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OKUN'S LAW: EVIDENCE FROM THE BALTIC STATES

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Abstract

Okun's law postulates a negative bi-directional relationship between unemployment and output. The purpose of the present study is to estimate the relationship for the Baltic States for the period 1997/1998-2007. Several methods were employed to examine Okun's proposition. First, the cointegration analysis and application of the error correction model showed if there existed a long term link between the variables. Additionally, two original Okun's equations were estimated: the difference specification and the gap specification, which relates cyclical output to the cyclical unemployment rate. Cyclical components were extracted with the help of Hodrick-Prescott filter. The results did not indicate any persistent evidence of the strong relationship between output and unemployment for the samples. Two explanations are in order: data reliability issues and labor market features.

Keywords: Okun's law, unemployment, output, Baltic States, ECM, difference specification, gap specification, cycles, Hodrick-Prescott filter.

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1 Introduction

Okun's law shows how the unemployment varies depending on the output or, conversely, how does output changes in response to the changes in unemployment. It rests on a simple intuition that more labor is required to produce more goods and services. Since the pioneering study carried out by Arthur M. Okun in early 1960s, the validity and the strength of this empirical relationship has been the subject of numerous studies, which used data from different countries and time periods. On the whole, evidence shows support to Okun's law and it seems widely accepted. While the relationship is more of a statistical rather than theoretical nature (Knotek, 2007), most economists consider Okun's law as one of the most robust regularities in economy. Nevertheless, the relationship is still important in several respects (Perman & Tavera, 2007). First of all, from the theoretical point of view, Okun's law together with the Phillips curve serves to derive the aggregate supply curve. Secondly, it is a reasonable rule of thumb for structural and stabilization policies, which can help to measure the social cost of idle labor resources by calculating the output gap and estimate the impact of changes in the labor market on output. Thirdly, the Okun's law coefficient is of potential use for forecasting developments in the main macroeconomic indicators.

After the accession to the European Union in May 2004, the Baltic States exhibited a high, in some cases unsustainable growth. This growth was accompanied by fairly high employment and inflation rates. Since the outburst of the world financial crisis in 2008, the Baltic States saw reverse developments in their economies: a sharp increase in the unemployment rate and drop in the output growth. The aim of this paper is to explore the validity of Okun's law and estimate the Okun's coefficient for the three Baltic States: Estonia, Latvia and Lithuania. Furthermore, this paper will test for the possible asymmetric behavior of the relationship. To the best knowledge of the author, the present paper is the first attempt to study Okun's phenomenon in the Baltic States.

The main research question goes as follows: **Does Okun's law hold for the Baltic economies?** Additionally**,** two sub-questions would deal with the quantification of the Okun's law coefficient (OLC) and the design of the relationship: 1) *What is the empirical trade-off between the unemployment rate and output in the Baltic States? 2) Do the data for the Baltic States show evidence that the relationship is non-linear?*

The paper proceeds as follows: Section 2 discusses the theoretical background and outlines the Okun's relationship by presenting original formulations. Section 3 reviews the existing literature, providing insight into empirical evidence and modern research directions in the field. In section 4 the methodology of the present study is introduced, while section 5 describes the data and its modifications. The following section presents the empirical results. Next, discussion follows in section 7. Section 8 provides suggestions for further research and section 9 concludes.

2 Theoretical Background

The "goods market – labor market – financial market" nexus has always occupied researches' minds. Three cornerstone variables in macroeconomics: output, inflation and unemployment are used to derive the aggregate supply curve. In the general equilibrium potential output is balanced with the sustainable price development and the natural rate of unemployment (alternatively referred to as non-accelerating inflation rate of unemployment or NAIRU). The NAIRU can be seen as the unemployment rate at which maximum production (potential output) is achieved without inflationary pressure. When the actual unemployment rate is above the NAIRU, there are idle resources and economy is functioning below its capacity. If unemployment is on the other hand below the NAIRU, output growth and price developments are unsustainable. To what extent does unemployment impact output then? Among the most important contributions in the analysis of the relationship between the two variables is the work by Arthur M. Okun "Potential GNP: Its measurement and significance" (1962).

In his seminal paper, Okun tried to find out how much output can an economy produce under conditions of full employment, in other words what is the level of potential output. U.S. quarterly data covering the period from 1947:2 to 1960:4 was used for the analysis. Okun assumed the unemployment rate as a proxy for all the ways in which output is affected by the labor market. He discussed the following labor market components: labor force participation, hours worked and man-hour productivity; and concluded that these components summed together produce an effect reflected in the unemployment rate. Hence, the measurement of the potential GNP was simplified to the estimation of "how much output is depressed by unemployment in excess of a certain threshold". Even though the key focus was put on measuring the potential GNP, Okun provided a concept which later was named in his honor. The relationship, known as Okun's law, postulates a bi-directional relationship between output and the unemployment rate. To get a mathematical derivation of the relationship from the production function according to Prachowny (1993), refer to Appendix 1.

Okun offered three alternative specifications of the relationship. Up until now they are the basis of virtually all re-formulations. For that reason they are presented in brief here.

1) *First differences* specification related percentage changes in the unemployment rate to the real GNP growth:

$$u_t - u_{t-1} = \alpha + \beta g_t^y \qquad (2.1)$$

where u_t is the unemployment rate at time t, g_t^y is the real GNP growth at time t, β is the slope and α is the intercept.

The β coefficient is expected to have a negative sign because the fast real output growth would be associated with the decreasing unemployment rate. Thus, for each extra one percent of output, unemployment should be β % lower. Correspondingly, given previous quarters, one percentage point increase in unemployment would result in 1/ β decrease in output.

2) *Trial gaps* specification employed exponential paths of potential output to estimate the percentage "gap" between the actual and the potential GNP, which were then related to the unemployment rate:

$$u_t = \gamma + \delta \ (y_t - y^*_t) \qquad (2.2)$$

where u_t is the unemployment rate at time t, $(y_t - y^*_t)$ is the percentage difference between the actual and the potential GNP, γ and δ are the intercept and the slope, respectively. The intercept γ is interpreted as the NAIRU. Okun assumed it to be equal to four percent as a "reasonable target under existing labor market conditions" (Okun, 1962). The equation *(2.2)* can be reformulated:

$$u_t - u^*_t = \delta \ (y_t - y^*_t) \qquad (2.3)$$

Thus, the unemployment gap on the left is related to the output gap on the right via the coefficient δ. Given that actual output is below potential, one percent increase in unemployment is associated with output loss of 1/ δ of potential output or a somewhat larger percentage of actual output.

3) *Fitted trend and elasticity* specification assumes a constant elasticity relationship between the ratio of the actual to the potential employment rate (full employment) and the ratio of actual to potential output:

$$n_t / n^*_t = (y_t / y^*_t) \ b \qquad (2.4)$$

Additionally, assuming a constant exponential growth rate of potential output and deriving a logarithmical equation:

$$\log n_t = \log (n^*_t / y^*_t{}^{b}) + b \log y_t - (br) \ t \qquad (2.5)$$

where b is the output elasticity of the employment rate, r is the potential growth rate and t is time. The b coefficient in this specification has the same meaning as β in the first difference equation.

All three specifications of the relationship yielded similar results. The β and δ coefficients in the first differences and the trial gaps equations equaled to 0.3 and 0.36, respectively, and the elasticity coefficient ran from 0.35 to 0.4 in the fitted trend equation. The consistency in the results made Okun conclude that there existed an approximate 3-to-1 link between output and unemployment. In other words, one percent rise in unemployment on average resulted in three percent drop in output.

3 Literature Review

Following the work of Okun, a large body of literature emerged on the relationship between output and unemployment. The most influential are *inter alia* Gordon and Clark (1984), Prachowny (1993), Weber (1995), Attfield and Silverstone (1997), Lee (2000), Harris and Silverstone (2001), and Silvapulle et al (2004). Okun himself pointed out that his model specifications were simple reduced form representations of the relationship. With time Okun's specifications were modified, datasets changed, and sophisticated econometric procedures allowed for a more detailed examination. On the whole, the results tend to support Okun's law, but the Okun's law coefficients vary over time and space and depend on the chosen methodology. This section will present empirical evidence and explain the methodologies used previously. It will proceed with the discussion of the problems and important developments in the later research: dynamic versions of Okun's law and the examination of non-linearity of the relationship.

3.1 Empirical Evidence

Copious amount of studies has attempted to estimate the Okun's law coefficient for a wide range of countries. Appendix 2 summarizes selected literature. Especially large interest was drawn to the regional estimates[1] and OLC convergence issues, OECD countries[2], EU countries[3] and re-estimating the value of the coefficient for the U.S. data[4]. Appendix 3 shows some coefficients for the selected group of countries obtained by different researchers. As can be seen from the table, coefficients vary across countries and time periods. Estimates of the fall of unemployment rate associated with the increase in output by one percent range between 0.3%-0.5% for the U.S., approximately 0.2-0.5% in European countries and around 0.1% in Japan. Remarkably, changes in the output growth do not lead to equal changes in the unemployment rate. This obtuse reaction is explained by the fact that "employment may not be easily variable" (Okun, 1962), which can be for several reasons. First of all, high transaction costs are associated with firing old personnel, recruiting and training new employees. Secondly, contractual commitment makes companies less flexible in their employment policies. Moreover, firing employees can be viewed as an undesired action; it is preferred to cut the working hours during downturns rather than lay off the personnel.

