The Validity of Okun's law in Curaçao

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Abstract[1]

This paper tests the validity of Okun's law by examining the relationship between output growth and unemployment in Curaçao using annual time-series data for the period 1987-2015. Following two versions of Okun's law, growth or difference and gap models were constructed. In the gap models, the Hodrick Prescott filter and Cubic/Quartic equations were applied to calculate potential output and natural unemployment in Curaçao.

To this end, an Autoregressive Distributed Lag (ARDL) approach to co-integration and an Error Correction Model (ECM) were applied to account for short-run and long-run dynamics.

The empirical results verify a *significant* negative relationship between real GDP growth and the change in (the cyclical component of) unemployment in Curaçao in both the short run and long run. Overall, Okun's coefficients for Curaçao, i.e., the responsiveness of unemployment to output growth, are fairly consistent with studies conducted in other countries.

JEL Classification Numbers: E23, N16

Keywords: Okun's law, Autoregressive Distributed Lag approach (ARDL), Co-integration, Error Correction Model (ECM).

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[1] The views expressed in this paper are from the authors and do not necessarily represent those of the Centrale Bank van Curaçao en Sint Maarten (CBCS) or the Central Bureau of Statistics Curaçao (CBS). However, the authors thank Candice Henriquez, Eric Matto, and Marelva de Windt from the CBCS, as well as Sean de Boer and Harely Martina from the CBS, for their interest, support, and valuable contribution to this paper.

Abbreviations

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criteria
ARDL	Autoregressive Distributed Lag
BG	Breusch-Godfrey
BLUE	Best Linear Unbiased Estimator
CUSUM	Cumulative Sum Control Chart
DF-GLS	Dickey-Fuller-Generalized Least Squares
ECM	Error Correction Model
EG	Engle-Granger
GDP	Gross Domestic Product
HP	Hodrick Prescott filter
JB	Jarque-Bera
OLS	Ordinary Least Squares
PP	Phillips Perron
drGDP100	Real GDP growth rate
logUMT_diff	Growth in the unemployment rate
VECM	Vector Error Correction Model

Introduction

A high unemployment rate, especially among youth, is a global concern, particularly in Caribbean countries, including Curaçao. In 2014, Curaçao's youth and total unemployment rates were 33.2% and 12.6% compared to the Caribbean averages of 24.6% and 10.4% and the world averages of 14.0% and 5.9%, respectively.[2] *To maximize output and support macroeconomic stability, full employment—a situation where everyone capable of working is able to get a job if they would like to—is a necessary goal. In macroeconomic literature, the relationship between changes in unemployment and output growth is known as Okun's law or Okun's rule of thumb because the relationship constitutes an empirical observation. Arthur Okun (Okun, 1962) was the first economist to investigate this relationship in the United States. In his original study, he argued that by increasing output by 3%, unemployment would decrease by 1%. He was, therefore, in favor of output expansion policies to reduce unemployment and poverty (Abbas, 2014). The literature suggests that Okun's relationship is fairly stable over the long run, but over the short run, the relationship can differ considerably depending on the country and/or time period considered.*

This paper contributes to existing macroeconomic literature by examining the validity of Okun's law in Curaçao based on annual time-series data. To the authors' knowledge, no previous studies have been conducted on the applicability of Okun's law in Curaçao. If indeed a relationship exists between unemployment and output growth in Curaçao, we will be able to estimate the real output growth rate required to reduce the unemployment rate. Although Curaçao's unemployment rate declined from 13.0% in 2013 to 12.6% in 2014 and to 11.7% in 2015,[3] *this figure is still relatively high compared to the Caribbean and world averages. Also, while the unemployment rate in Curaçao has been declining in the past two years, real output has been stagnant—contrary to Okun's law.*

The paper is structured as follows. Section 2 elaborates on various types of unemployment as well as existing literature on the relationship between output growth and changes in unemployment. Section 3 discusses the various versions of Okun's law that exist and that have been used in the studies cited in section 2. Section 4 shows the development of the unemployment and output growth rates in Curaçao. Section 5 outlines the data and method used to investigate the validity of Okun's law in Curaçao. Section 6 discusses the main empirical results and section 7 presents the conclusions of this study.

Literature review

Types of unemployment

Generally, the literature distinguishes three types of unemployment: (1) frictional unemployment, (2) structural unemployment, and (3) cyclical unemployment (Levine, 2013).

[2] Data for Curaçao come from the Central Bureau of Statistics Curaçao, and data for Caribbean small states and the world are derived from the World Bank Database. Note that data for 2014 are used because data for 2015 were available only for Curaçao. As defined by the World Bank, Caribbean small states include Antigua and Barbuda, Bahamas, Barbados, Belize, Guyana, Suriname, Dominica, Grenada, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, and Trinidad and Tobago.

[3] Data are derived from the Central Bureau of Statistics Curaçao.

Frictional unemployment occurs when people move into and out of jobs, such as unemployed college graduates searching for a job, family caregivers returning to the labor force, and employees quitting their jobs prior to obtaining a new one (Levine, 2013).

Structural unemployment arises when jobseekers do not quickly occupy vacant jobs, thereby lengthening the time period of their job search – also known as the spell of unemployment (Mocan, 1999 and Levine, 2013). Barriers in the employee-to-job matching process include, among other things, mismatches between the available skills of the unemployed and the skills required by the employers, the composition of the unemployed (e.g., employees who are permanently or temporarily laid off), and the labor market institutions (e.g., the duration of unemployment benefit programs) (Levine, 2013).

Both frictional and structural unemployment arise as a result of problems in the employee-to-job matching process (Levine, 2013). However, frictional unemployment is mostly voluntary and has a shorter duration than structural unemployment. In the case of frictional unemployment, someone may have the skills to do a job, but he/she is not aware of a vacancy that matches his/her skills.

Cyclical unemployment occurs because of a downturn in a country's business cycle. Employers react to this negative economic development by (temporarily) laying off employees and/or cutting the working hours of their employees. When the economy is recovering, employers might be reluctant to hire more workers (or those previously laid off) right away (Levine, 2013). Consequently, businesses may first increase their current employees' working hours, implying that changes in the business cycle do not automatically translate into changes in the unemployment rate (Levine, 2013). The impact of business cycle fluctuations on the unemployment rate might occur with a time lag.

If after a recession, an economy continues to expand slowly while the unemployment rate remains high for a long period of time, cyclical unemployment can become structural unemployment (Levine, 2013). This shift occurs because at the time of displacement, the skills of the cyclically unemployed matched those required by the employers. However, the longer the unemployed remain outside the workforce, the larger the chance their skills become deficient. Hence, when the economy starts to grow again and businesses start to hire new workers, the skills of the long-term unemployed no longer match those required by the employers anymore.

Levine (2013), among others, notes that none of these unemployment types can be measured directly. Therefore, researchers estimate the nonaccelerating inflation rate of unemployment (NAIRU) referred to as *the natural rate of unemployment*. Because the NAIRU does not take into account fluctuations in aggregate demand (i.e., business cycle fluctuations), it represents the extent of long-term slack in the labor market, which can be useful information for policymaking (Levine, 2013).

The relationship between changes in unemployment and output growth

A wide range of studies emphasize the relationship between changes in unemployment and output growth in a country. Nevertheless, among others, Alamro and Al-dalaien (2014) argue that this relationship does not always hold because output growth occurs in two different ways. The first way stems from rising labor productivity, which does not lead to job creation. The second way is through increasing labor supply, which may lead to job creation, thus reducing the unemployment rate. Given these two ways of generating output growth, many economists have investigated the firmness of the relationship between output growth and unemployment.

