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Nektarios A. Michail

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Address
80 Kennedy Avenue
CY-1076 Nicosia, Cyprus

Postal Address
P. O. Box 25529
CY-1395 Nicosia, Cyprus

E-mail
publications@centralbank.gov.cy

Website
http://www.centralbank.gov.cy

Fax
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Examining the stability of Okun's coefficient

Nektarios A. Michail*

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Abstract

The stability of Okun's coefficient in the US from 1949 to 2015 is examined using a GARCH model in order to capture the volatility in the series. Once the volatility is taken into account, rolling estimations suggest that the coefficient for the unemployment rate is very stable across time, irrespective of the specification (gap or growth model) or the length of the window. In addition, the results suggest that short-term shocks were more important to output fluctuations during the 1970s stagflation period while long-term shocks were significant only when data from the recent global financial crisis were incorporated.

Keywords: unemployment, GARCH, volatility, rolling window, Okun's law

JEL Classification: C32, E23, E24

***** Economic Research Department, Central Bank of Cyprus and Department of Commerce, Finance and Shipping, Cyprus University of Technology. Email: nektariosmichail@centralbank.gov.cy. I would like to thank George Georgiou, Marios Polemidiotis, Christos Savva and the participants at the 9th International Conference on Computational and Financial Econometrics (CFE 2015) for their comments and suggestions.

Examining the stability of Okun's coefficient

1. Introduction

According to Okun (1962), a one percentage point change in unemployment is associated with an approximately two to three percent change in real GDP. This observed relationship has been so consistent thus far that it has been dubbed a "law". Indeed, its practicality and simplicity has led scholars like Blinder (1997) to remark that it "closes the loop between [US] real output growth and changes in unemployment with stunning reliability" (p.24).

The relationship is also well-established outside the realm of academia. Pierdzioch et al (2011) find that professional economists' forecasts of changes in the unemployment rate and the growth rate of real output are consistent with Okun's law. In addition, professional economists do not believe in potential asymmetries in Okun's law over the business cycle, but are in favour of the classic linear version. Complementing their results, Ball et al (2015) have also found proof that output and unemployment projections of professional forecasters are consistent with Okun's law, with Guisinger and Sinclair (2015) showing that this relationship is weaker in real-time data. The strength of the relationship is such that Barnes et al (2012) find, using US real-time data, that a positive (negative) error in Okun's law in real time implies that GDP will be later revised to show less (more) growth than initially estimated by the statistical agency.

Over the years, many empirical macroeconomists have tested the robustness of the relationship with almost all consenting that the relationship still exists. For example, Lee (2000) finds that Okun's law is statistically valid for most countries, but the quantitative estimates are far from uniform. In addition, there is mixed evidence of asymmetric behaviour.

More recent studies such as Owyang and Sekhposyan (2012), find that periods of high unemployment are correlated with an increased sensitivity of the unemployment rate to GDP fluctuations, while they find a great degree on instability in the historical estimates of the Okun's coefficient using a rolling window approach. On the other hand, Daly et al (2014) find that the breakdown of Okun's law during the Great Recession can be explained through the recent revisions to US GDP data.

Other studies have also emphasised whether the relationship between unemployment and output is stable. These can be divided into two general groups: the first, consistent with the production theory, suggests that output changes are considered to be a function of changes in unemployment (e.g. Okun ,1962; Lee, 2000; Apergis and Rezitis, 2003), while the second estimates the inverse relationship, i.e. that changes in unemployment are caused by changes in output (see Cuaresma, 2003; Perman and Tavera, 2005; Huang and Lin, 2008, Virén, 2001).[1] Overall, both groups of studies largely confirm that a relationship between output and unemployment exists, but the evidence on the size and asymmetry of the coefficient differs.

Further to the above, a popular strand of the literature, which has been developed in recent years, examines the asymmetry in the relationship between GDP and

[1] As Lee (2000) suggests, the general conclusions arising from both specifications are qualitatively the same. However, it should be noted here that the only distinction when the direction of causality differs regards policy implications/measures. If policymakers believe that changes in unemployment cause changes in output (as originally formulated by Okun (1962) and employed in this paper), then the former will be the focus of policy measures, e.g. through employment boosting policies. If output changes are thought to cause changes in unemployment then increases in output will be the main focus of policy, e.g. through increases in spending or strategies affecting the supply side. Even though the evaluation of such measures is beyond the scope of this paper, it should be emphasised that since the relationship between the two is most likely bi-directional (since both specifications yield qualitatively similar results) the stability of the relationship, as evidenced in this paper, helps in focusing on the performance of policy measures and not on notions of shifts in the relationship.

unemployment. By differentiating between positive and negative differences from cyclical unemployment they study whether this distinction is significant. While overall there is a consensus that an asymmetry exists, conclusions reached are often contradictory. For example, using regime-switching methodology, Holmes and Silverstone (2006), find that the notion of jobless recoveries may be exaggerated. On the other hand, Valadkhani and Smyth (2015), using a similar methodology, find that there is a regime switch in the US after the Great Moderation period (post-1984), which suggests that jobless recoveries are not a new phenomenon.