Notably, empirical estimates are also sensitive to the model specification. The widely used models are the difference specification *(2.1)* and the gap specification *(2.3)*. Almost never is the fitted trend and elasticity equation *(2.5)* applied. The first specification has an important drawback. According to Attfield and Silverstone (1997), if model variables are integrated of order one, I(1) and cointegrated, then the model is misspecified – it should be modeled in an error correction model. In the gap version the problem arises with the measurement of the trend components, i.e. in attempting to estimate the output and unemployment gaps. To extract trends from the time series authors usually choose from the linear trend representation, quadratic trend, Hodrick-Prescott filter, Baxter and King Band

Pass filter, Beveridge-Nelson decomposition, the unobserved components model estimated using the Kalman filter, etc.

3.2 Problems and Developments

3.2.1 Unemployment-output relationship

Because of the fact that the relationship is indigenously bidirectional, researchers have been juggling the equations and both regressed output on unemployment (e.g. Freeman, 2001) and vice versa (e.g. Sögner & Stiassny, 2002). Yet, the interpretation of the results frequently misguided the authors and Okun himself, which lead to spurious results. Barreto and Howland (1993) maintained that one should seriously consider the direction of the regression. They indicated that Okun erroneously assumed that it is possible to use the beta (β) to derive the reciprocal coefficient (1/β), thus being able to track the relationship in both ways. Okun was using the two coefficients interchangeably. Nevertheless, the relationship between real output and the unemployment rate is not perfectly linear. Due to this fact, separate regressions should be run of output on unemployment and unemployment on output, depending on the direction in which causality runs or what link is to be analyzed.

Another important consideration is the assumption Okun made in his study. He approximated labor force, working hours and productivity by the unemployment rate; however, each of these variables separately has an impact on the output gains or losses. Thus, as Freeman (2001) notices "a complete specification of the effect of the changing employment rates on output would include factors such as capital inputs, labor hours and participation rates, all measured as deviations from long-run trends"[5]. Yet, the measurement of these variables and their potential values poses a significant problem, so in attempting to include them into regressions, researchers get miscellaneous results. Gordon and Clark (1984) were the first ones to take account of these variables. They reported a short run Okun's coefficient for the U.S. of -0.23 and -0.5 for the long run. For more recent studies see Prachowny (1993), Attfield and Silverstone (1997) and Freeman (2001), who corrected for the omitted variables in the initial specification. Nevertheless, Attfield and Silverstone

(1997) showed that Prachowny's (1993) augmented estimation model exhibited high level of colinearity among the additional variables discussed above, confirming the plausibility of Okun's assumption.

3.2.2 Dynamic specifications.

Okun observed that both current and past output can have influence on the current level of unemployment. To account for this some researchers now tend to alter the original difference version or the gap version into the dynamic version of Okun's law. Evans (1989), for example, estimated a bivariate VAR model, Weber (1995) used an autoregressive distributed lag model (ARDL) with 2 and 4 lags, and most recently Petkov (2008) related cyclical output to cyclical unemployment in an ARDL model for the UK. A dynamic formulation accounts for the relevant lagged variables which were originally omitted. Common formulations of the dynamic specification would look like**:**

$$\Delta u_t = \alpha_0 + \sum_t \beta_t g_t^y + \sum_t \delta_t \Delta u_{t-1}$$, for the difference version, or *(3.1)*

$$u_t - u_t^* = \alpha_1 + \sum_t^T \beta_t (y_t - y_t^*) + \sum_t^T \gamma_t (u_{t-1} - u_{t-1}^*)$$, for the gap version *(3.2)*

The dynamic model does not allow for a simple interpretation of the coefficients as the original difference version. Weber (1995) suggests the following long-term calculation of the OLC:

$$\varphi = \frac{\sum_{q=0}^{n} \beta_q}{1 - \sum_{p=1}^{m} \gamma_p} \qquad (3.3)$$

3.2.3 Asymmetry in Okun's law

The conventional view of Okun implies a linear unemployment-output relationship, in the sense that unemployment reacts in the same way to the changes in output growth during both expansionary and recessionary periods. Lately, research in the field has been centering on investigating potential asymmetries in the relationship, suggesting that the variation in unemployment in response to the changes in output is different across business cycles. According to Silvapulle et al (2004), testing for asymmetries is crucial because ignoring asymmetry may lead to misspecified model, erroneous results and poor forecasting.

Lee (2000) exogenously imposed the asymmetry threshold on the unemployment variable and for a range of countries reported a significantly higher Okun's coefficient for decreases in unemployment. Likewise, Silvapulle et al (2004) exogenously imposed a threshold and found similar results for the U.S. data. Harris and Silverstone (2001), who used an asymmetric ECM, stated that failing to take account of asymmetries would result in rejecting Okun's proposition in the U.S. and New Zealand. Cuaresma (2003) applied a piecewise linear specification with endogenous threshold for the U.S. economy and found strong evidence of the nonlinearity. Most recently, Fouquau (2008) applied switching regime models and detected the existence of four regimes.

In general, recent research shows that the effect of the GDP on unemployment is asymmetric and that the unemployment is more sensitive to negative deviations in output. Silvapulle et al (2004) recap the possible explanations found in the previous literature. To sum, asymmetries can be attributed to the factor substitution during cycles, fluctuations in multi-factor productivity and labor force participation (or in general to the behavior of the labor market). Alternatively, they suggest that asymmetry can be linked to the rigidity of the labor market, for example, institutional restrictions imposed on employers to fire their employees. Or, on the other hand, due to the fact that companies invest heavily in training their staff, employers might be reluctant to fire workers.

4 Methodology

In the introduction of this paper the key research question was outlined, additionally two research questions were posed:

1) *What is the empirical trade-off between the unemployment rate and output in the Baltic States? 2) Do the data for the Baltic States show evidence that the relationship is non-linear?*

In order to answer the research questions this paper will first look at the characteristics of the time series, exploring their stationarity type and cointegration between the original variables, thereafter modeling the long run relationship through an error correction model, if they are cointegrated. As the next step the deviations from the equilibrium in the first difference and the gap specification will be considered. Lastly, asymmetry will be examined.

4.1 Error Correction Model

If time series X and Y are non-stationary, integrated of the same order and have a common trend, it is possible to model a long run relationship via the error correction model. The pretesting procedures will include Dickey Fuller General Least Squares (DF-GLS) test for unit root, Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests for stationarity of the time series around a deterministic trend and Engle-Granger (EG) two step cointegration test.

For two non-stationary variables to be cointegrated, they should be integrated of the same order and their linear combination $Y_t - \theta X_t$ should turn out to be stationary, I(0) (Stock & Watson 2003). To estimate the cointegration coefficient θ separate regressions will be run in both directions (since there is no reason to favor output on unemployment regression over the reverse option) and the error terms will be tested for stationarity. If the error terms are stationary, then there exists a cointegration relationship between the variables and the time series can be modeled in an error correction model (ECM). ECM fundamentally draws on Granger causality:

$$Y_t = a_0 + \sum_{i=1}^{p} \gamma_i Y_{t-i} + \sum_{j=1}^{p} \varphi_j X_{t-j} + \varepsilon_t , \qquad (4.1)$$

It is said that X Granger-causes Y if φ_j are jointly significant. To test whether the causation goes the other way around, Y is replaced with X in the regression and the same logic applies: if F-test is significant, then the null hypothesis that the Y does not Granger-cause X is rejected.

The vector error correction model (VECM) for I(1) time series is derived using a bivariate vector autoregression (VAR) augmented by including the lagged error term from the X on Y regression.

$$\Delta Y_t = a_0 + \sum_{i=1}^{q} \gamma_{1i} \Delta Y_{t-i} + \sum_{i=1}^{q} \varphi_{1i} \Delta X_{t-i} + a_1 (Y_{t-1} - \theta X_{t-1}) + \varepsilon_{1t} \qquad (4.2)$$

$$\Delta X_t = a_0 + \sum_{i=1}^{q} \gamma_{2i} \Delta Y_{t-i} + \sum_{i=1}^{q} \varphi_{2i} \Delta X_{t-i} + a_2 (Y_{t-1} - \theta X_{t-1}) + \varepsilon_{2t} \qquad (4.3)$$

Essentially, it can be viewed as an augmented system of Granger tests, where the additional regressor $Y_t - \theta X_t$ helps to predict the future values of ΔY_t or ΔX_t. In this case, the null that X/Y does not Granger-cause Y/X is rejected, if φs are jointly significant or α is significant.