A prominent study was carried out by the U.S. economist Arthur Okun in 1962. Okun found that an inverse relationship between economic growth and unemployment in the United States during the period 1947-1957. Okun concluded that increasing real GNP by 3% would lead to a fall in the unemployment rate by 1%.

Zagler (2003) applied a Vector Error Correction Model (VECM) to investigate Okun's law in four large European countries, namely, France, Germany, Italy, and the United Kingdom. The longest available time span was used for each country. Data for France and Italy covered the first quarter of 1970 to the second quarter of 2000. Data for the United Kingdom and Germany started in the first quarter of 1968, but ended in the first quarter of 2000 and the fourth quarter of 1997, respectively. Zagler concluded that a negative relationship exists between output growth and unemployment in the short run, but contrary to Okun's law, the relationship is *positive* in the long run.

Javeid (2005) used annual time-series data over the period 1981-2005 for Pakistan to investigate the relationship between changes in unemployment and GDP growth. He applied the difference version of Okun's law, using the Engle-Granger (EG) co-integration technique for the long-run relationship and the Error Correction Model (ECM) for the short-run behavior of GDP growth to its long-run value. The results showed a negative relationship between the unemployment rate and GDP growth. Furthermore, the data revealed a long-run relationship between the unemployment rate and GDP growth and suggested that GDP growth will adjust more quickly towards equilibrium in the long run. Okun's coefficient[4] was -2.8%, meaning that a 1% increase in GDP results in a 2.8% decrease in the unemployment rate.

Loría and de Jesús (2007) examined the applicability of Okun's law in Mexico using quarterly time-series data covering the first quarter of 1985 to the fourth quarter of 2006. They constructed three structural time-series models based on the Kalman filter, estimating Okun's coefficient between 2.3 and 2.5. An interesting finding from this study is that a bilateral causality seemed to exist between output growth and unemployment in Mexico.

Villaverde and Adolfo (2009) confirmed the validity of Okun's law in Spanish regions over the period 1980-2004, using the gap version and two detrending methods. They concluded that an inverse relationship existed between unemployment and output in the entire country and in most of its regions. Nonetheless, the magnitude of Okun's coefficients differed across the regions and depended on the detrending method used.

Arshad (2010) used the gap version and the Hodrick Prescott (HP) filter for short-run analysis to investigate the presence of Okun's relationship in the Swedish economy, while the co-integration and ECM were used to test the relationship between unemployment and GDP in both the short run and the long run. The study shows that Okun's law existed in the Swedish economy for the period

[4] Okun's coefficient represents the responsiveness of unemployment to output growth and should be negative.

starting from the first quarter of 1993 to the second quarter of 2009. Arshad found an Okun coefficient of -2.2%, proving both a long- and a short-run relationship between unemployment and GDP.

Ting and Ling (2011) examined Okun's relationship in the Malaysian economy. The relationship was measured using the difference and gap models with the HP filter in the latter case. The ARDL approach was used to determine co-integration between the variables and their causality. The authors found an Okun's coefficient of -1.8% at a significance level of 1%.

Stephan (2012) also found evidence for Okun's relationship in Britain and France.

Abbas (2014) investigated the long-term impact of economic growth on unemployment in Pakistan from 1990 to 2006, using the ARDL bounds testing approach to co-integration. The estimated results showed a significant long-run negative impact of economic growth on the unemployment level, but no relationship was observed in the short run. A 1% increase in economic growth was associated with a reduction in the unemployment level by 1.7% in the long run. The coefficient of short-run parameters is insignificant. The ECM term showed a high speed of adjustment because 83% of the short-run disequilibrium was adjusted in a year.

In contrast, Lal et al. (2010) tested Okun's relationship in Asian countries for the period 1980-2006. The study used an Engle-Granger co-integration technique to examine the long-run relationship between output growth and unemployment, and an error correction mechanism for short-run dynamics. The results suggest that Okun's law does not apply in all Asian countries. In addition, Arewa and Nwakanma (2012) used the difference and gap approaches to test the applicability of Okun's relationship in Nigeria for the period 1981 to 2011. No evidence was found to support the negative relationship between output and unemployment.

Overall, the negative sign of Okun's coefficient has been confirmed in most studies, but its magnitude is difficult to determine *a priori* because it depends on various factors that vary by country. These factors include (1) technological costs, such as training; (2) costs of employment protection laws; and (3) the number of employees that enter and exit the labor market (Ball et al., 2013). In addition, the magnitude of Okun's coefficient is sensitive to the model specification, choice of control variables (if any), econometric models, and time periods applied.

Okun's law in a nutshell

As noted in the literature review, previous authors have used various versions of Okun's law (Arshad, 2010 and Alamro and Al-dalaien, 2014) in conducting their studies:

(a) The growth or difference version;
(b) The gap version;
(c) The dynamic version; and
(d) The production function version.

These versions will be described below.

(a) The growth or difference version: $U_t - U_{t-1} = \alpha + \beta(Y_t - Y_{t-1}) + \varepsilon_t$

uses the first difference of output growth and the first difference of unemployment where U_t is the actual unemployment rate at time t, U_{t-1} is the actual unemployment rate at time $t-1$, Y_t is the real output growth at time t, Y_{t-1} is the real output growth at time $t-1$, and ε_t is the error term at time t. This equation shows how the output growth and unemployment rates change simultaneously, where β is Okun's coefficient with a negative value. This means that an increase in output should lead to a decrease in the unemployment rate and a reduction in output is associated with a rise in the unemployment rate.

(b) The gap version: $U_t - U_t^* = \alpha + \beta(Y_t - Y_t^*) + \varepsilon_t$

where U_t is the actual unemployment rate at time t, U_t^* is the natural rate of unemployment, Y_t is the actual output at time t, Y_t^* is the potential output at time t, and ε_t is the error term at time t. In this version, Okun focused on the gap between actual and potential output where *full employment* is achieved. According to Okun, a high unemployment rate will be associated with idle resources, whereby actual output is expected to be below its potential and vice versa. Okun's gap version was based on the assumption that full employment occurs when the unemployment rate is 4%. Given this assumption, Okun constructed a series of potential output levels for the United States. However, by changing the full unemployment rate, different potential output levels can be measured.

(c) The dynamic version: $\Delta U_t = \beta_0 + \beta_1 Y_t + \beta_2 Y_{t-1} + \beta_3 Y_{t-2} + \beta_4 \Delta U_{t-1} + \beta_5 \Delta U_{t-2} + \varepsilon_t$

where ΔU_t is the first difference of current unemployment rate, ΔY_t is the first difference of current real GDP, ΔU_{t-1} is the first lag of unemployment rate, ΔU_{t-2} is the second lag of unemployment rate, ΔY_{t-1} is the first lag of real GDP, ΔY_{t-2} is the second lag of real GDP, and ε_t is the error term at time t. According to Okun's observations, current unemployment can be affected by current and past output as well as past unemployment as shown in the dynamic version. Unlike the previous two versions, Okun's coefficient cannot be interpreted with β .