As such, even though the relationship between output and the unemployment rate is more than evident in the literature, the stability of this relationship and the subsequent changes in magnitude have not yet been clearly examined. Could the changes in the magnitude of Okun's coefficient across studies be attributed, at least to some extent, to changes in the volatility of the series? Furthermore, is the asymmetry of the relationship stable across time, or does it also record fluctuations?

This paper addresses these issues and contributes to this large literature in the following ways: first, the results from a rolling GARCH (1,1) model show that Okun's coefficient is very stable across time, irrespective of the length of the window. Compared to simple OLS rolling regressions, GARCH models always have lower standard deviation of the coefficient value. As such, it appears that taking into account the effects of volatility does help in presenting a more concrete image regarding the stability of Okun's coefficient.

Second, past values of the variance (i.e. long-run effects) appear to be significant only when the recent data from the global financial crisis are incorporated, suggesting both that breaks in the relationship during that period can be explained through the GARCH term and that the global financial crisis has also increased the overall volatility of the series. Third, while an asymmetry between the effects of positive and negative unemployment exists, this is not a stable relationship as the magnitude changes significantly over time. Overall, the findings suggest that professional forecasters were justified in using just the linear coefficient of Okun's regression.

2. Methodology and Data

In contrast to the usual estimation of the Okun's law using simple OLS regression, this paper employs a GARCH(1,1) model in order to capture the effect of volatility in the series. Models in which volatility is taken into account were first introduced by Engle (1982), who developed a model describing a new class of stochastic processes called Autoregressive Conditional Heteroscedasticity (ARCH). These are zero mean, serially uncorrelated processes with non-constant variances conditional on the past, but constant unconditional variances. For such processes, the recent past gives information about the one-period forecast variance.

ARCH specifications have been generalized by Bollerslev (1986, 1987) to allow for past conditional variances in the current conditional variance equation, proposing what is known as the Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model. A basic GARCH model consists of a mean equation and a conditional variance equation. The advantage of this approach is that it models changes in output through changes in the unemployment rate, as does the basic Okun's law equation, and also allows for time-varying volatility.

The relationship (or trade-off as it has been commonly dubbed) between unemployment and output can be examined through two alternative specifications: a growth model and a gap model (Lee, 2000). Empirically, we expect that there should be no major differences between the two. The only difference which can be perhaps be pointed out is the fact that to construct the gap model one has to employ filtering techniques (most commonly the Hodrick and Prescott (1997) filter), which can in some instances create business cycle dynamics which are non-existent in the original series (Cogley and Nason, 1995).

However, since Staiger et al (2001) have shown that the filtered rate of unemployment has the properties of time-varying NAIRU, this approach has been utilised by many studies in computing cyclical components of employment and output (see inter alia Lee, 2000; Cuaresma, 2003; Valadkhani and Smyth, 2015). As such, the gap model is presented as the main workhorse for this paper, while a growth version is employed for robustness purposes.

In Section 1, there is mention of two groups of research being created, depending on the view of causality between output and unemployment. In this paper, output is viewed as being a function of unemployment, just like the original Okun's version. Given that this view is consistent with production theory, the same approach is used in the estimation.[2]

Formally, the GARCH (*p*,*q*) model can be formulated through a mean equation:

$$Y_t = a_0 + a_1 U_t + \varepsilon_t \tag{1}$$

where p and q are the orders of ARCH and GARCH terms respectively, Y_t signifies the deviation of output from its cyclical component, U_t is the unemployment rate deviation

[2] See footnote 1, p.3 for more details on the policy issues regarding the difference in specification.

from its cyclical component and ε_t is the error term, which follows evolves according to the following process:

$$\varepsilon_t \mid \Omega_t \sim N(0, h_t), h_t = \beta_0 + \sum_{k=1}^{q} \beta_k \varepsilon_{t-k}^2 + \sum_{j=1}^{p} \gamma_k h_{t-j} \tag{2}$$

In equation (2), ε_{t-k}^2 represent past squared values of the errors which can be interpreted as short-term shocks to the error variance and h_{t-j} represent past values of the error variance (interpreted as long-run shocks to the error variance). Testing for autocorrelation revealed that no such relationship exists and thus we have not included any past lags of output in the mean equation.[3] In addition, we use $p = 1$ and $q = 1$ both for consistency with the literature on GARCH modelling and because these provide the best fit for the models.