While the two-step EG has much appeal due to its simplicity, there are important drawbacks of this method. It assumes the existence of only one cointegration vector. It is indeed an important consideration, when dealing with a multivariate system. Nevertheless, given that only one cointegration relationship is of interest here and this paper investigates it in a bivariate setting, Engle-Granger procedure is considered sufficient to analyze the relationship.

4.2 First Difference and Gap Specifications

First, it should be mentioned that the present paper is based on the assumption, made by Okun. All relevant labor market factors (labor force participation, hours worked and man-hour productivity) which change *pari passu* with employment are highly collinear with unemployment and can be collectively approximated by the unemployment rate. This assumption allows for the use of the reduced form specifications of OL.

Secondly, depending on the stationarity tests, a suitable model will be applied. The choice is among the two most common reduced form specifications – the *first difference* and the *trial gap specification* (see equations *(2.1)* and *(2.3)*, respectively). The corresponding econometric equations have the following form:

$$u_t - u_{t-1} = \alpha + \beta g_t^y + \varepsilon_t \qquad (4.4)$$

$$u_t - u^*_t = \alpha + \beta (y_t - y^*_t) + \varepsilon_t \qquad (4.5)$$

Due to the fact that the past values of both variables may have impact on the level of the unemployment at the time period *t*, the paper will also consider dynamic models as in *(3.1)* and *(3.2)*. The optimal number of lags to be included in the regression will be determined by Akaike Information Criterion (AIC). The contemporaneous relationship between the output and unemployment gap is measured by β, while the long run effect, following Weber (1995) is computed as a function of the coefficients as in *(3.3)*.

As already noted above, the problem with the gap specification is that neither the natural rate of unemployment nor potential output is an observable variable. Consequently, the deviations from the potential values or cyclical components of time series need to be estimated. Okun himself used an exponential trend extraction to separate trend from the cyclical component. The major drawback is that it assumes a deterministic trend, which is not always the case in time series analysis. For this reason the present paper will employ Hodrick-Prescott filter as the most common filter to deal with stochastic trends in the OL literature.

4.2.1 Hodrick-Prescott filter

Hodrick-Prescott filter (HP filter hereafter) generalizes the linear trend representation by allowing the trend slope to change smoothly and gradually over time. It was introduced by Hodrick and Prescott in 1997 to study real business cycles. Later many authors adopted the method and it became very popular in empirical economic research.

Generally, a time series consists of a trend, a cyclical component, which reflects medium term changes, repeated in cycles, a seasonal component and an irregular random component. Seasonal component is redundant if the seasonally adjusted data is used. Therefore, time series y_t is represented by the sum of a trend $y*_t$ and a cyclical component y_t^c:

$$y_t = y*_t + y_t^c \qquad (4.6)$$

HP filter works by minimizing the sum of the squared deviations between the trend $y*_t$ and the actual series y_t (variance of cyclical component y_t^c), with a penalty for the curvature (the second difference of the time series) that keeps the trend smooth (λ).

$$\min_{\{\tau_t\}} \sum_{t=1}^{T} (y_t - y*_t)^2 + \lambda \sum_{t=2}^{T} \left[(y*_{t+1} - y*_t) - (y*_t - y*_{t-1}) \right]^2 \qquad (4.7)$$

The first term of the equation penalizes the cyclical component; the second term penalizes variations in the growth rate of the trend. The larger is λ, the smoother is the trend. Conversely, when λ tends to zero, trend tends to the original time series. Conventionally, λ is equal to 100 for annual data, 1600 for quarterly data and 44000 for monthly data.

Nevertheless, one should be precautious when using these values. Hodrick and Prescott (1997) used the U.S. GNP data to estimate the λ. Since λ penalizes the curvature, it is likely to be different across time series. As pointed out by Harvey and Jaeger (1993), this is one of the major drawbacks of the HP filter: mechanical smoothing using the arbitrary λ values might lead to generating spurious cycles, which do not exist in the original series and over-smoothing of the structural breaks. Therefore, it is also advisable to check several values of λ and how well does the trend fit the actual data.

4.3 Asymmetry in Okun's Law

Following Cuaresma (2003) methodology, this paper adopts the approach which allows for a regime-dependent Okun's coefficient. This implies that the effect of the output gap on unemployment gap changes depending on the regime or the threshold value for the output gap.

To test for the possible presence of asymmetry in the relationship an exogenous threshold will be imposed in gap equations. An exogenous threshold is introduced at zero. Namely, if the cyclical output is below the threshold value zero (actual output is below the trend), the model is considered to be in the state of recession; if it is above zero, it is in the state of expansion. Thus, the dummy variable is added and the equation gets the following form:

$$u_t - u_t{}^* = \alpha + \sum_{p=1}^{m} \gamma_p (u_{t-p} - u_{t-p}{}^*) + \sum_{q=0}^{n} \beta_q (y_{t-q} - y_{t-q}{}^*) + \delta D + \varepsilon_t \quad (4.8)$$

$$\text{where D} = \begin{cases} 0, if\,(y_{t-q} - y_{t-q}{}^*) < 0 \\ 1, if\,(y_{t-q} - y_{t-q}{}^*) > 0 \end{cases}$$

In this case, testing for the non-linear behavior is delimited to testing the significance of the coefficient *δ*. If the coefficient is statistically significant, the relationship is indeed dependant on the regime.

It should be noted that the exogenously imposed threshold might be less powerful in examining the possible presence of the asymmetries in the relationship. However, the period under observation did not show much variability in business cycles (see Data section for more discussion). Thus, most likely, non-linearity will not be observed in the sample. Nevertheless, it is useful to check, as argued by Harris and Silverstone (2001).

5 Data

Two key variables are unemployment and production. Different papers employed different estimates for production. Originally, Okun used the gross national product (GNP) for his study. However, latter research mainly employed gross domestic product (GDP). The present paper will follow the suit and use the GDP measure instead of GNP. GDP was collected via Eurostat (2010), which uses national accounts for the reports. Similarly, Eurostat provided unemployment rates estimated from the Labor Force Survey (LFS) which is a household survey of work-related statistics. For the analysis GDP measured in millions of national currencies with the base year 2000 and the unemployment rate among all working age population were chosen. All data is quarterly, seasonally adjusted and covers time period 1997:1-2009:4 for Estonia, 1998:1-2009:4 for Latvia and 1998:1-2009:3 for Lithuania. The dynamics of the variables used in the analysis are showed in the figures below.

Figure 1: Estonia GDP (mill EEK) and unemployment rate%: 1997:1:2009:4.

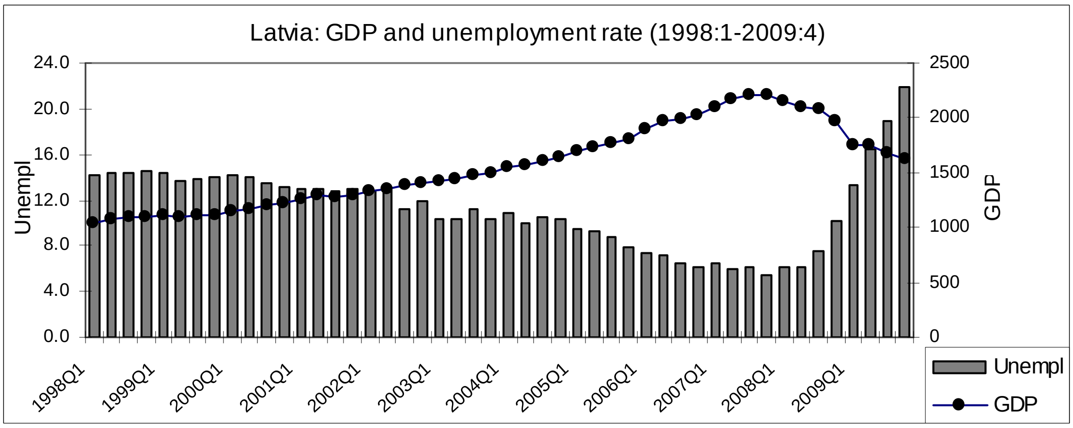

Figure 2: Latvia GDP (mill LVL) and unemployment rate%: 1998:1-2009:4.

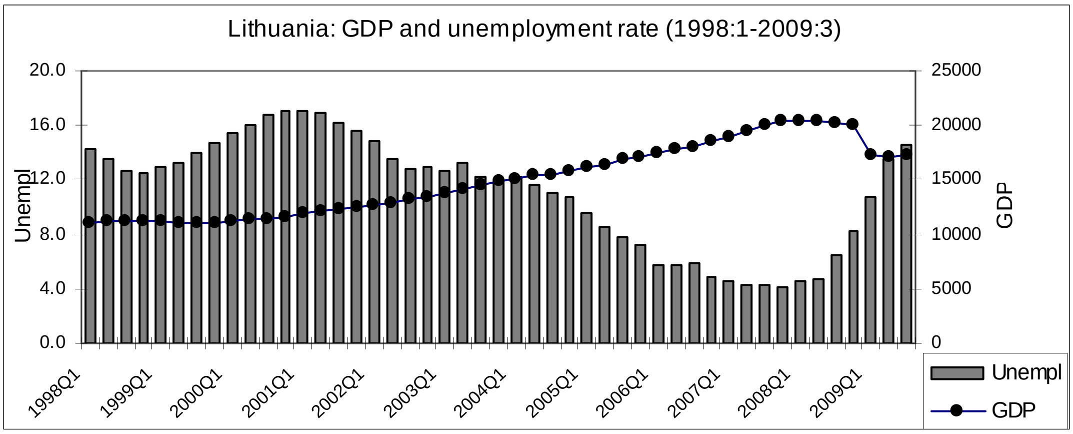

Figure 3: Lithuania GDP (mill LTL) and unemployment rate%: 1998:1-2009:3.