(d) The production function version: $Y_t = \alpha(k + c) + \beta(\gamma n + \delta h) + \tau$

where Y_t is the output growth at time t, k is the capital input, c is the utilization rate, n is the number of workers, and h is the number of working hours. In addition, α and β are output elasticities, γ and δ are the contributions of workers and weekly working hours to the labor input, and τ is the disembodied technology factor. According to the production function version, the production of goods and services requires an optimal combination of labor, capital, and technology to produce output.

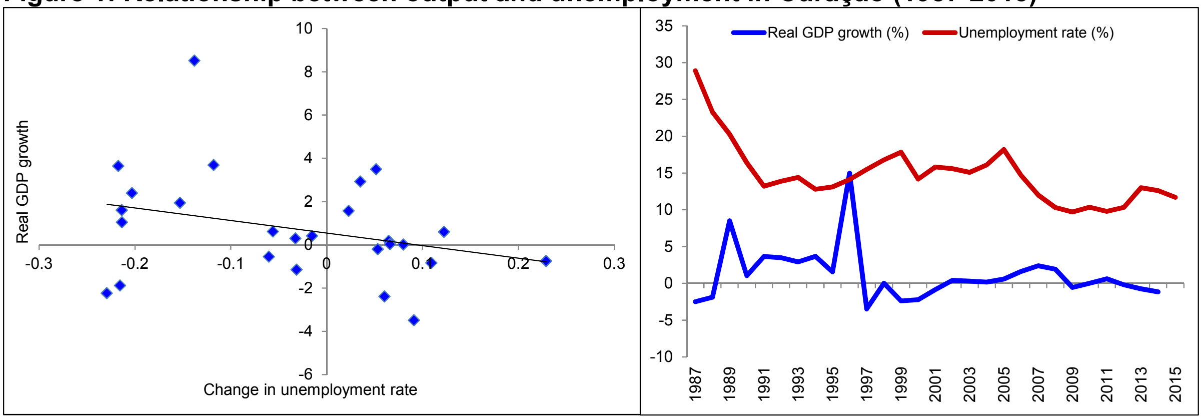
The Curaçao economy

Between 1987 and 2015,[5] Curaçao's economy expanded by 1.1% on average. However, this growth figure generates a distorted picture of the economy of Curaçao because it includes a trend break in 1996 caused by the introduction of a new System of National Accounts (SNA) in that year. Consequently, the nominal GDP level in 1996 differs greatly from the 1995 level, generating a considerable GDP growth of 15.0% in 1996 without a useful explanation. Removing the trend break in 1996 leads to a much lower GDP growth of 0.6% on average, broadly in line with the average GDP growth of 0.5% registered in a more recent period of 2005-2015. This adjustment implies that Curaçao has recorded GDP growth in certain years (i.e., in the periods 1989-1996 and 2006-2008),[6] but that overall, the country has been coping with a tenuous economy (i.e., GDP growth around the zero line).

In addition, during the entire period of 1987-2015, Curaçao's unemployment rate averaged 14.9%. However, in the shorter period of 2005-2015, the unemployment rate was lower, i.e., 12.1% on average. This means that Curaçao's unemployment rate has declined overall, albeit still higher than the Caribbean and world averages of 10.4% and 5.9%, respectively.

Figure 1 shows the development in the real GDP growth rate and the unemployment rate in Curaçao over the period 1987-2015. It seems that Okun's relationship does not apply for the entire period. Particularly in the last two years, the Curaçao economy has been stagnant (i.e., contracting in 2013 and 2014 and growing only marginally in 2015), while the unemployment rate has been declining. This contradictory development raises the question of whether Okun's relationship is applicable in the Curaçao economy in the short and/or long run or not, a question that will be dealt with in the next sections.

Figure 1: Relationship between output and unemployment in Curaçao (1987-2015)



Source: Authors' calculations based on data from the Central Bureau of Statistics Curaçao

[5] See footnote 2.

[6] The years in which Curaçao registered only tepid economic growth (i.e., below 1.0%) are excluded.

Data and method

Similar to earlier studies, this paper seeks to investigate the relationship between changes in unemployment and output growth in Curaçao by using two versions of Okun's law.

Sample and assumptions

Annual time-series data are used for the period 1987-2015. The real GDP growth rate, inflation rate, and unemployment rate are from the Central Bureau of Statistics Curaçao (CBS) and not seasonally adjusted because annual data are used.[7] In addition to the standard mathematical assumptions that follow from using OLS regression (see **Appendix 1)**, this paper makes the following assumptions:

1. Any eventual errors in the nominal GDP and inflation data from the CBS are too small to impact economic growth significantly.
2. Curaçao's labor market is *not* rigid in the long run.
3. Gross Domestic Product (GDP) is an economic indicator *at least* as good as the Gross National Product (GNP).
4. Due to the introduction of the new SNA in 1996, this year is excluded from the sample to prevent a trend break.
5. Because of missing data for the unemployment rate in 1999, 2010, and 2012, the figures are estimated using a *Phillips curve equation* (see **Appendix 2** for further details).

Empirical model specifications

In this paper, two versions of Okun's law are used:

The growth or difference version: $U_t - U_{t-1} = \alpha + \beta(Y_t - Y_{t-1}) + \varepsilon_t$ (1)

where U_t is the natural logarithm of the actual unemployment rate at time t, U_{t-1} is the natural logarithm of the actual unemployment rate at time $t-1$, Y_t is the natural logarithm of the actual real GDP growth level at time t, and Y_{t-1} is the natural logarithm of the actual real GDP growth level at time $t-1$. This equation shows how the real GDP growth rate and the unemployment rate change simultaneously. β stands for Okun's coefficient having a negative value, meaning that an increase in the growth rate of real GDP leads to a decrease in the unemployment rate and vice versa.

The gap version: $U_t - U_t^* = \alpha + \beta(Y_t - Y_t^*) + \varepsilon_t$ (2)

where U_t is the natural logarithm of the actual unemployment rate at time t, U_t^* is the natural logarithm of the natural unemployment rate at time t, Y_t is the natural logarithm of the actual real GDP growth at time t, and Y_t^* is the natural logarithm of the potential real GDP growth at time t. In the gap model, the right-hand side represents the *output gap*, while the left-hand side captures the *unemployment gap*. Thus, the difference between the actual and natural unemployment captures cyclical unemployment, while the difference between the actual and potential output represents cyclical output.

[7] Seasonal adjustment is required for only daily, weekly, monthly, and quarterly data.

In this paper, two decomposition methods are used for the gap model to estimate natural unemployment (U_t^*) and potential output (Y_t^*), namely, the HP filter and the cubic (CE) and quartic (QE) equations, to assure that the obtained results are not sensitive to the applied method. The HP filter is a popular method used in other studies (Hodrick and Prescott, 1997, Ting and Ling, 2011, Alamro and Al-dalaien, 2014, and Huang, 2003), while the CE and QE are based on Maclaurin series (Weisstein, 2016).

The general equation for the HP filter (Hodrick and Prescott, 1997) is:

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

The first part of this equation shows the sum of squared deviations that penalizes the cyclical component, while the second part indicates the multiple lambda (λ) that penalizes the rate of the structural (trend) component. In this paper, a lambda of 100 is applied.