Data for the estimation are obtained from the FRED database. Seasonally adjusted real GDP (code: GDPC1) and civilian unemployment rate (code: UNRATE) data were obtained at a quarterly frequency from 1949:1 to 2015:2. Cyclical output and unemployment series were estimated using the Hodrick-Prescott filter using data for the entire period. To compare Okun's coefficients as well as changes in volatility over time, an 80-quarter (or 20-year) window was constructed, from which recursive estimates are presented.

Given that the sample employed can perhaps be considered as too small for GARCH models to yield precise estimates, we also employ the monthly industrial production index (code: INDPRO, 1949M1-2015M6) as a proxy for GDP growth, together with the unemployment rate for the same period and frequency. Through this, it is possible

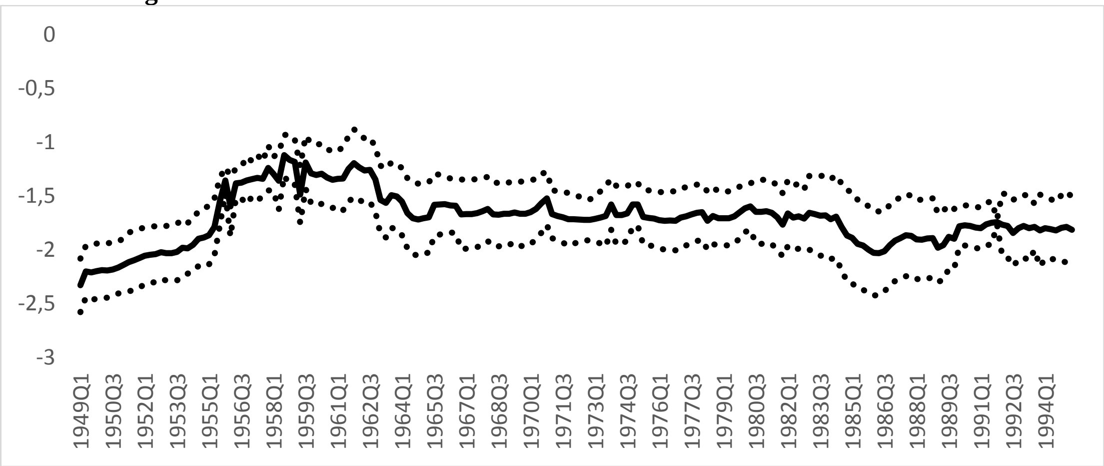
[3] Autocorrelation test results are available upon request.

to increase the sample size above the 500-observation threshold which Hwang and Pereira (2006) propose for the elimination of biases and convergence errors in GARCH models. The results, as presented in the following Sections, are qualitatively the same across different window sizes.

3. Results

This section provides the results of the empirical estimation for the Okun's law coefficients across time. Figure 1 presents Okun's coefficient in a GARCH(1,1) rolling regression with a 80-quarter (20-year) window using the gap model, with the horizontal axis dates referring to the starting point of the window. Okun's coefficient is significant at all points in time, as the dotted 95% confidence intervals suggest, and appears to be rather stable across the estimation periods. In fact, although the OLS coefficient is not reported here for compactness purposes, the coefficient using the GARCH model has much less standard deviation. A comparison of the variability of the estimated coefficient values of GARCH models and their OLS counterpart is found in Table 1.[4]

