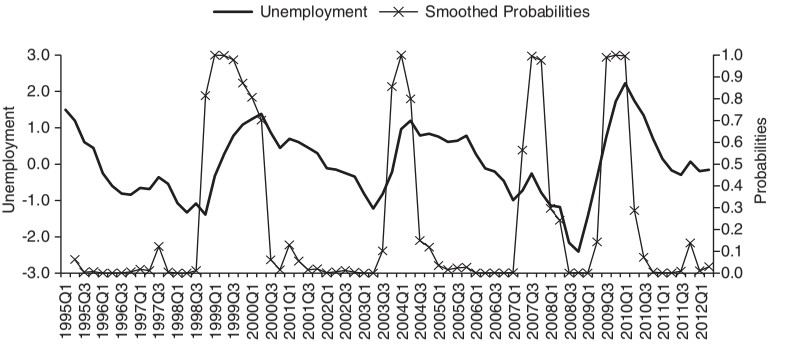

Figure 9: Smoothed transition probabilities for the downswing regime: The Slovak Republic

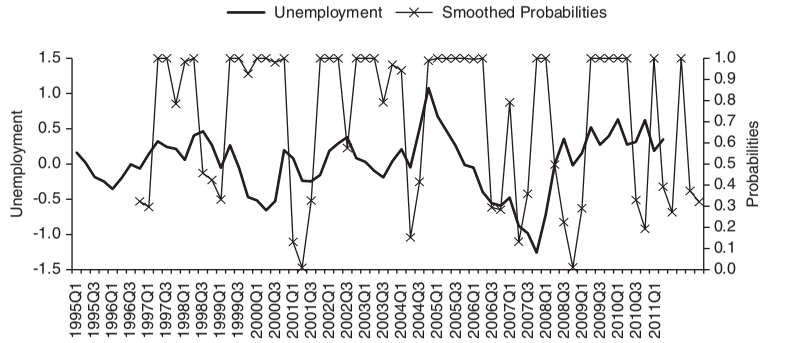

Figure 10: Smoothed transition probabilities for the downswing regime: Slovenia

Table 4: Tests of linearity *versus* Markov Regime Switching in the difference model

Countries	Log Likelihood (H_0)	Log Likelihood (H_A)	LR test statistic	χ^2 *p*-value	Davies *p*-value
Czech Republic	−13.687	−3.955	19.465	(0.003)	(0.058)
Estonia	−95.653	−87.617	16.071	(0.006)	(0.095)
Hungary	0.710	25.121	48.821	(0.000)	(0.000)
Latvia	−53.315	−70.350	34.069	(0.000)	(0.001)
Lithuania	−143.507	−129.743	27.529	(0.000)	(0.000)
Poland	−77.992	−65.433	25.118	(0.000)	(0.003)
Russia	−44.947	−33.200	23.494	(0.002)	(0.053)
Slovak Republic	−50.019	−28.823	42.392	(0.000)	(0.000)
Slovenia	−22.627	−15.098	15.058	(0.019)	(0.249)

crisis and real GDP in transition economies decreased dramatically because of Russian crisis. This is evident in Figures 2–10 as a downswing regime between 1998 and 1999 not only in Russia, but also in all other transition economies.

ALTERNATIVE SPECIFICATIONS

As we mentioned above, the empirical literature shows that the estimation of Okun coefficients is sensitive to the detrending techniques used to derive potential output and unemployment. In this section, we estimate an alternative specification, namely, the difference model of Okun's law with a time trend to account for any trends in unemployment during the transition. A regime-dependent version of the difference model can be reformulated in terms of a Markov regime-switching model as follows:

$$\Delta u_t = \alpha(s_t) + \beta(s_t)\Delta y_t + \gamma(s_t)t + \sum_{i=1}^{k} \rho_i(s_t)\Delta u_{t-i} + \varepsilon_t \qquad (6)$$

where Δu_t is yearly change in unemployment, Δy_t is yearly change in output and t indicates a time trend. Next, using the LR test statistic we test for a linear specification *versus* a Markov regime-switching model and the results are given in Table 4. It is evident that the modified Davies (1987) *p*-values reject the null hypothesis of no regime switching in Okun's law for all countries at the 10% significance level except for Slovenia. As in the gap

