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# Is there an asymmetric response in unemployment rate to changes in output? A hidden cointegration approach

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# Είναι η αντίδραση της ανεργίας στις μεταβολές του ΑΕΠ μη συμμετρική? Μια προσέγγιση κεκαλυμμένης συν-ολοκλήρωσης

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**ΠΕΡΙΛΗΨΗ**

Στο συγκεκριμένο άρθρο ερευνάται η σχέση μεταξύ της ανεργίας και του ΑΕΠ σε μια σειρά από επιλεγμένες χώρες –Αυστραλία, Καναδάς, Γερμανία, Ελλάδα, Ιαπωνία και Ηνωμένες Πολιτείες Αμερικής– για μια εκτεταμένη χρονική περίοδο. Τα τριμηνιαία στοιχεία που χρησιμοποιούνται τόσο για την ανεργία όσο και για το ΑΕΠ εκτείνονται χρονικά από τη δεκαετία του 1960 (με εξαίρεση την Ελλάδα) έως το 2014. Σκοπός της εργασίας αυτής είναι η διερεύνηση της συμμετρικής ή μη συμμετρικής αντίδρασης της ανεργίας στις μεταβολές του ΑΕΠ. Για το λόγο αυτό χρησιμοποιείται η οικονομετρική μέθοδος της κεκαλυμμένης συν-ολοκλήρωσης (Granger-Yoon 2002, hidden co-integration approach). Η μέθοδος προϋποθέτει τον εκ των προτέρων (*ex ante*) διαχωρισμό των χρονολογικών σειρών, της ανεργίας και του ΑΕΠ, σε θετικά και αρνητικά στοιχεία αντίστοιχα. Η ύπαρξη μιας μη συμμετρικής συμπεριφοράς της μεταβλητής της ανεργίας είναι κρίσιμη για την εκτίμηση της περαιτέρω πορείας της, ειδικά κατά την ανάκαμψη της οικονομίας, μιας και συνδέεται άμεσα με την πιθανή αναγκαιότητα εφαρμογής ενεργητικών πολιτικών στις αντίστοιχες αγορές εργασίας. Με βάση τα εμπειρικά αποτελέσματα διαπιστώνουμε ότι στις τέσσερεις από τις έξι εξεταζόμενες χώρες –συμπεριλαμβανομένης και της Ελλάδας– η ανεργία αντιδρά ασύμμετρα στις μεταβολές του ΑΕΠ.

CONTENTS

## ABSTRACT

In this paper we investigate the relationship between unemployment and output in selected countries -Australia, Canada, Germany, Greece, Japan, and the Unites States- for a prolonged period of time. We use quarterly data for unemployment and output, spanning the time period from the 1960s (with the exception of Greece) to 2014. Our aim is to investigate whether unemployment is characterized by an asymmetric behavior with respect to changes in output. In order to do that, we employ the Granger-Yoon 2002 hidden cointegration approach which ex ante decomposes the aggregate output and unemployment variables in positive and negative values. Assessing the potential existence of asymmetry in the response of unemployment to changes in output is essential for the evolution of unemployment following the rebound in output after crises and, hence, the potential need for the implementation of active labour market policies. Our results indicate that in four out of six of the investigated countries –including Greece– the unemployment rate responds asymmetrically to changes in output.



**Keywords:** Unemployment and output relationship, hidden co-integration, crouching error correction model.
**JEL Classification:** E32, C24.

## 1. Introduction

One of the perpetual macroeconomic questions in the modern economic literature is the existence of a long run relationship, symmetric or asymmetric, between unemployment and GDP growth in an economy. In the absence of an integrated theory that connects unemployment to economic growth, Okun's law became a rule of thumb for policy makers and macroeconomic forecasters justifying a negative connection between these two variables. This law was intuitively appealing, as it was natural to expect that unemployment falls when the economy expands and vice versa. However, late experience after the most recent economic crises in a number of economies pointed to a potential non-linear response of unemployment to changes in output. Empirical evidence was called upon to resolve this issue.

Against this background, the aim and the motivation of this paper is to provide some additional evidence on this important issue, in particular in the aftermath of the Great Recession. To that end, we examine the possible asymmetric link between unemployment and output growth in five main economies, i.e. Australia, Canada, Germany, Japan, and the United States, for a prolonged period of time (from the 1960s to 2014), including Greece, which is currently struggling to exit from the turmoil of the most recent deep economic recession.

The main contribution of the present paper lies in the application of a novel econometric approach, known as the "hidden co-integration" (HC) approach, in order to investigate such non-linearities, in other words, asymmetries in the relationship between unemployment and output growth. We employ a symmetric/asymmetric Error Correction (EC) approach, developed by Granger and Yoon (2002) which, in its dynamic representation, leads to the Crouching Error Correction Model (CECM). Our empirical findings can be summarised as follows: in four out of six of the investigated countries we find clear evidence of existing asymmetries in the unemployment rate response to changes in output. This result reinforces the evidence provided in the relevant international literature, according to which non-linearities constitute a significant characteristic of this relationship. Additionally, it validates the usefulness of the hidden cointegration approach as an econometric tool towards the disclosure of such aim.