Figure 1 – Okun's coefficient. Dashed lines are the 95% confidence intervals

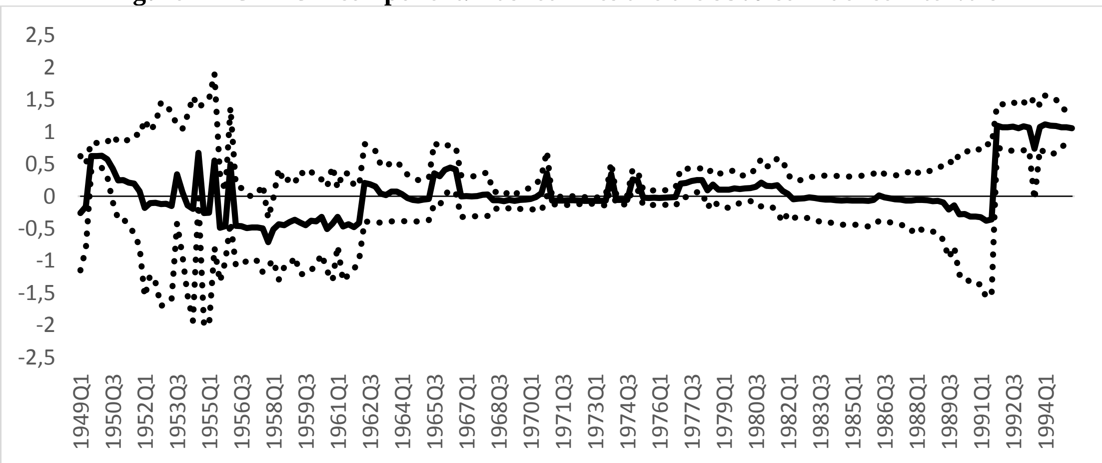


[4] Results of the OLS specification are available upon request.

Figures 2 and 3 present the GARCH and ARCH terms respectively. As can be observed, while the ARCH term is statistically significant across most specifications (and especially in the stagflation period of the 1970s), the GARCH term is significant only after the incorporation of data from the recent global financial crisis. This suggests that long-term shocks (i.e. the GARCH term) became much more important in explaining contemporaneous volatility in the recent years. In contrast, short-run shocks (i.e. the ARCH term) were more important for output volatility in the past and have been declining since the late 1970s.

These results can shed light on both the pass-through of oil shocks during the 1970s through the ARCH term, as well as the persistence of uncertainty in output during the global financial crisis through the prominence of the GARCH term in the recent periods. As such, we may conclude that GARCH models can correctly capture the effects of adverse shocks and of uncertainty persistence in the economy.

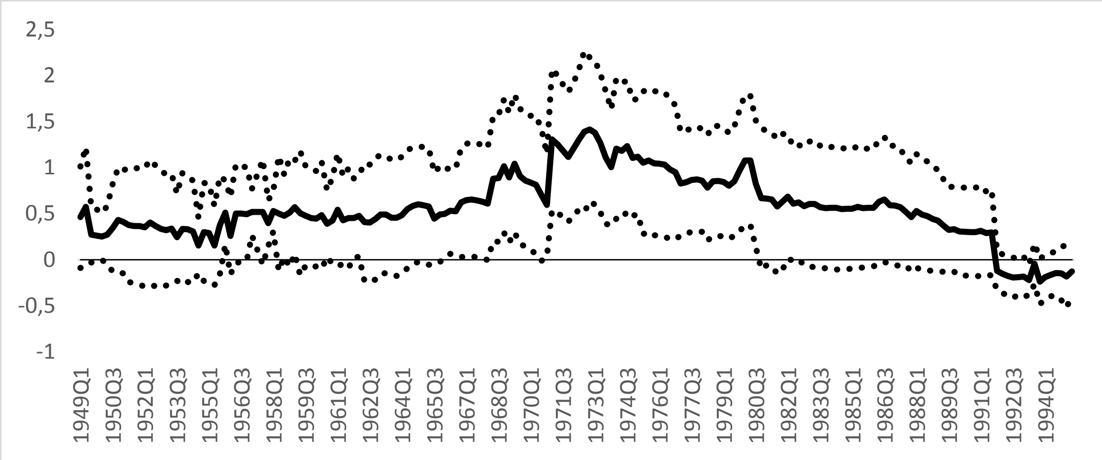
Figure 2 – GARCH component. Dashed lines are the 95% confidence intervals



Given that many researchers have suggested that there exists a great deal of asymmetry in the estimates of the Okun's coefficient, we also distinguish between positive and negative unemployment using the Holmes and Silverstone (2006) and Valadkhani and

Smyth (2015) notion, which distinguishes between positive and negative differences from cyclical unemployment. The results from the specification are found in Figure 4.