Table 5: Okuns law: The difference model

	Regime 1: Upswing in the Economy		Regime 2: Downswing in the Economy		Regime 1: Upswing in the Economy		Regime 2: Downswing in the Economy		Regime 1: Upswing in the Economy		Regime 2: Downswing in the Economy	
	Czech Republic				*Estonia*				*Hungary*			
αst	0.238**	(0.092)	2.065***	(0.303)	0.981***	(0.333)	2.074**	(0.822)	−0.281***	(0.103)	0.922***	(0.033)
βst	−0.025	(0.022)	−0.223***	(0.029)	−0.117***	(0.025)	−0.186***	(0.065)	0.032*	(0.017)	−0.134***	(0.001)
γst	−0.004	(0.004)	−0.031***	(0.005)	−0.028***	(0.006)	−0.003	(0.017)	0.005**	(0.002)	−0.011***	(0.000)
ρ_1	1.464***	(0.116)	0.590***	(0.141)	0.911***	(0.091)	0.614**	(0.286)	1.512***	(0.091)	0.414***	(0.014)
ρ_2	−0.635***	(0.108)	0.046	(0.120)	−0.253***	(0.080)	0.013	(0.229)	−0.716***	(0.082)	0.272***	(0.014)
σ_{st}	0.218		0.215		0.657		0.657		0.174		0.013	
pij	0.927		0.907		0.601		0.195		0.909		0.461	
d	13.69		10.84		2.51		1.24		11.08		1.86	
P-χ^2	9.047 (0.170)				3.735 (0.712)				12.583 (0.050)			
N-χ^2	0.075 (0.963)				4.520 (0.104)				1.120 (0.571)			
H-χ^2	6.938 (0.543)				4.673 (0.791)				10.701 (0.219)			
	Latvia				*Lithuania*				*Poland*			
αst	−0.145	(0.143)	1.712**	(0.763)	−1.021	(0.693)	3.908***	(0.612)	−0.366	(0.504)	2.382***	(0.052)
βst	0.001	(0.030)	−0.239***	(0.028)	−0.238**	(0.101)	−0.361***	(0.038)	−0.095**	(0.040)	−0.114***	(0.029)
γ_{st}	−0.005	(0.004)	−0.016	(0.017)	−0.005	(0.010)	−0.026*	(0.015)	0.014	(0.010)	−0.024***	(0.007)
ρ_1	0.903***	(0.172)	0.212	(0.126)					0.865***	(0.064)	0.784***	(0.069)
ρ_2	−0.295	(0.255)	0.528***	(0.131)								
ρ_3	0.289	(0.247)	0.154	(0.135)								
ρ_4	−0.300**	(0.030)	−0.752***	(0.137)								
σst	0.411		0.631		0.993		1.486		0.612		0.509	
pij	0.956		0.959		0.830		0.872		0.908		0.921	
d	23.22		24.85		5.91		7.85		10.94		12.70	
P-χ^2	11.775 (0.161)				11.992 (0.151)				13.091 (0.069)			
N-χ^2	0.429 (0.806)				11.707 (0.002)				3.945 (0.139)			
H-χ^2	6.743 (0.874)				7.736 (0.101)							

Table 5: (continued)

	Regime 1: Upswing in the Economy		Regime 2: Downswing in the Economy		Regime 1: Upswing in the Economy		Regime 2: Downswing in the Economy		Regime 1: Upswing in the Economy		Regime 2: Downswing in the Economy	
	Russia				*Slovak Republic*				*Slovenia*			
αst	−0.365**	(0.165)	1.202***	(0.205)	0.894***	(0.211)	1.637***	(0.034)	0.135	(0.168)	0.476***	(0.156)
βst	−0.059***	(0.015)	−0.094***	(0.019)	−0.137***	(0.027)	−0.208***	(0.002)	−0.042**	(0.020)	−0.093***	(0.019)
γ_{st}	0.007	(0.005)	−0.017***	(0.004)	−0.006	(0.004)	−0.043***	(0.001)	0.001	(0.003)	−0.009**	(0.003)
ρ_1	0.521***	(0.106)	0.760***	(0.179)	1.019***	(0.133)	0.360***	(0.018)	0.771***	(0.124)	1.372***	(0.212)
ρ_2	0.121	(0.141)	−0.265	(0.191)	−0.209	(0.203)	−0.163***	(0.021)	0.027	(0.112)	−0.982***	(0.181)
ρ_3	0.308**	(0.137)	−0.189	(0.216)	−0.216*	(0.122)	0.220***	(0.013)				
ρ_4	−0.391***	(0.094)	−0.024	(0.164)								
σ_{st}	0.288		0.335		0.535		0.026		0.292		0.166	
p_{ij}	0.800		0.840		0.880		0.591		0.551		0.208	
d	5.01		6.28		8.33		2.45		2.23		1.26	
P-χ^2	8.913 (0.349)				4.764 (0.445)				9.064 (0.170)			
N-χ^2	1.166 (0.558)				11.029 (0.004)				0.235 (0.887)			
H-χ^2	10.433 (0.578)				4.002 (0.947)				3.074 (0.929)			

*, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Notes: The figures in parentheses give the standard errors of coefficients. σ_1 gives the standard error of regression for the upswing regime, and σ_2 shows the standard error of regression for the downswing regime. p_{ii} indicate regime transition probabilities. P-χ^2 indicates the Portmanteau serial correlation test, N-χ^2 indicates the normality test and H-χ^2 indicates the heteroskedasticity test of the residuals (for more details on these tests, see Krolzig (1997)).

model, a nonlinear (regime switching) relationship between unemployment and output is appropriate.