All three states show more or less similar developments in respect to both production figures and the unemployment rates. High unemployment rates in the late 1990s and early 2000s were accompanied by relatively low and slowly growing production levels. The situation, nonetheless, changed after the Baltic States joined the EU in May 2004. Easier access to financial and goods markets, favorable trade conditions as well as foreign direct investment boosted the economies, and we saw reverse developments. A discussion went about overheating of the economies: if before they were operating under the potential levels, in the mid-00s over-production and over-employment posed a threat of "hard landing" (Taimre, 2008). Yet the world financial crisis of 2008, introduced crucial corrections and the Baltic economies observed dramatically rising unemployment and plummeting output levels.

Indeed, the fact that in 2008 the Baltic States stepped into a new business cycle deserves special attention. This could mean the existence of structural breaks in the data, which would eventually undermine the results. As can be seen from the graphs in Appendix 4 (shows plots of the HP filtered cyclical components) outliers are present in the data. It is obvious that some observations do not belong to the model and might potentially bias the results. Indeed, preliminary regressions and stationarity tests showed that the results are very sensitive to the inclusion of the last five to seven observations, which can be seen as the consequences of the crisis. Since only a few observations after the structural break are in disposition and, unfortunately, no meaningful analysis can be executed, this paper will sacrifice eight observations from the dataset, in order to avoid misleading results. Thus, the shortened sample will run until the last quarter of the year 2007, leaving 44 observations in Estonian dataset and 40 observations in Latvian and Lithuanian sample.

Before going on with the econometric analysis some data modifications were in order. The first concerned the fact that the output figure was given in levels, while the unemployment rate in percentage terms. The most common option to make the two time series comparable is to transform GDP into natural logarithms, as it converts changes in the variables into percentage changes. For the gap specification the cyclical component was extracted via the application of the Hodrick-Prescott filter using the smoothing parameter of 1600. Additionally, it should be noted that the cyclical unemployment is expressed in percentage terms, while cyclical output – in levels. To overcome this problem, it is proposed to express the cyclical output as the difference between the actual output in logarithms minus the potential output in logarithms.

6 Empirical results

To make an analysis of the relationship between the unemployment rate and output, several models were considered. It should be noted, though, that the used methodology was not meant to generate substitutable or comparable results, but rather explore the data from different points of view. First, the long run relationship was examined via the study of the time series: type of their stationarity, cointegration and application of the error correction model if necessary. The results showed whether in general there existed a long run equilibrium relationship between the original variables and what is this relationship if any. Secondly, the relationship was analyzed by using the OLS regressions applied to the Okun's specifications: the first difference and the gap equations. Finally, asymmetry was considered. For the analysis STATA econometric software was used.

6.1 Stationarity Tests

Before examining the time series, it is crucial to consider whether it is stationary or not. If time series exhibit strong trends, results may prove unreliable and erroneously indicate the presence of the relationship because of the similar trend (Granger & Newbold, 1974). The most common unit root test is augmented Dickey Fuller (ADF) test. However, ADF does not perform well when the sample is small; therefore, the Dickey Fuller generalized least squares (DF-GLS) which carries out Elliott-Rothenberg-Stock (1996) test for AR unit root was employed. DF-GLS has more power in case of small samples. Complimentary, a Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test was conducted to test whether the time series were stationary around a deterministic trend. The two tests were run for the output in logarithms and the unemployment time series, and their first differences, as well as the cyclical components. Appendix 5 shows the descriptive statistics for the variables and unit root and trend stationarity test results.

The original variables proved to be non-stationary for all countries. DF-GLS test showed that times series are, indeed, random walk processes, while the KPSS test rejected the hypothesis of the series being trend stationary. When examining the first differences, no presence of the unit root was detected for Estonia and Latvia. Similarly, KPSS test showed that both differenced time series for Estonia and Latvia are stationary. The tests for the Lithuanian unemployment data showed rather inconclusive results. Test statistics were contradictory and could not safely detect the order of integration[6]. In order to be able to model time series for Lithuania in the methodology framework which has been chosen, this paper will assume the Lithuanian unemployment series to be I(1). Thus, output in logarithms and unemployment are both integrated of order one, I(1) for all three states. Hence, we can proceed with testing for cointegration.

In case of the cyclical components, tests also showed mixed results. The unit root and trend stationarity tests were inconsistent for all HP filtered data. It was not possible to safely identify the order of integration. For the majority of time series DF-GLS showed the presence of the unit root, while the KPSS test, suggested it to be variance stationary. Again, this could suggest that the cyclical components are fractionally integrated of order *d* (the level of integration is not an integer), so that $I(0)<I(d)<I(1)$. Since this paper does not deal with the issue of fractionally integrated time series, different smoothing parameter for the HP filtering was used to check the robustness of the results. For the sake of this study λ of 400 was chosen, it makes the trend approach the original time series, than λ of 1600. Thus, the deviations from the smoothed component are smaller and have a better behaved distribution. The regressions which were run for HP 400 filtered series showed quite similar results to

those obtained by using λ of 1600, this is why they are not reported here but are available upon request.

6.2 Cointegration Analysis

Appendix 6 presents the results of the cointegration regressions and the residual stationarity tests. The results from the EG procedure showed no presence of the cointegrating relationships for the variables in Estonia and Lithuania. Error terms from all auxiliary regressions turned out to be clearly non-stationary. Scattering the residuals across time also plainly indicated that their distribution is not constant. If a long run relationship would be present, contemporaneous effect of X on Y would be measured by the X's coefficient and corrected by the error term. However, given that the error term is not stationary (its distribution is not constant), no presence of cointegration was detected. As a result no ECM can be applied for Estonia and Lithuania. The presence of the cointegrating relationship, according to Attfield and Silverstone (1997), would imply that the first difference version is misspecified. Indeed, the variables which are cointegrated should have been modeled via the error correction regression. However, given that the time series showed no presence of the long term relationship in form of cointegration, first difference specification can enter the analysis as it models two nonstationary variables (differenced unemployment and differenced output in logarithms).

For Latvia, tests could not safely reject the presence of the cointegration vector. DF-GLS could not reject the presence of the unit root in the error terms, while the ADF using the MacKinnon p-values clearly indicated that the residuals were stationary. Plotting residuals against time and its lagged values supported the ADF test. Therefore, it was decided to proceed with the ECM for Latvia. Nevertheless, the first difference model will be considered as well.

6.3 Error Correction Model

All variables which enter the ECM for Latvia: the first differences of the variables and the error correction term are stationary, so the whole system is stationary as well. Table in Appendix 7 summarizes the results for the F-test of the joint significance of the lagged values of explanatory variable and t-values for the residuals. The maximum number of lagged values was set to four, for not to lose many degrees of freedom. Interestingly, the results show that the data does not indicate any long term causality which runs from the change in the unemployment rate to the change in output. If consider the reverse relationship the F-tests of the lagged explanatory variables showed they are not jointly significant, whereas the residual term turned out to be a good predictor for the change in unemployment. Thus, it can be concluded that the there exists a long term relationship which runs from output to unemployment and is captured by the coefficient on the lagged residuals.

6.4 First Difference and Gap Specifications

Apart from the ECM, non-stationary time series can be modeled either by taking the first differences of the variables or removing the trend component from the series. The first difference and the gap specifications of Okun deal with these issues. Overall, five regressions were considered: 1) static first difference version, 2) dynamic first difference version, 3) static gap version , 4) dynamic gap version and 5) dynamic gap version with a dummy variable. The regression results, estimated parameters and diagnostic tests are reported in the Appendix 8. The necessary number of lags was estimated by the AIC. Diagnostics consisted of tests for the residual autocorrelation (Breusch-Godfrey test), homoscedasticity (White's test), residual normality (Jarque-Bera test) and Ramsey's RESET test of specification errors.

6.4.1 Estonia

The first difference regressions did not find any relationship between the change in the unemployment rate and the output growth in the static form. The hypothesis that the coefficient is significantly different from zero was rejected. When the dynamics was taken into account the coefficient on the output growth showed a correct sign and was statistically significant. Nevertheless, much of the R-squared came from the inclusion of the lagged dependent variable into the equation. Moreover, there seemed to exist a problem with the residual autocorrelation, indicating a possible misspecification of the model.