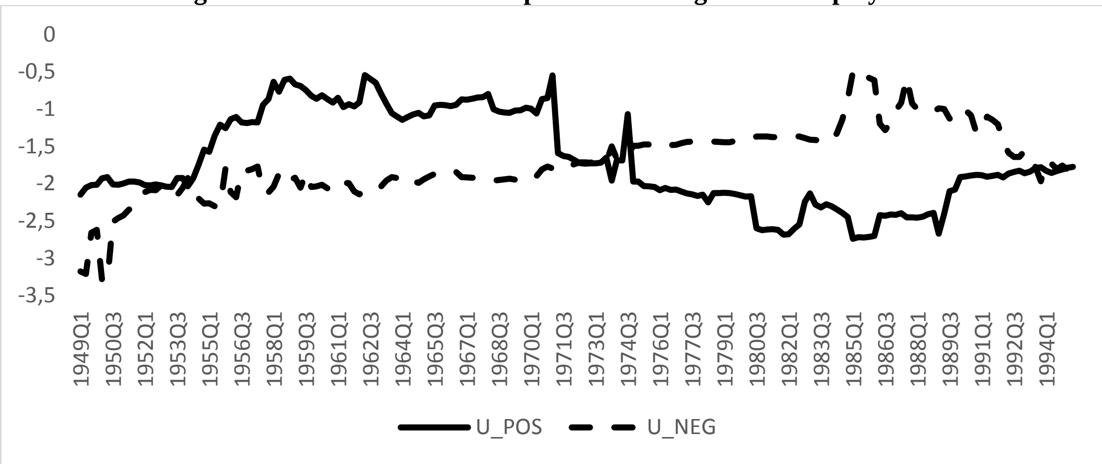
Figure 3 – ARCH component. Dashed lines are the 95% confidence intervals



Interestingly, the magnitude of the effects is not stable over time, with output registering higher sensitivity to positive unemployment (i.e. the unemployment rate is greater than cyclical unemployment such as in downturns) until the samples ending in the early 1990s. From that point onwards, negative unemployment (i.e. the unemployment rate is less than cyclical unemployment such as in upswings) had a greater effect on output. However, it appears that this phase also reached its end as in the last few samples positive unemployment appears to have slowly regained its strength.

The main conclusion to be derived from Figure 4 is that while asymmetric effects of unemployment on output exist, these are not constant through time. On the contrary, Okun's coefficient is much more stable and perhaps for this reason much more reliable than the asymmetric effects estimates. This provides support for the use of the linear Okun's coefficient by professional economists as described by Pierdzioch et al (2011)

Figure 4 – Distinction between positive and negative unemployment



The findings suggest that employing a model specification accounting for the volatility of the series can assist greatly in correctly specifying the magnitude of the coefficient. In addition, it appears that perhaps the changes in the relationship during the global financial crisis and the great degree of variability found in some studies (see Owyang and Sekhposyan, 2012), can be explained by the long-run volatility term. Thus, it appears that the relationship between the two variables does not change over time; instead, it is volatility which is the driver of the higher coefficient standard deviation in OLS estimations.

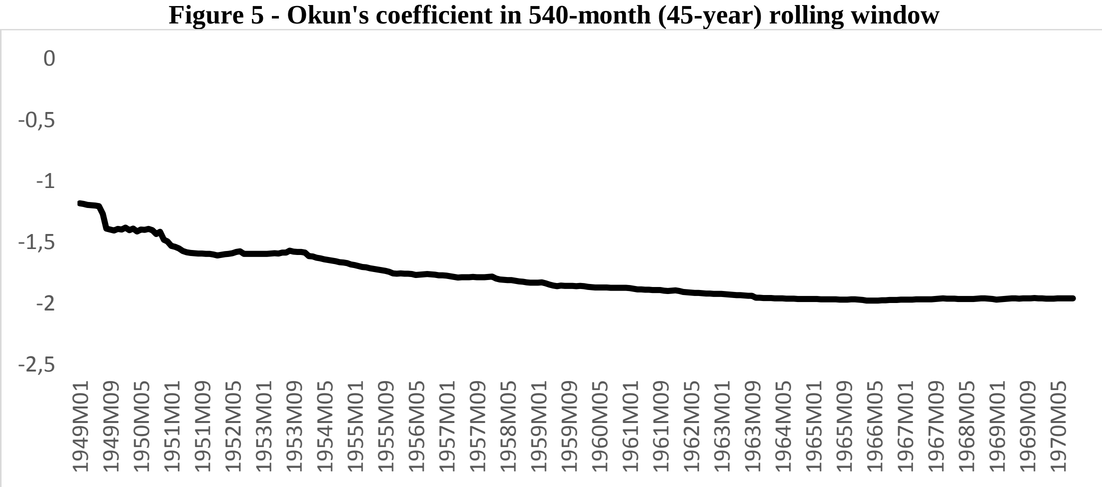
Another important implication which arises from the results of this section is that the perception of jobless recoveries (a theme which has gained notoriety during the global financial crisis) may have indeed been exaggerated as Holmes and Silverstone (2006) also find. Given that the Okun's coefficient has been relatively stable around two (and subsequently the reverse Okun's coefficient around 0,5), real GDP growth unrelated with a reduction in unemployment appears to be inconsistent with the results of this section. This is further supported by the fact that, according to FRED data, the unemployment rate has followed the same declining course during the global financial crisis as in previous recessions.[5] Thus, while there may be some lagging in the relation of changes unemployment rate (which is beyond the scope of this paper as well as the Okun's law in general) to changes in real GDP, there appears to be no strong evidence to support the hypothesis of jobless recoveries.