Maximum likelihood estimates of the Markov regime-switching model implied by the difference specification (equation 6) are reported in Table 5. Again, the estimates of Okun coefficients are negative for all countries in the upswing and downswing regimes. Table 5 indicates that the Okun coefficients are statistically significant at the 5% level for all countries in the upswing regime except for the Czech Republic and Latvia. Moreover, all Okun coefficients are statistically significant at the 5% level for all countries in the downswing regime-implying substantial job losses in contractions in all countries. These results are broadly in line with the gap model presented above.

CONCLUSIONS

Okun's law implies the presence of a systematic relation between unemployment and output changes; as such, it is of interest to explore the nature of this empirical relationship. Whereas Okun's law has been widely explored in the developed and developing economies, few studies explored unemployment and output changes in transition economies and those studies assume a linear relation between unemployment and output changes. However, given the asymmetric behavior of key macroeconomic variables over the business cycle, it is of considerable interest to explore the nature of unemployment behavior in transition economies over different phases of the business cycle.

The principal objective of this article is to examine the nonlinear relation between unemployment and output changes for nine transition economies by means of a Markov regime-switching model. Our empirical results show a statistically significant Okun's law for transition economies and imply the Markov regime-switching model is more appropriate than a linear model in characterizing Okun's law. The unemployment rate displays statistically different behavior over the business cycle in transition economies. In general, job losses in downswing regimes exceed job gains in upswing regimes suggesting relatively poor job growth in recoveries and the results are robust across different specifications of Okun's law. Overall, there is diversity in the response of unemployment to output across regimes and countries.

Even though there is no consensus on the sources of poor job growth in recoveries, adopting the Euro for some countries that are not members of the Eurozone would add to the costs of macroeconomic adjustment as labor mobility to prosperous areas in Central and Eastern European economies seems low. These countries should improve the business climate that limits

job growth in small- to medium-sized enterprises and improve infrastructure/transportation networks and housing that limit labor mobility.

Acknowledgements
We thank the editor, Josef Brada, and two anonymous referees for comments that led to significant improvements in the article. We are solely responsible for any remaining errors.

REFERENCES

Adanu, K. 2005: A cross-province comparison of Okun's coefficient for Canada. *Applied Economics* 37(5): 561–570.

Babecky, J, Du Caju, P, Kosma, T, Lawless, M, Messina, J and Room, T. 2010: Downward nominal and real wage rigidity: Survey evidence from European firms. *Scandinavian Journal of Economics* 112(4): 884–910.

Basu, S, Estrin, S and Svejnar, J. 2005: Employment determination in enterprises under communism and in transition: Evidence from Central Europe. *Industrial and Labor Relations Review* 58(3): 353–369.

Boeri, T. 2000: *Structural Change, Welfare Systems and Labour Reallocation*. Oxford University Press: Oxford.

Boeri, T and Garibaldi, T. 2006: Are labour markets in the new member states sufficiently flexible for EMU? *Journal of Banking & Finance* 30(5): 1393–1407.

Cho, J and White, H. 2007: Testing for regime switching. *Econometrica* 75(6): 1671–1720.

Clements, MP and Krolzig, H-M. 1998: A comparison of the forecast performance of Markov-switching and threshold autoregressive models of US GNP. *Econometrics Journal* 1(1): 47–75.

Cuaresma, JC. 2003: Okun's law revisited. *Oxford Bulletin of Economics and Statistics* 65(4): 439–451.

Davies, RB. 1987: Hypothesis testing when the nuisance parameter is present only under the alternative. *Biometrika* 74(1): 33–43.

Dickey, DA and Fuller, WA. 1979: Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association* 74(366): 427–431.

Gabrisch, H and Buscher, H. 2006: The relationship between unemployment and output in post-communist countries. *Post-Communist Economies* 18(3): 261–276.

Garcia, R. 1998: Asymptotic null distribution of the likelihood ratio test in Markov switching models. *International Economic Review* 39(3): 763–788.

Gomme, P. 1999: Shirking, unemployment and aggregate fluctuations. *International Economic Review* 40(1): 3–21.

Hamilton, JD. 1994: *Time series analysis*. Princeton University Press: Princeton, NJ.