The cubic equation (CE), a third-order polynomial equation, is used to determine trend and cyclical components of unemployment:

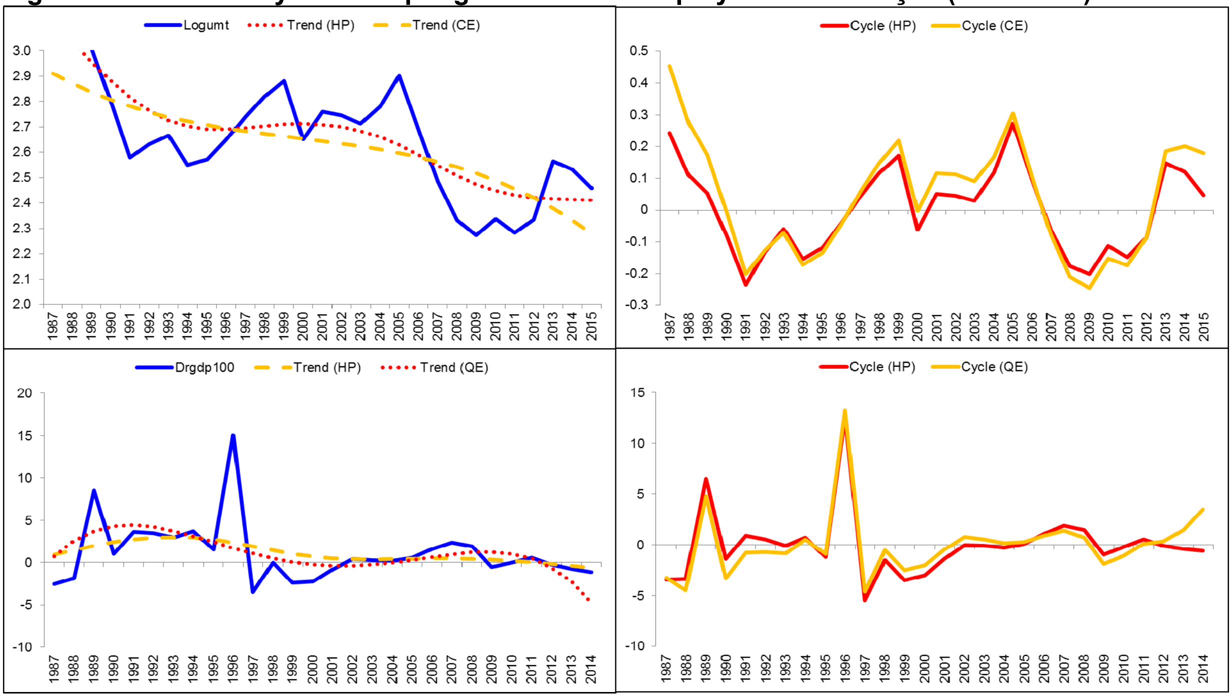
$$F(x)=\alpha_0+\alpha_1x^3+\alpha_2x^2+\alpha_3x+\varepsilon$$

The quartic equation (QE), a fourth-order polynomial equation, is used to extract trend and cyclical components of real GDP growth:

$$F(x)=b_0+b_1x^4+b_2x^3+b_3x^2+b_4x+\varepsilon$$

Figure 2 depicts the trend and cyclical output growth and unemployment in Curaçao using the HP filter and the CE/QE. After decomposing the unemployment and real GDP growth rates into their trend and cyclical components, co-integration and ECM techniques were applied to test the short and long-run causal relationships between the variables. The bounds testing approach was used to co-integrate within an Autoregressive Distributive Lag (ARDL) framework as proposed by Pesaran and Pesaran (1997), Pesaran and Shin (1999), and Pesaran, et al. (2001). Rather than the *static* version, the ARDL *dynamic* version was used for the growth/difference and gap versions because lagged terms of the dependent variable are included as independent variables, providing a better clarification of the unemployment and GDP growth relationship. Furthermore, the ARDL technique was used instead of conventional techniques, such as Engle and Granger (1987), Johanssen (1991), and Gregory and Hansen (1996) because it offers a number of benefits (Abraham, 2014 and Pesaran, et al., 2001).

Figure 2: Trend and cyclical output growth and unemployment in Curaçao (1987-2015)



Source: Authors' calculations

The most important benefit is that the ARDL technique does not require that variables be integrated by the same order (Abraham, 2014 and Pesaran et al., 2001). In essence, the ARDL technique can be used when variables are integrated of order one, zero orders, or fractionally integrated. However, if variables are integrated of order two, spurious results are generated. Another benefit is that the bounds testing procedure of the ARDL technique is more efficient for small and finite samples. Finally, the ARDL technique generates unbiased estimates for the long-run model.

ARDL technique to examine co-integration and ECM

Similar to Alamro and Al-dalaien (2014), the following ARDL equation was used:

$$\Delta U_t = \alpha_0 + \sum_{i=1}^{n} \beta_i \Delta U_{t-i} + \sum_{i=0}^{n} \gamma_i \Delta Y_{t-i} + \lambda_1 U_{t-1} + \lambda_2 Y_{t-1} + \varepsilon_t \qquad \text{(1a)/(2a)}$$

In this equation, β_i and γ_i represent the short-run dynamics of the model, whereas λ_1 and λ_2 stand for the long-run relationship. As such, the null-hypothesis of the model is:

$H_0: \lambda_1 = \lambda_2 = 0$ (there is no long-run relationship/no co-integration)
$H_1: \lambda_1 \neq \lambda_2 \neq 0$

In the *first stage* of the modeling process, a bounds test was conducted for the null hypothesis of no co-integration between the variables. The calculated Wald statistic was compared to the critical value tabulated by Pesaran (1997) and Pesaran et al. (2001). If the test statistic is above the upper critical value, the null hypothesis of no long-run relationship is rejected; if the test statistic is below the lower critical value, the null hypothesis is not rejected. However, if the test statistic is between the two critical bounds, the result is inconclusive. If the order of integration of the variables is known and all variables are *I(1)*—integrated of order one, then the result is based on the upper critical bound. But if all variables are *I(0)*—integrated of order zero, then the result is based on the lower critical bound.

The ARDL technique estimates $(p+1)^k$ number of regressions to obtain the optimal lag length for each variable, where p is the maximum number of lags and k is the number of variables.

In the *second stage,* the ARDL model was estimated with the optimal lag length chosen according to the Akaike Information Criteria (AIC). The restricted version of the above equation was then solved for the long run:

$$U_t = \alpha_0 + \sum_{i=1}^{k} \gamma_i U_{t-i} + \sum_{i=0}^{k} \vartheta_i Y_{t-i} + \varepsilon_t \qquad (1b)/(2b)$$

If there seems to be a long-run relationship, we estimated the ECM, which provides the speed of adjustment back to long-run equilibrium after a short-run shock. The conventional ECM estimates the following equation:

$$\Delta U_t = \alpha_1 + \sum_{i=1}^{l} \delta_i \Delta U_{t-i} + \sum_{i=0}^{l} \omega_i \Delta Y_{t-i} + \rho_1 ECT_{t-1} + \varepsilon_t \qquad (1c)/(2c)$$

In the *last stage*, the goodness of fit of the ARDL models was checked, and diagnostic and stability tests were conducted. The diagnostic tests examine the presence of serial correlation and heteroscedasticity, the functional form, and normality of the errors per model.

Empirical results

Checking the presence of unit root

Although not required when using the ARDL technique, the variables were checked whether they were stationary or not (Alamro and Al-dalaien, 2014). The Augmented Dickey Fuller (ADF)[8] and Phillips-Perron[9] (PP) tests were conducted, which provide the unit root level in the null hypothesis against the stationary level in the alternative hypothesis. The model intercept and trend were used for the unit root test and the lag length was based on the AIC.