The gap regressions showed more explanatory power and the coefficients proved to be significant in all HP filtered regressions. The dynamic regression with one lagged cyclical unemployment and fourth lag of the cyclical output demonstrated the highest adjusted R-squared (0.6059) and the coefficients were significantly different from zero. The significance of the fourth lag in the regression might indicate that a time of approximately one year is needed for impact of cyclical output to be reflected in cyclical unemployment. Diagnostic tests indicated no important structural problems in the dynamic regressions. The dummy variable introduced into the last regression turned out to be insignificant and even lowered the adjusted R-squared. In general, it can be seen that the relationship even though weak, is indeed negative as suggested by the theory.

6.4.2 Latvia

The regressions which were run with Latvian data showed that there is hardly any relationship present. Only the dynamic version of the difference specification indeed showed a significant coefficient on the output growth rate and the adjusted R-squared was pretty high – around 0.72. Yet again, this was mainly due to the fact that the lagged values of the differenced unemployment were included which have a large portion of this explanatory power over the dependent variable. The static gap regression also showed significantly negative coefficient on the cyclical output. Nevertheless, the dynamic version and the inclusion of the dummy variable did not improve the explanatory power of the regressors.

6.4.3. Lithuania

In case of Lithuania all regressions showed statistically significant coefficients with the right sign and reasonable adjusted R-squared values. Nevertheless, serial autocorrelation (which was detected in all the regressions apart form the dynamic gap model with the dummy) might undermine the results, since in its presence OLS is still linear and unbiased, but not efficient, so the t-tests are misleading and R-squared is likely to be overestimated. Therefore, it is impossible to draw safe inferences from the regression results in this case. The residual autocorrelation can predominantly be the result of the model misspecification - most likely the regressions omitted some variable whose systematic effect was reflected in the error terms. The dummy included in the dynamic gap model turned out to be significant and its inclusion improved the results; if the dummy was omitted from the regression, no Okun’s relationship would be detected.

7 Discussion

The econometric analysis revealed some interesting observations about the relationship between the unemployment rate and output in the Baltic States. Interestingly, the nature and extent of this output-unemployment nexus contradicts in several respects to the majority of the previous studies. First, the analysis of the time series showed that the long run relationship in form of cointegration is present only in Latvia. The first difference model and the gap model showed some evidence of the OL in Estonia. For Latvia no link was established at all, while the inferences drawn from the Lithuanian regressions could be wrong due to important considerations about the residual autocorrelation issues. Asymmetry argument is supported only in the case of Lithuania. The logical conclusion would be that the relationship is very weak in the Baltic States. Okun's Law has been a reliable regularity for economists during a long time. Nevertheless, it seems that nowadays there is little persistent evidence of its presence in the Baltic States. There are two major arguments why OL might have not been detected for the chosen datasets. They are discussed in turn here.

7.1 Data Issues

The first important consideration and at the same time, limitation of the present study is the sample size. Unfortunately, there were little observations which could have been included in the research. Not much variability in the business cycles was present during the time span this research covers, and as a result variations in the production and unemployment rate were comparably small. Given that, no or little evidence of the relationship could have been established via the econometric procedures.

Another point to consider is the hidden economy and migration, which also might have introduced some important adjustments. Underreported revenues might bias the GDP estimates. For instance, recent study by A.T.Kearney (2009) showed that the size of the shadow economy in 2005 in Estonia, Latvia and Lithuania was 38.2%, 39.4%, and 30.2% of GDP, respectively. Likewise, Latvijas Darba devēju konfederācija (LDDK, 2009) cites the shadow economy estimates for the years 1999-2006 and the average for the three states: 37.5%, 38.2% and 29.1% of GDP, for Estonia, Latvia and Lithuania. Apart from that, the labor markets in the Baltic States are characterized by migration and outflow of working age population abroad (Paas et al., 2003). Thus, the fact that migration causes overall labor force decrease and corrects the unemployment rate also should be taken into account.

7.2 Considerations about Okun's Law Strength

Generally, output is a function of productivity, labor and capital. If unemployment as a linear function of labor, then indeed, Okun's law might have sense. However, employed people produce output, not the unemployed. Consequently, that is the number of the employed labor force and their productivity that affects production levels. Moreover, with the advancements in technology, it is very likely that the productivity of one person increases and there is no need for a company to employ more people instead. Thus, for a constant or even growing output there can be increases in unemployment as well. On the one hand the argument that more people produce more output indeed supports the Okun's relationship. On the other hand, productivity might undermine Okun's dispute. Therefore, the relationship is possibly much more complicated than it might look at the first glance. It is very likely that the Okun's assumption that the labor force, hours worked and productivity can be approximated by the unemployment rate is overly strong.

Moreover, the features of the labor market can also be an issue. Since there is a great mismatch between the demand and the supply of labor in terms of qualifications and skills, as well as high costs of firing, searching and hiring an employee, companies might be reluctant to fire their workers in the recession times (but cut working hours instead) or make them work more during the expansion periods, instead of employing more people. Another argument which is related to the market rigidities is the possibility of unemployment rate inelastic response to the GDP changes. That is, unemployment could react more fiercely to large shifts in the production rather then to moderate changes (Fouquau, 2008). Consider a company, which employs N people and produces Y of output. If Y is fluctuating around its equilibrium value, the company most likely will not hire new personnel in case of an insignificant increase in Y, or fire the old staff members if Y goes down for some little value. If, on the other hand, Y deviates a lot from the long term values, the company would suffer from decreasing revenues and will be forced to reduce its staff; or enjoy rising demand for its production and will have to employ more people to produce more.

Lastly, most of the solid evidence in favor of the OL proposition comes from the developed countries. The research in developing and transitory economies shows little support for Okun's law. For example, Moosa (2008) examined the OL in the North African countries and found no relationship present. He discussed the following possible reasons: the fact that unemployment is not cyclical but rather structural or frictional; the rigidity of the market and the structure of the economies, which are dominated by the government and one sector. Savulea (2008) examined the relationship for Romania and similarly found that the law is valid only to a very little extent. Lal et al (2010) tested the validity of Okun's law for some Asian countries by examining the cointegration, and also failed to find reliable evidence of OL.

8 Suggestions for Further Research

There are several important directions to be pointed out for further research and some limitations of the present paper which should be taken into consideration in the upcoming studies.

First and foremost, micro level data could be used to study the Okun's phenomenon. To the best knowledge of the author there has been no studies using the micro data, which is an important gap. Macro level data, even though it provides with general implications, can be too "clumsy". In contrast, micro level data obtained from executive surveys or interviews with HR managers could be much helpful in drawing inferences about the possible causes and inter-dependence between the companies' performance and its employment policies.

Secondly, other econometric procedures could be used to study OL. As it was shown in the present paper, it is very likely that some variables are fractionally integrated. It would be interesting to see how to model fractionally integrated time series and whether the results would considerably differ from the ones obtained in the present study. Moreover, other trend-cycle decomposition methods could be used e.g. Beveridge-Nelson decomposition, Kalman filter applied for the unobserved components model, or multivariate models etc. Additionally, the treatment of the possible asymmetry is quite superficial in this paper. It assumes only two states of the economy – the recession and the growth phase. Nevertheless, if, as guessed above, OL holds for the extreme values, and not for the moderate, a more sophisticated approach with endogenous thresholds should be considered.

Thirdly, the dataset should be revised in some time and more observations included. The results obtained in this study could reject the existence of the OL solely due to the limited and unreliable dataset. Additionally, the augmented version of the OL (e.g. see Prachowny (1993)) could be used, as it has more solid theoretical foundation. The labor force, hours worked and the productivity would provide more insight into the relationship between the goods and labor market. Moreover, subsamples could be examined and the impact of the EU accession could be analyzed. This paper does not deal with the issue of the possible break in the sample in 2004, due to small number of observations. Nevertheless, the fact that Baltic States' population starting with 2004 gained legal access to labor markets in the EU, could have had an impact on the relationship validity.

9 Conclusions

Okun's Law, discovered in the beginning of the 1960s proposes a relationship between the unemployment rate and output. On the whole, empirical evidence tends to support the Okun's proposition, despite the fact that the OLC estimates depend heavily on the time period, geographical entities being analyzed, and econometric procedures used. This paper contributed to the existent body of literature by providing evidence from the Baltic States.

The study departed from the stationarity issues and analysis of the cointegration between the time series. Interestingly enough, the long run relationship was found only for Latvia, the first difference and the gap specifications showed some reasonable results for Estonia, while only some evidence of asymmetry was found for Lithuania.

Contrary to expectations, little evidence of the OL relationship was detected. Even though the results were not robust to the specifications, this fragile relationship seems to be negative indeed. Two main arguments are in order. First, the possibility that the data is unreliable, noisy and the sample size is too small. Second, concerns the structural features of the labor markets in the Baltic States. Rigid labor market structure and inelastic unemployment rate response to the shifts in the output could possibly result in little evidence in favor of the OL proposition. Combining the two arguments, it does not seem that unrealistic that only a very weak link was established for the samples. The data shows little variability and is in some sense monotonous (the latest observations associated with the world financial crisis were excluded, as they might have resulted in wrong conclusions). Nevertheless, it is very possible that these observations represent a structural feature of the economy, rather than outliers in the data, thus their inclusion would provide more evidence in favor of Okun’s Law. Therefore, it is proposed to re-examine the relationship in some time, when more observations could be included. Additionally, as pointed out by many researchers, inferences about OL are very sensitive to the methodologies used, so future research might focus on applying different econometric techniques as well.