Hansen, B. 1992: The likelihood ratio test under non-standard conditions: Testing the Markov switching model of GNP. *Journal of Applied Econometrics* 7(S1): 61–82.

Harris, R and Silverstone, B. 2001: Testing for asymmetry in Okun's law: A cross-country comparison. *Economics Bulletin* 5(2): 1–13.

Hodrick, RJ and Prescott, EC. 1997: Postwar US business cycles: An empirical investigation. *Journal of Money, Credit and Banking* 29(1): 1–16.

Holmes, MJ and Silverstone, B. 2006: Okun's law, asymmetries and jobless recoveries in the United States: A Markov-switching approach. *Economics Letters* 92(2): 293–299.

Huang, H and Chang, Y. 2005: Investigating Okun's law by the structural break with threshold approach: Evidence from Canada. *The Manchester School* 73(5): 599–611.

Huang, H and Lin, S. 2006: A flexible nonlinear inference to Okun's relationship. *Applied Economics Letters* 13(2): 325–331.

Huang, H and Lin, S. 2008: Smooth-time-varying Okun's coefficients. *Economic Modelling* 25(5): 363–375.

Izyumov, A and Vahaly, J. 2002: The unemployment–output tradeoff in transition economies: Does Okun's law apply? *Economics of Planning* 35(4): 317–331.

Krolzig, H. 1997: *Markov-Switching Vector Autoregressions Modeling, Statistical Inference, and Application to Business Cycle Analysis*. Springer: Berlin.

Lee, J. 2000: The robustness of Okun's law: Evidence from OECD countries. *Journal of Macroeconomics* 22(2): 331–356.

Lehmann, H and Muravyev, A. 2011: *Labor markets and labor market institutions in transition economies*. IZA Discussion Paper No. 5905, August, IZA: Bonn.

Malley, J and Molana, H. 2008: Output, unemployment and Okun's law: Some evidence from the G7. *Economics Letters* 101(2): 113–115.

Mise, E, Kim, TH and Newbold, P. 2005: On the sub-optimality of the Hodrick-Prescott filter. *Journal of Macroeconomics* 27(1): 53–67.

Moosa, IA. 1997: A cross-country comparison of Okun's Coefficient. *Journal of Comparative Economics* 24(3): 335–356.

Neftci, SN. 1984: Are economic time series asymmetric over the business cycle? *Journal of Political Economy* 92(2): 307–318.

Okun, AM. 1962: Potential GNP: Its measurement and significance. *Proceedings of the Business and Economic Statistics Section of the American Statistical Association*: 98–104.

Onaran, Ö. 2008: Jobless growth in the Central and Eastern European Countries: A country specific panel data analysis for the manufacturing industry. *Eastern European Economics* 46(4): 90–115.

Pedersen, TM. 2001: The Hodrick–Prescott filter, the Slutzky effect, and the distortionary effect of filters. *Journal of Economic Dynamics and Control* 25(8): 1081–1101.

Perman, R and Tavera, C. 2005: A cross-country analysis of the Okun's law coefficient convergence in Europe. *Applied Economics* 37(21): 2501–2513.

Rand, J and Tarp, F. 2002: Business cycles in developing countries: Are they different? *World Development* 30(12): 2071–2088.

Schettkat, R. 1996: Labor market flows over the business cycle: An asymmetric hiring cost explanation. *Journal of Institutional and Theoretical Economics* 152(4): 641–653.

Schiff, JA, Egoumé-Bossogo, P, Ihare, P, Konuki, T and Krajnyák, K. 2006: *Labor market performance in transition: The experience of Central and Eastern European countries*. IMF Occasional Paper No. 248, July, IMF: Washington DC.

Silvapulle, P, Moosa, IA and Silvapulle, MJ. 2004: Asymmetry in Okun's law. *Canadian Journal of Economics* 37(2): 353–374.

Sögner, L. 2001: Okun's law. Does the Austrian unemployment-GDP relationship exhibit structural breaks? *Empirical Economics* 26(3): 553–564.

Svejnar, J. 1999: Labour markets in the transitional Central and Eastern European Economies. In: Ashenfeldter, O and Card, D (eds). *Handbook of Labour Economics* Vol. 3–4, Elsevier Science: North Holland, Amsterdam, pp. 2809–2857.

Villaverde, J and Maza, A. 2009: The robustness of Okun's law in Spain, 1980–2004: Regional evidence. *Journal of Policy Modeling* 31(2): 289–297.

Viren, M. 2001: The Okun curve is non-linear. *Economics Letters* 70(2): 253–257.

Weber, CE. 1995: Cyclical output, cyclical unemployment, and Okun's coefficient: A new approach. *Journal of Applied Econometrics* 10(4): 433–455.