4. Robustness Checks

Since it can be argued that the sample size of the rolling windows can perhaps be too small for the GARCH estimates to be precise, this section re-estimates the models in the previous one, using the monthly industrial production index in place of real GDP. To exceed the 500-observation threshold of Hwang and Pereira (2006) a 45-year (or 540-observation) window is employed.

Figure 5 presents the results from this longer window specification. Okun's coefficient is found to be very close to two (as in section 3) and in addition it also has the lowest standard deviation of all gap versions (Table 1).

Figure 5 - Okun's coefficient in 540-month (45-year) rolling window



Figures 6 and 7, report the changes in the GARCH and ARCH coefficient estimates through time in the same specification. Again, when data points from the global

[5] See https://fredblog.stlouisfed.org/2014/10/how-fast-has-the-unemployment-rate-declined/ for a discussion.

financial crisis are incorporated into the estimation windows, the ARCH term is reduced (even though it is still significant) and the GARCH term increases, noting the significant change in the volatility of the series.

Figure 6 - GARCH component. Dashed lines indicate the 95% confidence intervals

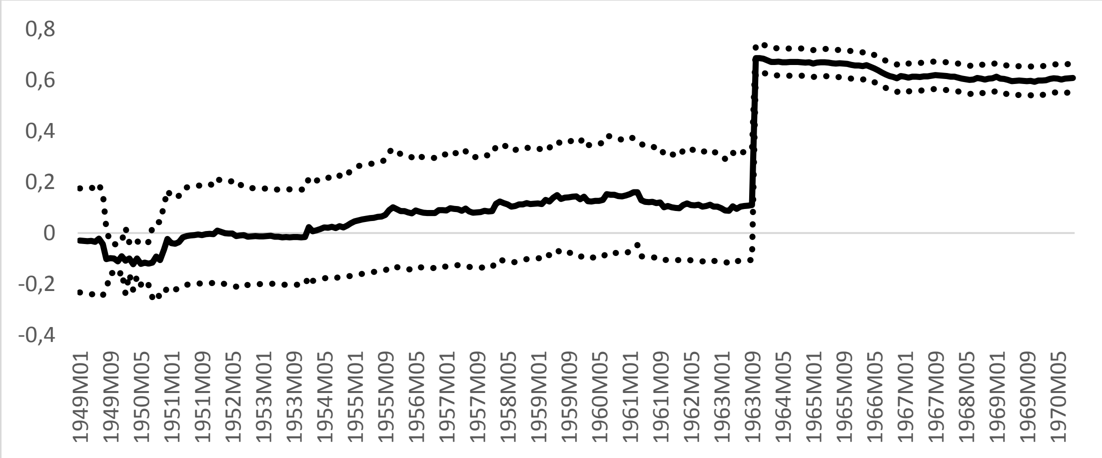
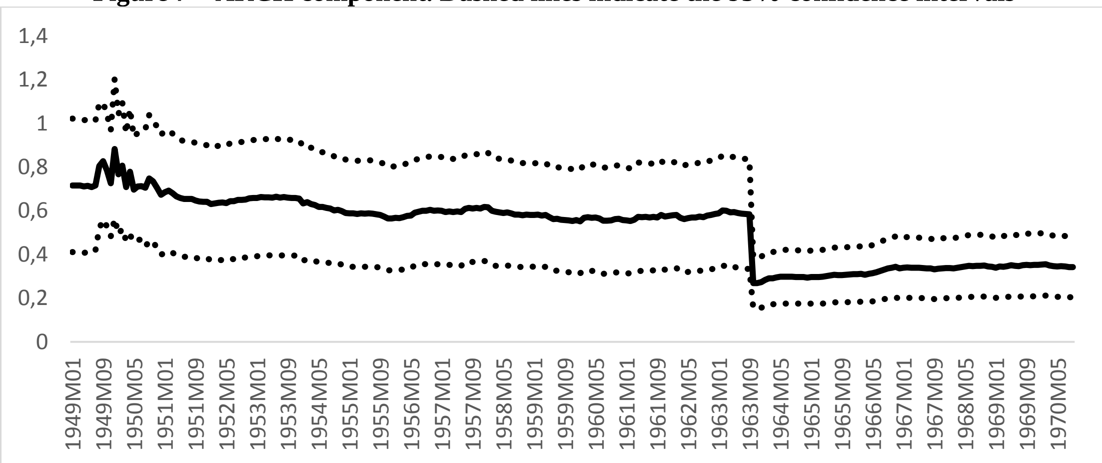