Despite the fact that the present paper has raised many questions, it is a first step in the OL research in the Baltic States. Undoubtedly, it needs further elaboration, research and revision in some time. Nevertheless, it is obvious that Okun’s law is not a law, but rather a statistical regularity which has exceptions.

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Appendix 1

Derivation of Okun's Law by Prachowny (1993)

Consider the following Cobb-Douglas aggregate production function in natural logarithms:

$$y = \alpha\,(k + c) + \beta\,(\gamma\,n + \delta\,h) + \tau$$

where y is the output, k is the capital stock and c is its utilization rate, n represents the number of workers and h is the number of working hours. α and β are output elasticity, while γ and δ are workers' contribution and working hours contribution to the final production. The coefficient τ is productivity factor.

The potential output is derived from the same equation, however, using sustainable or long term levels of production factors:

$$y^* = \alpha\,(k^* + c^*) + \beta\,(\gamma\,n^* + \delta\,h^*) + \tau^*$$

Thus, the output gap (actual minus potential output) is calculated as follows:

$$y - y^* = \alpha\,(k - k^*) + \alpha\,(c - c^*) + \beta\,\gamma\,(n - n^*) + \beta\,\delta\,(h - h^*) + (t - t^*)$$

Given that $u = l - n$ (where u is the unemployment rate and l is the total labor force), and assuming for simplicity that $k = k^*$ and $t = t^*$, modify equation (3) into:

$$y - y^* = \alpha\,(c - c^*) + \beta\,\gamma\,(l - l^*) - \beta\,\gamma\,(u - u^*) + \beta\,\delta\,(h - h^*)$$

The $\beta\,\gamma$ coefficient basically shows the degree of correlation between unemployment and output gap. Due to high degree of colinearity between $(u - u^*)$ and other components on the right side of the equation and difficulties in measuring them, these variables are usually omitted, leaving:

$$y - y^* = \beta'\,(u - u^*)$$

Alternatively, rearranging, we get:

$$(u - u^*) = 1 / \beta'\,(y - y^*)$$

Appendix 2

Literature review

Review of selected papers on Okun's Law, methodologies and samples used, main results and conclusions.

Authors	Specification & research method	Sample	Main results and conclusions
Attfield & Silverstone (1997)	Augmented gap model; cointegration framework	U.S.	Re-estimated the OLC using the datasets of Prachowny (1993),Gordon (1987) and Adams and Coe(1990). For the first two datasets find evidence that the variables are cointegrated, that was not taken into account by previous authors. Found the OLC for U.S.of around 2.25, which mainly supports previous research.
Barreto & Howland (1993)	Three specifications of OL	U.S.; Japan (1953-1982)	Emphasized the choice of the direction of the regression, depending on which relationship one is concerned about. Okun was wrong in using the reverse coefficient of the OLC, need to run two different regressions. In the OL literature, the wrong regression has generated much confusion and severe overestimation of the relevant parameters, e.g. for Japan.
Bisping & Patron (2005)	VAR applied to gap specification	U.S.	Examined OL relationship disaggregated by the region, race and gender in the US. Found evidence that the relationship is different among regions and demographic groups.
Christopoulos (2004)	Cointegration; Fully modified OLS	Greek regions 1971-1993	OL holds in approximately half of the Greek regions. Indicates the presence of a rigid labor market and highly regulated environment.
Cuaresma (2003)	Gap version; HP filter and bivariate structural time series; Piecewise linear specification with exdogenous threshold	U.S.: 1947:1-1999:4	Strong evidence of nonlinearity: effect of GDP growth on unemployment is asymmetric and significantly higher in recessions than in expansions, and shocks to unemployment tend to be more persistent in, the expansionary regime.
Evans (1989)	Bivariate VAR model	U.S.: 1950-1985	Introduced the VAR model to quantify the Okun's law coefficient. The OLC estimates obtained were in the range of -0.30, thus confirming Okun's result.
Freeman (2001)	Augmented gap version; Baxter and King band pass filter	10 Industrial countries	Omission of capital and labor input may have biased the previous results. The re-estimated OLC is about 1/2 rather that 1/3 for the US.
Fouquau (2008)	Gap model: switching regime models	OECD countries	Showed the existence of four regimes. For extreme low or high values of cyclical unemployment strong negative relationship between both variables. Yet, when unemployment is at intermediate levels, the relationship is weaker.
Gordon, Clark (1984)	Augmented gap version	U.S.: 1954-1983	Estimated the OLC starting with the aggregate production function, including several variables of the supply side (productivity, hours worked and labor force). Estimated short run OLC of -0.23 and a long-run OLC of -0.5.

Harris & Silverstone (2001)	Assymetric ECM model	7 OECD countries: 1978-1999	States that failure to take account of the assymetric behavior would result in rejecting the OL. Moreover, SR adjustments to the disequilibrium are different across business cycle: they depend on whether the economy is in the growth state or in the downturn.
Lee (2000)	First difference method; Gap model: HP filter, BN decomposition; Kalman filter; VECM; assymetries	16 OECD countries: 1955-1996	Analysis included first difference and gap specifications; the first one was further examined in an ECM. Additionally author allowed for asymmetric behavior introducing a threshold dummy variable. In general, OL seems to hold, quantitative estimates vary across countries.
Perman & Tavera (2007)	Dynamic gap rolling regressions	EU countries: 1970:1-2002:2	Medium term convergence for several sub-groups, but no strong evidence indicating the convergence in the estimates of the OLC.
Petkov (2008)	ARDL: gap verion	UK:1973:3-2003:3	Overall, OL holds, however, some differences over time and in-between specifications are present.
Prachowny (1993)	Augmented gap version in gaps	U.S.:1947:1-1988:4	Explored the possibility of estimating the OLC with the help of a production function. Introduced weekly hours, capacity utilization and labor force to the original regression. The estimates of the OLC turned out about twice as large as the expected of around 1/3.
Silvapulle, Moosa & Silvapulle (2004)	Dynamic gap specification. Unobserved components model. Exogenously imposed threshold	U.S.: 1947:1-1999:4	Found strong evidence that the cyclical unemployment indeed responds asymmetrically to cyclical output.
Sögner, Stiassny (2000)	First difference model. Bayesian methods and Kalman filtering to test for structural stability	15 OECD countries	The reaction of unemployment on the changes in output depends considerably across countries. Bayesian methods did not indicate any presence of structural instability, whereas Kalman filtering showed that in some countries the relationship is asymmetric.
Villaverde, Maza (2007)	Static gap specification. HP filter and quadratic trend	Spain: 1980-2004	OL holds for the most of the Spanish regions and for the whole country, nevertheless, quantitative values differ across regions. Results were sensitive to the detrending technique.
Virén (2001)	ECM; Exogenous threshold model estimator	20 OECD countries: 1960-1997	Studied the nonlinear output growth effects. Showed that the output growth exhibits strong effect on unemployment when unemployment is low and vice versa.
Weber (1995)	1) Static OLS; 2) Dynamic OLS with 2 and 4 lags; 3) Cointegration regression; 4) VAR	U.S.: 1984:1-1988:4	Empirical estimates of OLC around -0.25, lower than originally estimated by Okun.

Appendix 3

Okun's coefficients for selected countries

The table presents Okun's coefficient for a number of developed countries. Author and the time period analyzed are found in the header row of the table unless specified otherwise. Please refer to Appendix 2 for a brief description of the methods used.

Country	Mossa (1960-1995)	Lee (1955-1996)	Sögner and Stiassny (1960-1999)	Schnabel (1960s-2000)	Others
Australia		-0.65		-0.36	Harris and Silverstone:-0.501
Canada	- 0.49	-0.60	-0.60	-0.33	Harris and Silverstone:-0.386
EU				-0.23	
France	-0.36	-0.34	-0.43	-0.17	Perman and Tavera (1970-2002) :-0.531
Germany	-0.41	-0.40 (1960-1996)	-0.38	-0.27	Perman and Tavera (1970-2002):-0.967 Harris and Silverstone:-0.389
Italy	-0.18	-0.92	-0.21	-0.14	Perman and Tavera (1970-2002):-0.493
Japan	-0.09	-0.23	-0.12	-0.04	Harris and Silverstone:-0.091
Spain				-0.48	Perman and Tavera (1970-2002): -0.595
Sweden		-0.53	-0.35	-0.25	Perman and Tavera (1970-2002): -1.453
UK	-0.37	-0.72	-0.58	-0.50	Petkov (1973-2003): -0.2338 Perman and Tavera (1970-2002): -0.752 Harris and Silverstone:-0.263
U.S.	-0.46	-0.54	-0.52	-0.42	Weber (1948-1988): -0.314 and -0.260 Gordon and Clark (1967-1986): -0.5 Evans (1950-1989): -0.3

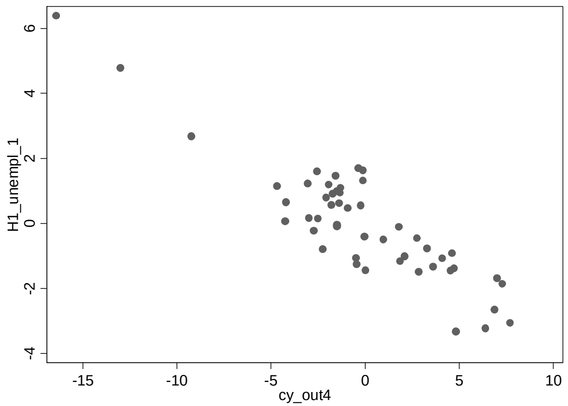
Source: Schnabel (2002), completed by the author.