The ADF and PP test results proposed to reject the null hypothesis of the presence of unit root (see **Table 1**). This indicates that we accept that the two variables are stationary on first difference, i.e., integrated of order one with intercept only and with intercept and trend.

[8] Dickey and Fuller (1979) and Dickey and Fuller (1981)
[9] Phillips and Perron (1988)

Table 1: Unit root test results

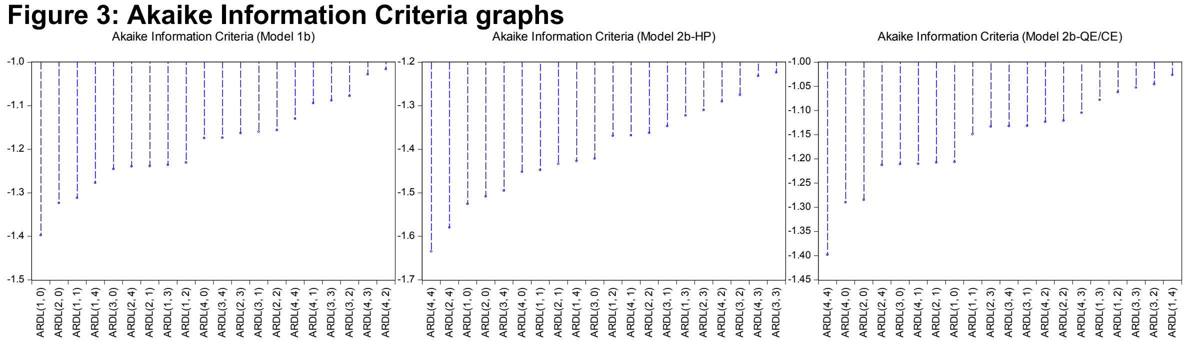
	D(Logumt)	D(Drgdp100)
Intercept only		
ADF-statistic	-4.058	-11.462
p-value	0.004***	0.000***
PP-statistic	-4.01	-10.749
p-value	0.005***	0.000***
Intercept and trend		
ADF-statistic	-4.036	-11.228
p-value	0.020**	0.000***
PP-statistic	-3.951	-10.515
p-value	0.0240**	0.000***

Source: Authors' calculations
**** and ** mean significant at the 1% and 5% significance level, respectively.*

Testing the existence of co-integration

To check the existence of co-integration among the variables, the bounds test, which is a three-step procedure, was implemented. In the *first step*, the lag order was selected based on the AIC criteria because the computation of F-statistics for co-integration is sensitive to the lag length. As shown in **Figure 3**, the growth/difference model is an ARDL (1,0) equation consisting of 1 lag for the dependent variable (unemployment) and 0 lags for the independent variable (output growth), while the gap models are ARDL (4,4) equations consisting of 4 lags for both the dependent and the independent variables.

Figure 3: Akaike Information Criteria graphs



Source: Authors' calculations

In the *second step*, the Wald test was conducted to check for the presence of a long-term relationship (see **Table 2**). Given that the order of integration of all variables is *I(1)*, the null hypothesis of no co-integration is rejected because in all models the F-statistic exceeds the upper critical bound, which implies the existence of a long-term relationship.

Table 2: Co-integration test results			
Wald Test			
Equation	**(1a)**	**(2a)-HP**	**(2a)-CE/QE**
F-statistic	5.695**	3.191*	4.322**
Chi-square	11.390***	6.381**	8.645**

Source: Authors' calculations
**** and ** mean significant at the 1% and 5% significance level, respectively.*

Given that a long-term relationship exists, ARDL estimation occurred in the *third step*. **Table 3a** and **Table 3b** show the empirical results of the ARDL estimation for the long run and short run, respectively. According to the growth/difference model, in the long run, a 1% increase in the real GDP growth rate leads to a 2.3% decrease in the unemployment rate. In the *short run*, a 1% increase in the real GDP growth rate leads to a decrease of 1.9% in the unemployment rate. According to the gap models, in the *long run*, an increase in the real GDP growth rate by 1% leads to a decrease in the unemployment rate by 2.9% (HP) or 2.4% (QE/CE). In the *short run*, an increase in the real GDP growth rate by 1% leads to a decrease in the unemployment rate by 2.1% (HP) or 3.5% (QE/CE). Okun's coefficients in the gap models depend on the decomposition method used, i.e., the HP filter or the Quartic/Cubic equations.

Table 3a: Long-run relationship in difference and gap models					
ARDL Long-run output-unemployment relationship					
Equations	Estimation	T-statistic	Adj. R^2	DW	(Wald) F-statistic
(1b)	$\Delta U_t = -2.3\Delta Y_t$	-2.303**	0.649	1.786	22.289***
(2b)-HP	$\Delta U_t = -2.9\Delta Y_t$	-5.382***	0.564	2.148	36.118***
(2b)-QE/CE	$\Delta U_t = -2.4\Delta Y_t$	-2.020*	0.604	2.383	4.723***

Source: Authors' calculations

Table 3b: Short-run relationship in difference and gap models						
ARDL Short-run output-unemployment relationship						
Equations	ECM(-1)	Estimation	T-statistic	Adj. R^2	DW	(Wald) F-statistic
(1c)	88.4%	$\Delta U_t = -1.9\Delta Y_t$	-1.848*	0.177	1.998	4.714***
(2c)-HP	109.4%	$\Delta U_t - -2.1\Delta Y_t$	-2.040*	0.186	1.951	9.447***
(2c)-QE/CE	133.1%	$\Delta U_t = -3.5\Delta Y_t$	-2.690**	0.261	2.101	31.282***

Source: Authors' calculations

As expected, the error correction term (ECM(-1)) is negative and statistically significant in all models. According to the difference model, about 88.4% of the previous year's disequilibrium in real GDP growth converges back to the long-run equilibrium in the current year. According to the gap models, about 109.4% (HP) or 133.1% (QE/CE) of the previous year's disequilibrium in real GDP growth converges back to the long-run equilibrium in the current year. Overall, the long-run results differ from the short-run results, but both confirm the existence of Okun's relationship in Curaçao, and Okun's coefficients are fairly in line with other studies discussed in section 2. In addition, the ECM coefficients suggest that the adjustment/correction process in Curaçao is quite fast.

An adjusted R-squared of 0.649 and 0.178 for the difference models and an adjusted R-squared of 0.564/0.186 (HP) and 0.604/0.261 (QE/CE) for the gap models imply that, on average, respectively, 64.9%/17.8%, and 56.4%/18.6% and 60.4%/26.1% of the fluctuations in unemployment in the growth/difference models and gap models can be explained by changes in economic growth. Important to note is that in the difference models we observed the impact of changes in real GDP growth on changes in total unemployment, while in the gap models we observed the impact of changes in the cyclical component of real GDP growth (output gap) on changes in the cyclical component of unemployment (unemployment gap).