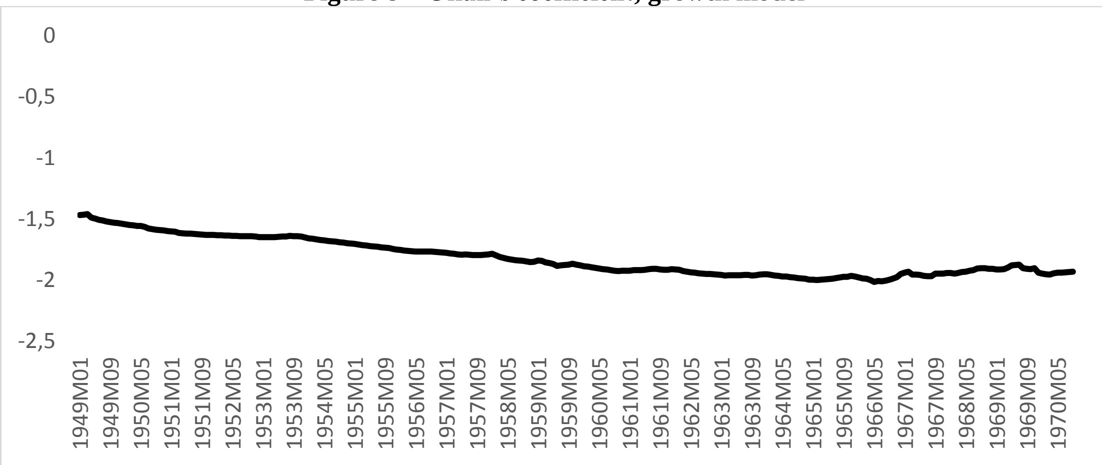
Figure 7 – ARCH component. Dashed lines indicate the 95% confidence intervals



The final test of robustness is conducted through the growth version of Okun's law. As stated in Section 2, criticism of the gap model can be placed on the relative imprecision of the cyclical unemployment and output estimates through the HP filter since they are highly dependent on the start- and end-year. In addition, since the growth model is much more useful in real-time applications and it can perhaps be considered as more intuitive, it is used to further test the results of the previous Section. As such, the Y_t and U_t deviations from their cyclical components in equation (1) are replaced with quarterly growth rates in the case of output, and first differences in the case of the unemployment rate.

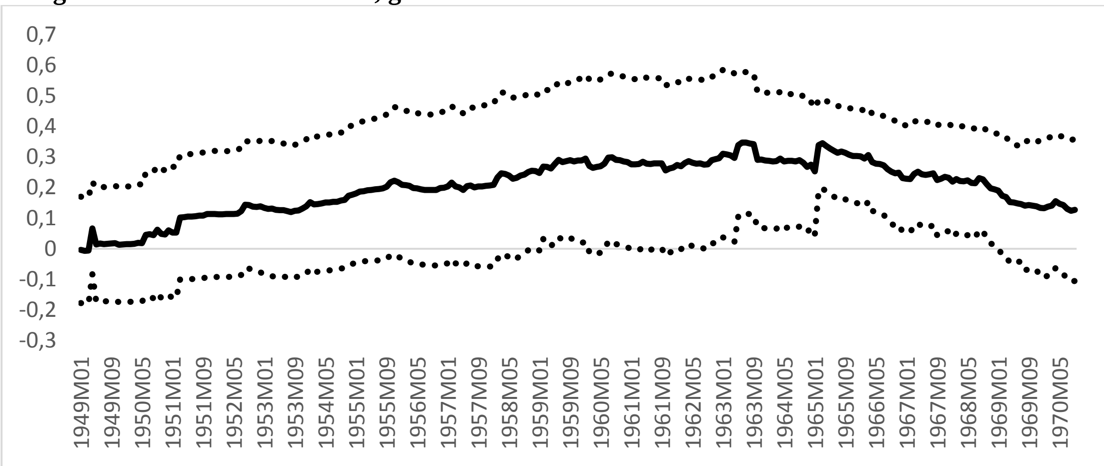
Figure 9 presents the Okun's coefficient of the growth model using a 540-observation window, and, perhaps surprisingly, it appears that the standard deviation of this estimate is much lower than not only its OLS counterpart but all other GARCH models based on the gap version (see Table 1). As the coefficient from the estimation is very close to two in most windows, the argument in favour of the stability of Okun's law through time is further solidified.