Appendix 4

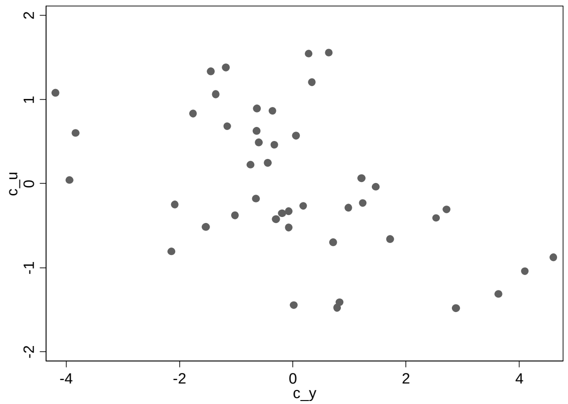
Cyclical unemployment as a function of cyclical output

Estonia

Cyclical *u* as a function of cyclical *y* (whole sample)

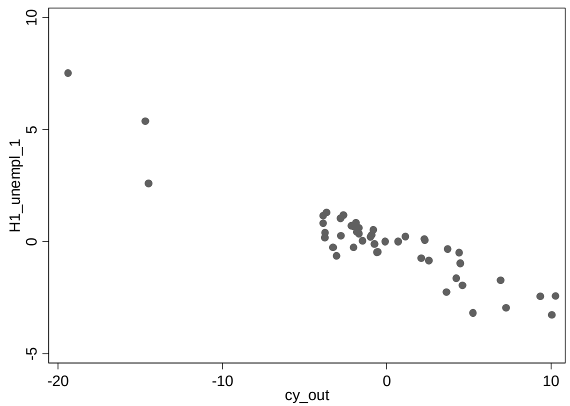


Cyclical *u* as a function of cyclical *y*
(shortened sample: 1997:1-2007:4)

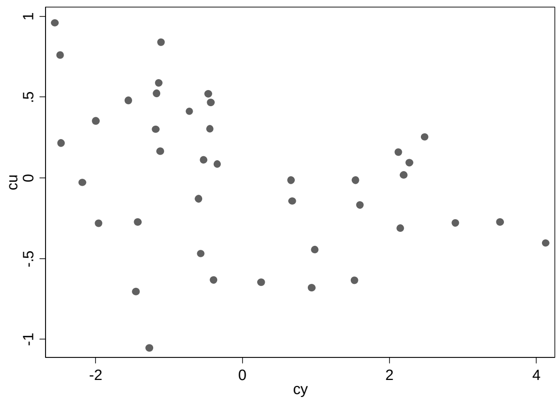


Latvia

Cyclical *u* as a function of cyclical *y* (whole sample)

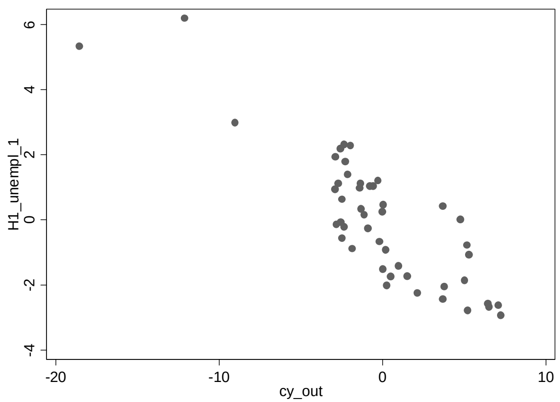


Cyclical *u* as a function of cyclical *y*
(shortened sample: 1997:1-2007:4)

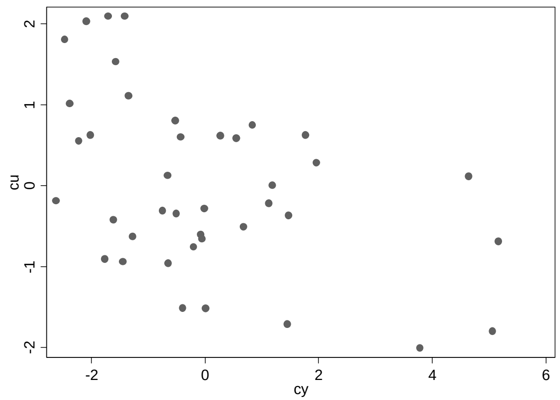


Lithuania

Cyclical *u* as a function of cyclical *y* (whole sample)



Cyclical *u* as a function of cyclical *y*
(shortened sample: 1997:1-2007:4)



Appendix 5

Descriptive statistics and stationarity tests.

AIC: Akaike Information criterion. BIC: Schwarz-Bayesian Information Criterion. DF-GLS: Dickey Fuller GLS test for unit root with H_0: Series has a unit root. KPSS: Kwiatkowski-Phillips-Schmidt-Shin tests for trend stationarity with H_0: Series is trend stationary. ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Table 5a: Descriptive statistics and stationarity tests for Estonia (1997:1-2007:4)

	u	*d.u*	$u^{c\ HP1600}$	*Ln(y)*	*d.Ln(y)*	$y^{c\ HP1600}$
Mean	9.425			10.25268		
Median	9.65			10.2459		
St. dev.	2.489151			.0546357		
Observations	44			44		
AIC	1	0	1	1	4	4
BIC	1	0	1	1	0	4
DF-GLS	-1.060	-3.790***	-2.316	-2.514	-3.043*	-3.309**
KPSS	.261	.0615*	.0957*	.202***	.0521*	.104*
Order of Integration	I(1)	I(0)	≈I(0)	I(1)	I(0)	I(0)

Table 5b: Descriptive statistics, unit root and stationarity tests for Latvia (1998:1-2007:4)

	u	*d.u*	$u^{c\ HP1600}$	*Ln(y)*	*d.Ln(y)*	$y^{c\ HP1600}$
Mean	10.985			7.284235		
Median	11.2			7.254337		
St. dev.	2.901065			.2312484		
Observations	40			40		
AIC	2	1	4	1	0	1
BIC	2	1	0	1	0	1
DF-GLS	-1.524	-5.19***	-2.548	-1.658	-3.091*	-2.520
KPSS	.223	.0439*	.0775*	.255	.0629*	.186***
Order of Integration	I(1)	I(0)	≈I(0)	I(1)	I(0)	≈I(0)

Table 5c: Descriptive statistics, unit root and stationarity tests for Lithuania (1998:1-2007:4)

	u	*d.u*	$u^{c\ HP1600}$	*Ln(y)*	*d.Ln(y)*	$y^{c\ HP1600}$
Mean	11.535			9.548486		
Median	12.65			9.520819		
St. dev.	4.068361			.2005351		
Observations	40			40		
AIC	2	1	4	3	4	4
BIC	2	1	4	2	4	4
DF-GLS	-1.671	-2.794	-2.662	-1.494	-3.481**	-1.196
KPSS	.234	.08*	.117*	.222	.121**	.154***
Order of Integration	I(1)	≈I(0)	≈I(0)	I(1)	I(0)	≈I(0)

Appendix 6

Cointegration regressions and residual stationarity tests

Cointegration regressions and residual stationarity tests. For the ADF test, MacKinnon p-value is reported in brackets

Table 6a: Co-integration regressions and residual stationarity tests for Estonia.

	ln_y (regressor)	*u* (regressor)	Adj R-squared	ADF	DF-GLS
u (dependent variable)	-7.87103		0.5356	-1.313 (0.6234)	-0.992
ln_y (dependent variable)		-.0694232	0.5356	-2.076 (0.2543)	-0.998

Table 6b: Co-integration regressions and residual unit root tests for Latvia.

	ln_y (regressor)	*u* (regressor)	Adj R-squared	ADF	DF-GLS
u (dependent variable)	-12.36429		0.9706	-4.929 (0.0000)	-2.474
ln_y (dependent variable)		-.0785618	0.9706	-4.996 (0.0000)	-2.517

Table 6c: Co-integration regressions and residual unit root tests for Lithuania.

	ln_y (regressor)	*u* (regressor)	Adj R-squared	ADF	DF-GLS
u (dependent variable)	-18.46422		0.8238	-1.273 (0.6416)	-1.953
ln_y (dependent variable)		-.0448614	0.8238	-1.468 (0.5493)	-2.032

Appendix 7

ECM and Granger causality test results for Latvia

F-statistic is statistic for joint significance of the coefficient on the lagged values of explanatory variable. Residual is the error correction term obtained from the auxiliary regressions and included in the ECM. ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively.