It is worth mentioning that it does not matter whether the output gap is replaced by the real GDP growth in the gap models; the magnitude and sign of Okun's coefficients remain roughly the same and significant, and the diagnostic test results remain robust. In addition, the adjusted R-squared remains more than half in the long run, but relatively low in the short run, evidence of a negative relationship between output growth and the cyclical component of unemployment. When output grows, cyclical unemployment declines, and vice versa. However, *the explanatory power* of the short-run models (the low magnitude of the adjusted R-squared) suggests a *weak* relationship between output growth and the cyclical component of unemployment in the short run. In other words, output growth does not automatically lead to employment gains in the short run. Given that Curaçao's real output has been stagnant during the period 2013-2015 (i.e., contracting in 2013 and 2014, and registering slight economic growth in 2015), the decline in the unemployment rate during that period could be related to *the structural and/or frictional unemployment* rather than the cyclical unemployment. A stagnation of the economy, therefore, does not necessarily lead to an increase in the unemployment rate as occurred in the past two years for Curaçao.

Testing the goodness of fit of the models

Diagnostic tests were conducted to ensure that all models meet the OLS regression assumptions, i.e., (1) zero autocorrelation, (2) homoscedasticity, (3) normally distributed errors, and (4) a linear model specification is the correct functional form. The Breusch-Godfrey (BG) Serial Correlation LM test (with 4 lags) was used to check the presence of autocorrelation.

To test for homoscedasticity, the models were subjected to the White Test, and the Jarque-Bera (JB) test was used to check normally distributed errors. Furthermore, the Ramsey RESET test was applied to check if the correct functional form of the models is linear (see **Table 4**).

Also, cumulative sum control chart (CUSUM) and cumulative sum control chart squared (CUSUMSQ) plots were drawn to check the stability of the models. **Appendix 3** shows that the plots remain within the 5% critical bounds, suggesting that the models are structurally stable.

Overall, the goodness of fit of the estimated models is viable, the models are significant, and the regression specifications fit well and pass all diagnostic tests.

Table 4: Diagnostic test results									
Checking OLS regression assumptions									
				HP-filter			QE-filter		
Equation	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)	(2a)	(2b)	(2c)
Normally distributed errors									
JB-statistic	1.228	1.152	1.152	0.338	0.439	2.966	0.533	0.277	0.796
P-value	0.541	0.562	0.562	0.844	0.803	0.227	0.766	0.871	0.672
Homoscedasticity									
F-statistic	0.425	0.301	0.335	0.774	0.524	0.555	0.693	0.645	0.622
Obs*R-squared	1.969	0.669	1.164	6.140	3.071	4.034	9.515	7.103	8.056
Scaled explained SS	0.552	0.239	0.354	2.647	1.965	2.386	1.230	1.667	1.005
Zero serial correlation									
DW-statistic	1.998	1.786	2.053	1.951	2.148	2.119	2.101	2.383	2.031
F-Statistic	0.181	0.469	0.306	1.671	0.078	1.152	0.525	0.030	0.629
Obs*R-squared	1.106	2.387	1.770	8.813	0.541	6.624	5.704	0.302	6.206
Linear relationship									
F-statistic	1.362	2.496	1.345	0.283	1.014	0.143	0.196	1.514	2.050
Likelihood ratio	3.567	5.599	3.420	1.013	2.917	0.495	1.051	-	8.690

Source: Authors' calculations

Conclusion

Okun (1962) argues that increasing output by 3% will lead to a 1% decline in the unemployment rate. This paper examines the validity of Okun's law in Curaçao. Curaçao is particularly interesting because in the last three years output has been stagnant (i.e., contracting in 2013 and 2014 and growing only marginally in 2015), while the unemployment rate has been declining—against Okun's relationship. Using ARDL techniques for co-integration with ECM over the period 1987-2015, statistically *significant* short- and long-run relationships were found between output and unemployment in Curaçao. In the gap models, the empirical results remained robust regardless of the de-trending method used.

According to the difference model, Okun's coefficient in the long run is -2.3%, while Okun's coefficient is -1.9% in the short run. This means that in the *long run*, an increase in the real GDP growth rate by 1% leads to a decrease in the unemployment rate by 2.3%. In the *short run*, an increase in the real GDP growth rate by 1% leads to a decrease in the unemployment rate by 1.9%. According to the gap models, Okun's coefficients are -2.9% (HP) or -2.4% (QE/CE) in the long run and -2.1% (HP) or -3.5% (QE/CE) in the short run. In the *long run*, an increase in the real GDP growth rate by 1% leads to a decrease in the unemployment rate by 2.9% (HP) or 2.4% (QE/CE). In the *short run*, an increase in the real GDP growth rate by 1% leads to a decrease in the unemployment rate by 2.1% (HP) or 3.5% (QE/CE).

The speed of adjustment to restore equilibrium in the respective ARDL dynamic models are about 88.4% and 109.4% (HP) or 133.1% (QE/CE) a year; i.e., about 88.4%/109.4%/133.1% of disequilibria from the previous year's shock converges back to the long-run equilibrium in the current year. Okun's coefficients estimated for the Curaçao economy are consistent with existing literature (e.g., Loría and Ramos, 2007, Arshad, 2010, Ting and Ling, 2011, and Javeid, 2005), but the ECM term (speed of adjustment) is relatively high.

Macroeconomic theory suggests that output growth has a *significant* negative relationship with unemployment according to the difference models and a significant negative relationship with the cyclical component of unemployment according to the gap models. In the latter case this means that when the Curaçao economy grows, the *cyclical component* of unemployment declines, and vice versa. However, the relatively low adjusted R-squared of the short-run models, even when the output gap is replaced by the real GDP growth, reveals a *weak* relationship between output growth and the cyclical component of unemployment in the short run. Output growth does not automatically lead to employment gains in the short run. Thus, the contradictory development observed in Curaçao for the period 2013-2015 (i.e., Curaçao's real GDP contracted during 2013-2014 and grew only slightly in 2015, while the actual unemployment rate declined) could be attributed to changes in *structural and/or frictional unemployment* rather than cyclical unemployment.

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Appendices

Appendix 1: Reliability and validity testing

5 Assumptions OLS (Blue estimators):

1) True model is linear in parameters
2) Random sampling
3) Independent variables uncorrelated with disturbance terms } Consistent } Efficient
4) No linear dependence in regressors
5) Homoscedasticity and no autocorrelation

Appendix 2: Phillips curve equation

According to the expectation-augmented Phillips curve, a negative relationship exists between the change of the inflation and unemployment rates in an economy (Blanchard and Illing, 2004). Following this line of thought, the following equation is assumed for Curaçao:

$$U_t = \beta_1 U_{t-1} + \beta_2 INF_t + \varepsilon_t$$

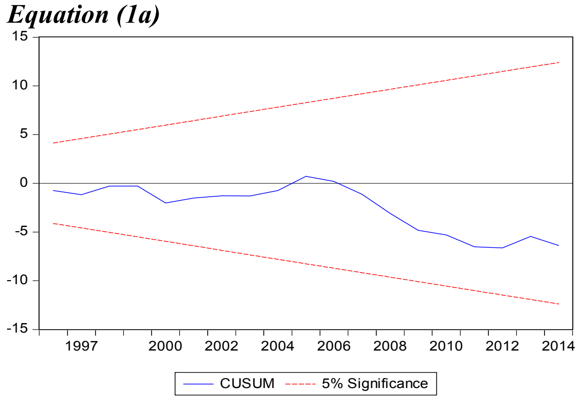
where U_t is the natural logarithm of the actual unemployment rate at time t , U_{t-1} is the natural logarithm of the actual unemployment rate at time $t-1$, INF_t is the natural logarithm of the actual inflation rate at time t , and ε_t is the error term at time t . The most important regression results are illustrated in the table below.