Figure 8 – Okun's coefficient, growth model



Figures 10 and 11 show the evolution of ARCH and GARCH terms over time using the growth model. As in Figures 7 and 8, the rise in the significance of the GARCH coefficient is observed after the 1962-2007 window where the data from the global financial crisis are incorporated. Subsequently, after the 1969M1-2013M12 period the term is once again insignificant in the estimates. The opposite holds for the ARCH term, which is significant throughout the entire period, with its values reducing in magnitude during the windows in which the GARCH term is statistically different from zero.

Figure 9 – GARCH coefficient, growth model. Dashed lines are the 95% confidence intervals



Overall, the results of this Section support and make the evidence presented in the previous one more robust through alternative specifications. As such, a safe conclusion would be that while the Okun's coefficient can experience some volatility, it has nevertheless been very stable for the US in the past 65 years, once we take into account the volatility of the series through a GARCH model.

Figure 10 – ARCH coefficient, growth model. Dashed lines are the 95% confidence intervals

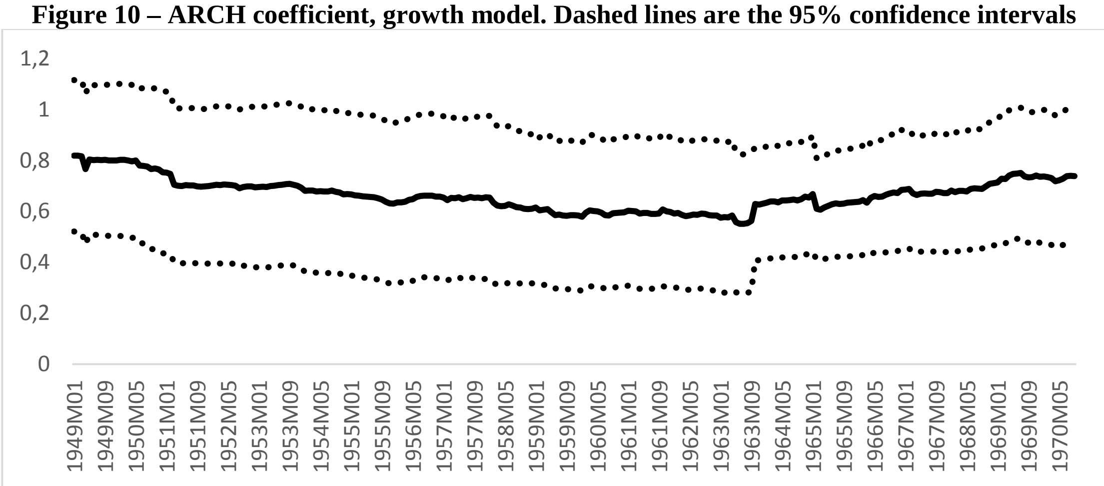


Table 1 - Comparison of the standard deviation of coefficient estimates

	OLS	GARCH
Quarterly		
80-observations (20-year)	0.30	**0.24**
Monthly		
240 observations (20-year)	0.84	**0.40**
540 observations (45-year)	0.44	**0.19**
540 observations (45-year) using the growth model	0.38	**0.15**

Conclusions

This paper has presented evidence that, once the volatility of the series is taken into consideration, the Okun's coefficient has remained very close to its originally specified value of two even though it has mildly oscillated during the 1949-2015 period. The findings suggest that the relationship between the two variables does not change over time; instead, it is volatility which is the driver of higher coefficient standard deviation in simple OLS estimations.

In addition, while asymmetric effects have been found in the estimates, these are not very stable since the magnitude of positive and negative unemployment fluctuates greatly over time. As such, the use of the linear Okun's coefficient for forecasting rather than the estimation of asymmetric effects is more than justified. Finally, it appears that the global financial crisis has increased the effects of long-run shocks on output volatility, as measured by the GARCH term, while the ARCH term was more significant in the stagflation years, where short-term shocks dominated GDP volatility.

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