Table 7: ECM and Granger causality test results

Null hypothesis	Lag number							
	1		2		3		4	
	F-statistics	Prob>F	F-statistics	Prob>F	F-statistics	Prob>F	F-statistics	Prob>F
Δy does not Granger cause Δu	-0.36	0.718	0.98	0.3881	0.46	0.7103	0.40	0.8077
	t-statistics	Prob>t	t-statistics	Prob>t	t-statistics	Prob>t	t-statistics	Prob>t
Residuals	-3.19***	0.003	-2.88***	0.007	-3.09***	0.004	-2.15**	0.042
Adj R-squared	0.3440		0.3554		0.4056		0.3700	
Null hypothesis	Lag number							
	1		2		3		4	
	F-statistics	Prob>F	F-statistics	Prob>F	F-statistics	Prob>F	F-statistics	Prob>F
Δu does not Granger-cause Δy	-1.44	0.160	0.79	0.4618	0.68	0.5695	0.81	0.5319
	t-statistics	Prob>t	t-statistics	Prob>t	t-statistics	Prob>t	t-statistics	Prob>t
Residuals	0.70	0.488	0.61	0.547	0.61	0.547	1.11	0.277
Adj R-squared	-0.0254		-0.0945		-0.1208		-0.1404	

Appendix 8

Regression results

Number of lags for dynamic models was chosen with the help of AIC and BIC. The table shows coefficient on the regressor and its standard error. ***, ** and * indicate statistical significance at 1%, 5% and 10%, respectively. For diagnostics test statistics is reported. In brackets below is given the probability P>| chi2 | or P > F for Ramsey's RESET test. B-G test – Breusch-Godfrey test for residual autocorrelation. J-B test – Jarque-Berra test for normality of residuals. White test –heteroscedasticity test. Ramsey's RESET test – general test of specification errors.

Table 8a: Regression results for Estonia

	Static 1st diff OLS (1)	Dynamic 1st diff OLS (2)	Static gap OLS-HP (3)	Dynamic gap OLS-HP (4)	Dynamic gap OLS-HP+ D(5)
g^y	-11.9557 (8.233686)	-18.1576*** (6.678865)			
g^y_{t-1}		11.19441** (5.187839)			
g^y_{t-2}		-8.589996* (4.99636)			
Δu_{t-1}		.9757792 *** (.146755)			
Δu_{t-2}		-.2993009*** (.0819198)			
u^c_{t-1}				.4192141*** (.1406742)	.4509109*** (.1473017)
y^c_t			-22.35234*** (6.154716)	-18.65378*** (5.862321)	-22.2541*** (7.515758)
y^c_{t-4}				-14.00187 ** (6.181165)	-13.30554** (6.281138)
D					.2060749 (.2668167)
_cons	.0718775 (.1801641)	.188297 (.1328566)	-.0022068 (.114645)	-.0323073 (.0891377)	-.1319036 (.1570492)
Adjusted R^2	0.0257	0.6639	0.2209	0.6059	0.6014
<u>Diagnostics tests</u>					
B-G test	1.592 (0.8103)	23.924 (0.0001)	16.592 (0.0000)	0.181 (0.6707)	0.342 (0.5585)
J-B test	1.83 (0.4010)	3.88 (0.1439)	0.31 (0.8561)	1.10 (0.5771)	1.57 (0.4572)
White test	0.47 (0.7917)	13.60 (0.4799)	2.33 (0.3119)	13.08 (0.1589)	16.36 (0.2304)
Ramsey's RESET test	0.47 (0.7064)	0.22 (0.8786)	1.09 (0.3664)	0.24 (0.8646)	0.19 (0.8998)

Table 8b: Regression results for Latvia

	Static 1st diff OLS (1)	Dynamic 1st diff OLS (2)	Static gap OLS-HP (3)	Dynamic gap OLS-HP (4)	Dynamic gap OLS-HP+ D(5)
g^y	-.9221927 (7.062449)	-9.095169* (5.35373)			
g^y_{t-1}		3.320612 (3.795528)			
Δu_{t-1}		.5060528*** (.0510685)			
u^c_{t-1}				.1908569 (.1655156)	.1735919 (.1697678)
y^c			-9.577216** (4.033895)	-4.094995 (6.331884)	-.2811537 (9.191773)
y^c_{t-1}				6.331884 (6.174747)	-3.327419 (6.264014)
D					-.1758754 (.3045603)
_cons	-.205227 (.1643339)	-.0480858 (.1140627)	-.0004491 (.0701465)	.0137247 (.0709573)	-.013677 (.1295014)
Adjusted R^2	-0.0266	0.7241	0.1063	0.0879	0.0702
Diagnostics tests					
B-G test	8.451 (0.0036)	1.645 (0.1996)	1.143 (0.2849)	0.797 (0.3719)	0.471 (0.4925)
J-B test	4.01 (0.1347)	0.48 (0.7884)	3.23 (0.1987)	4.15 (0.1253)	4.75 (0.0932)
White test	0.88 (0.6455)	5.32 (0.8058)	3.75 (0.1530)	6.00 (0.7396)	8.67 (0.7970)
Ramsey's RESET test	0.17 (0.9161)	1.52 (0.2281)	0.60 (0.6189)	0.19 (0.8991)	0.15 (0.9298)

Table 8c: Regression results for Lithuania

	Static 1st diff OLS (1)	Dynamic 1st diff OLS (2)	Static gap OLS-HP (3)	Dynamic gap OLS-HP (4)	Dynamic gap OLS-HP+ D(5)
g^y	-22.84083** (9.110739)	-39.59854*** (9.265505)			
g^y_{t-1}		86.26898*** (26.58597)			
g^y_{t-2}		-68.25297** (27.29979)			
g^y_{t-3}		18.3213* (9.820176)			
Δu_{t-1}		.504971*** (.1405971)			
u^c_{t-1}				1.171319*** (.1603452)	1.059003*** (.1571634)
u^c_{t-2}				-.4081841*** (.1468227)	-.2718166* (.1537744)
y^c			-25.09547*** (7.693873)	-7.508425 (10.39977)	-21.49551** (7.899812)
y^c_{t-1}				-1.346176 (9.985205)	
D					.5367045**

					(.2636229)
_cons	.098732	.3802033**	-.0066593	.0049214	-.228039
	(.1707423)	(.1645378)	(.1513869)	(.0774344)	(.1352853)
Adjusted R^2	0.1221	0.4660	0.1982	0.8168	0.8371
Diagnostics tests					
B-G test	7.321	22.342	27.062	3.289	2.608
	(0.0068)	(0.0000)	(0.0000)	(0.0697)	(0.1063)
J-B test	0.66	1.62	5.98	1.89	2.20
	(0.7179)	(0.4446)	(0.0502)	(0.3894)	(0.3336)
White test	3.58	22.36	2.15	12.48	8.74
	(0.1670)	(0.3211)	(0.3411)	(0.5680)	(0.7926)
Ramsey's RESET test	0.24	0.44	0.54	0.32	0.35
	(0.8701)	(0.7286)	(0.6554)	(0.8083)	(0.7869)

Abbreviations

ADF – Augmented Dickey Fuller unit root test

AIC – Akaike Information Criterion for determining lag length

ARDL – Autoregressive Distributed Lag model

DF-GLS - Dickey Fuller General Least Squares unit root test

ECM – Error Correction Model

EG – Engle Granger two step cointegration procedure

GDP – Gross Domestic Product

GNP – Gross National Product

HP – Hodrick-Prescott filter

KPSS – Kwiatkowski-Phillips-Schmidt-Shin stationarity test

NAIRU – Non-accelerating inflation rate of unemployment

OL – Okun’s Law

OLC – Okun’s Law Coefficient

OLS – Ordinary Least Squares

Footnotes

[1] See Christopoulos (2004) on study of the Greek regions, Bisping and Patron (2005) on the U.S. regions, Villaverde and Maza (2007) on the Spanish regions.

[2] E.g. Fouquau (2008), Harris and Silverstone (2001), Lee (2000), Schnabel (2002), Sögner and Stiassny (2002), Viren (2001).

[3] E.g. Perman and Tavera (2007)

[4] E.g. Prachowny (1993), Attfield, Silverstone (1997), Cuaresma (2003), Gordon and Clark (1984), Weber (1995), Evans (1989) etc.

[5] Even though such specification could be more correct to study the link between the labor market and the goods market it is out of the scope of this paper due to the data reliability and availability issues.

[6] It could be the case that the time series are not integrated of an integer value, but rather fractionally integrated, meaning that the order of integration is a non-integer. However, this issue is left as a suggestion for further studies.