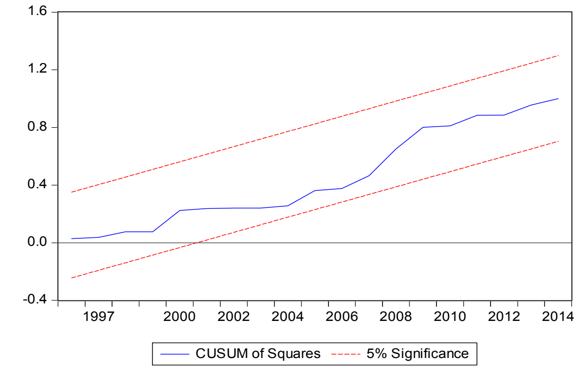
Dependent variable	U_t
Intercept	0.747
	(3.04)***
U_{t-1}	0.733
	(7.954)***
INF_t	-0.074
	(-1.967)*
R-squared	0.75
Adjusted R-squared	0.73
F-statistic	31.702***
Durbin Watson (DW)-statistic	1.74
Number of observations	24

**** and * mean significant at a significance level of 1% and 10%, respectively.*
Note that this equation uses the actual unemployment rate, meaning that the years 1999, 2010, and 2012 are excluded, thus generating a shorter sample of 24 observations compared to the total sample of 27 observations.

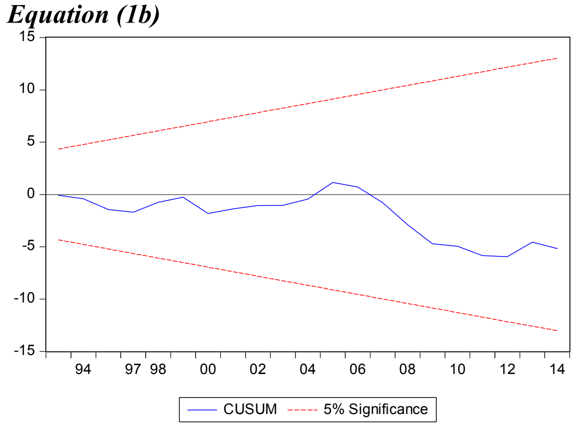
Appendix 3: CUSUM and CUSUMSQ plots of the models

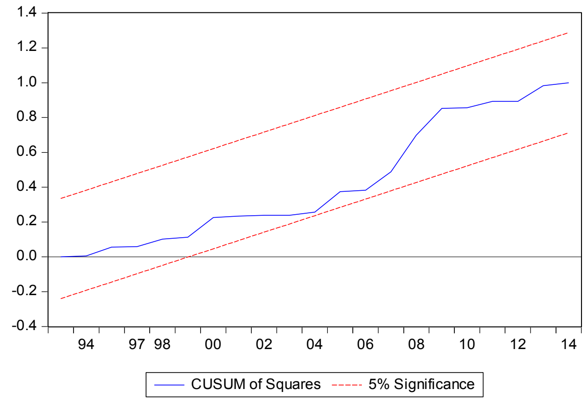
Equation (1a)



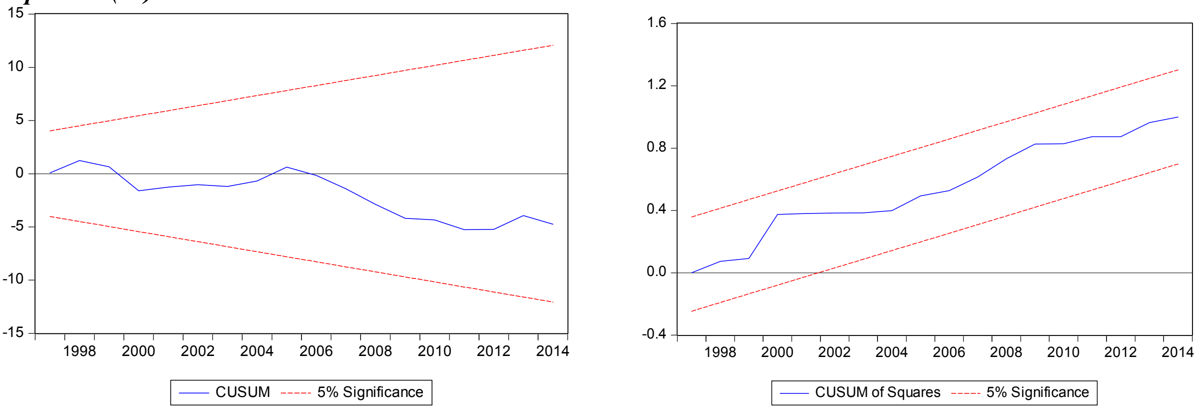


Equation (1b)

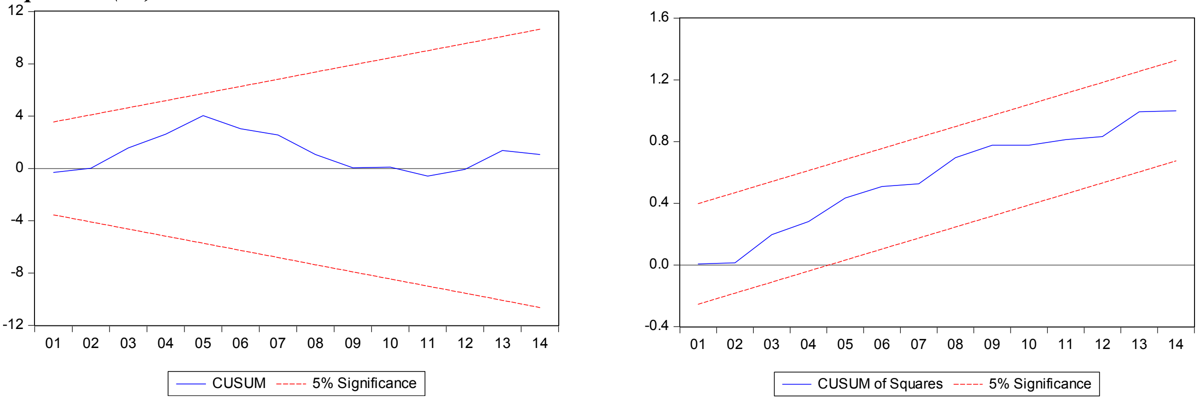




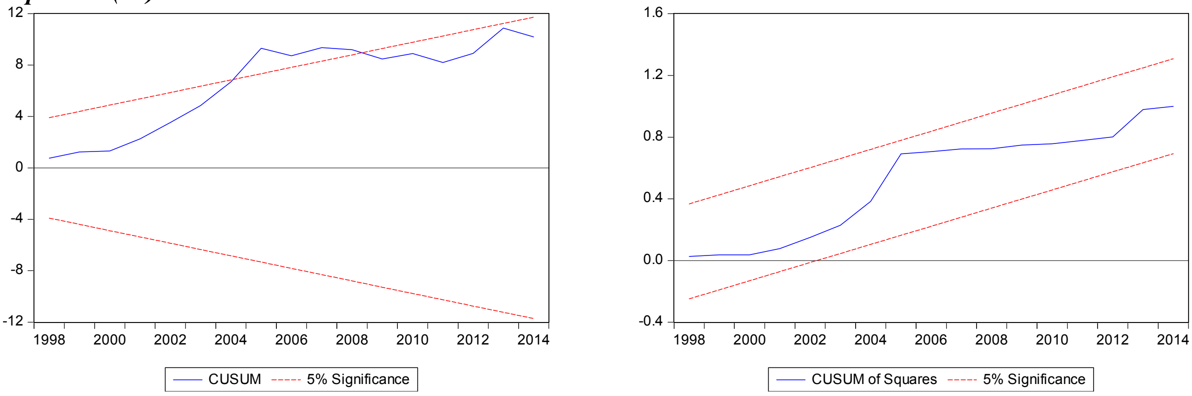
Equation (1c)



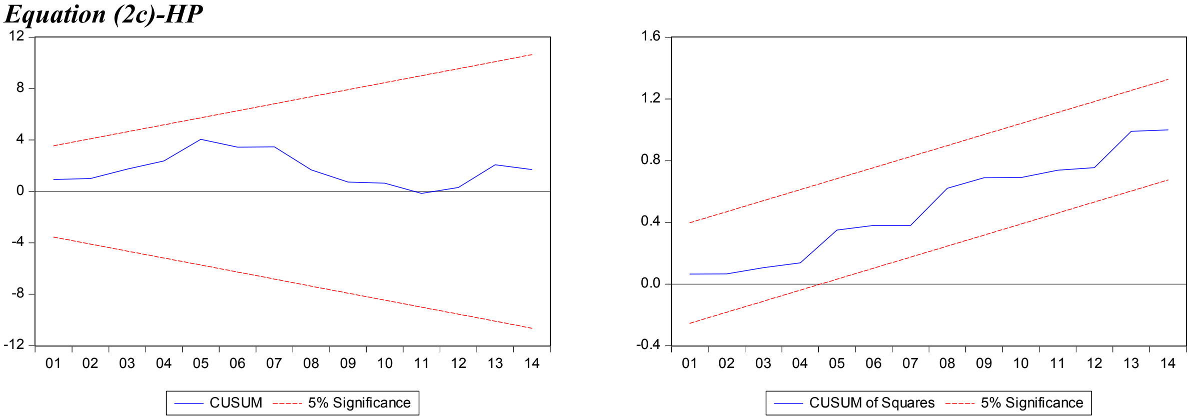
Equation (2a)-HP



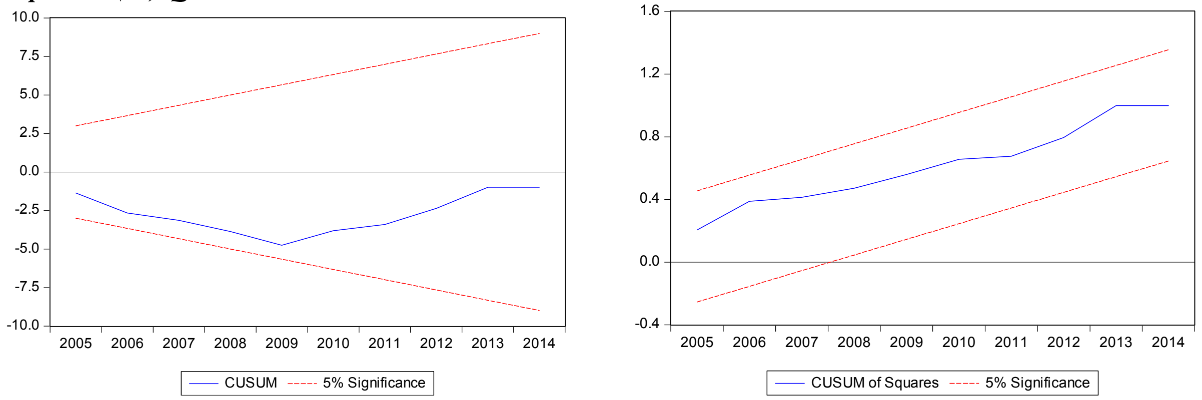
Equation (2b)-HP



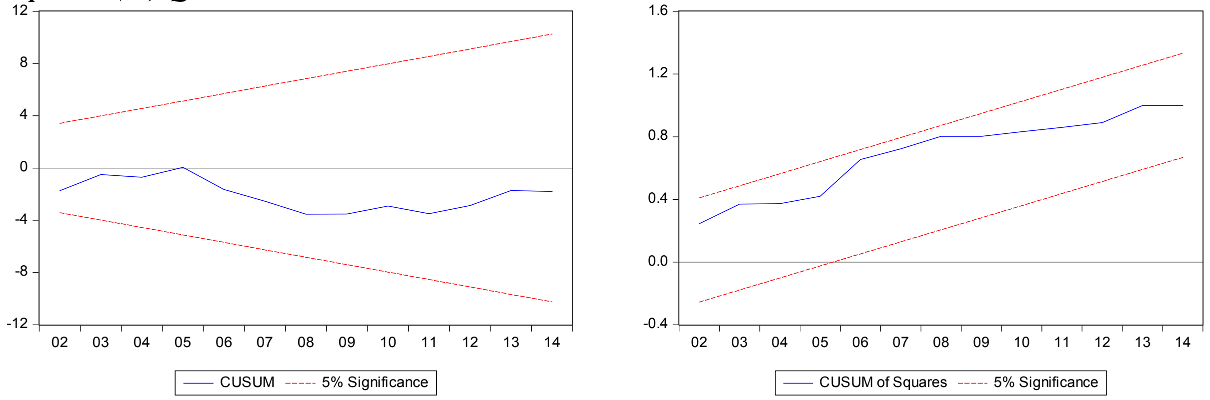
Equation (2c)-HP



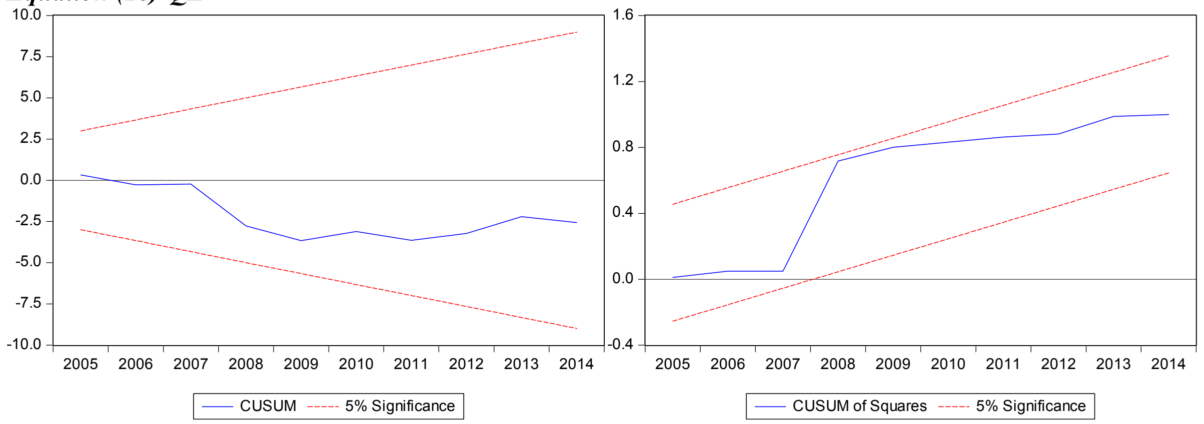
Equation (2a)-QE



Equation (2b)-QE



Equation (2c)-QE



Source: Authors' calculations