The paper is organized as follows. In Section 2, we briefly review the literature on the existence of a symmetric or asymmetric link between unemployment and changes in output, depending on the business cycle regime. In section 3, we present and analyse the hidden co-

integration methodology and the derived alternative Crouching Error Correction Models together with the advantages of their implementation. In section 4, we describe our data and present the empirical results. In the final section, we provide a final discussion of the obtained results and conclude.

## 2. Literature review

Following the notion that unemployment responses to output shocks need not be symmetric and might depend on the state of the business cycle, empirical evidence is called upon to resolve the issue of potential asymmetry.[1] All related applications connect the issue of investigating asymmetry with the validity of Okun's law and in most cases they refer to the USA or groups of OECD and/or advanced economies.

Half a century ago, the American economist Arthur Okun from Yale University was appointed by the President's Council of Economic Advisers to investigate the relationship between unemployment and economic growth. The ultimate purpose of the research project was to estimate the potential gains in real Gross National Product stemming from unemployment reduction (Tobin, 2010). The results reported in Okun's seminal paper (Okun, 1962) shaped what is now widely known as *Okun's Law,* which in its simplest interpretation it states that there is a negative relationship between changes in real GDP and unemployment in the long run.

Okun's law derived its value added from its intuitive appeal as it is natural to expect that unemployment falls when the economy expands and vice versa. Another issue that added to the attractiveness of the Okun's law was the absence of an integrated theory that connects unemployment to economic growth. In other words, Okun succeeded in filling a gap in the economic literature by offering a rule of thumb for policy makers and macroeconomic forecasters who have a special interest in the interactions between economic growth and employment.

With time, the employment-growth nexus received empirical support from several other studies which updated Okun's original work in many directions (e.g. Prachowny, 1993; Erber, 1994; Baker and Schmitt, 1999; and Ball et al, 2013). This added to the robustness of the Okun's

[1] Note that the above stated notion differs from the question of varying Okun coefficients over time or across different countries.

predictions and led many economists to accept Okun's law as a useful proxy in macroeconomics (e.g. Blanchard and Fischer, 1989, Abel et al, 2008, etc).

Economists' belief in Okun's law was shaken after the two jobless recoveries of the US economy in 1991 and in 2001 and the more recent jobless recovery experienced by both the US and the European economy. In each of these three recoveries, the length of time it took the unemployment rate to begin falling after each recovery's start was incompatible with Okun's predictions. The apparent breakdown in Okun's law raised many questions: Does Okun's rule of thumb work better during recessions than recoveries? Is it that unemployment simply response asymmetrically to GDP changes or there are deeper reasons that explain the phenomenon of unemployment hysteresis? For example, there may be a tendency for the magnitude of unemployment changes to depend on the sign of output changes with unemployment behaving as a lagging variable during recoveries. Or, it may be that (temporary) negative output shocks during recessions have permanent effects on unemployment implying that unemployment persists around a higher equilibrium level when economic activity picks up again. While there is a clear distinction between the issue of asymmetric response and the hysteresis hypothesis, the mechanics behind these two theories are not mutually exclusive. From this perspective, a growing body of the literature seeks to reassess the empirical relevance of the employment-growth nexus by linking asymmetric responses of unemployment to GDP with the predictions of the hysteresis hypothesis.

The empirical evidence in favor of the existence of asymmetric characteristics in the relationship between unemployment rate and output during recessions and expansions is quite significant for the USA. The related applications refer to various periods of time, mostly use quarterly data and are based on different methodologies to establish potential asymmetries in the unemployment response to changes in output. Already as early as during the 70s, Gilbert (1973) provided such evidence by distinguishing between equations including positive and negative output changes (and output gap changes) and concluded that Okun's law seems to be valid during economic recession, but not during economic expansions. In his thesis, Courtney (1991) argues that the Okun's law coefficient for the USA demonstrates systematic, not random, fluctuations which are dependent on the state of the business cycle and, indeed, estimates statistically significant differences in the Okun's law coefficient in growth cycle expansions and contractions (as well as in cycle through and peak periods). Among the related contributions in the 90s is the work of Palley (1993) who confirms the existence of asymmetric business cycle effects and shows that unemployment responds more strongly to negative output

growth. He bases his evidence on the detection of a significant dummy variable, which is included in order to reformulate Okun's law to take into account for the asymmetric nature of the US business cycle.

In linking the asymmetry feature to the hysteresis hypothesis, Schorderet (2001) reexamines the link between output and unemployment under the premise of the assumption that linearity is incompatible with the hysteresis hypothesis. He shows that the output series can account for the unemployment levels provided that the asymmetric response of unemployment based on the sign of the output growth is taken into account. He detects discrepancy in the Okun's coefficients, depending on the sign of output growth, hence, providing evidence to the hysteresis hypothesis. In the hidden cointegration application by Granger and Yoon (2002), basically providing the motivation and empirical technique for the present paper, the authors show (using monthly data) that there is an asymmetric response in unemployment to increases in output and also connect this finding of asymmetric behavior with the hysteresis hypothesis, implying that when output returns to a level where it was before the shock, unemployment fails to return to its original level.

Cuaresma (2003) formulates a business cycle regime-dependent specification (via the inclusion and estimation of a threshold parameter) of Okun's law to test the non-linearity hypothesis and finds that the nonlinear specification is highly significant when tested against the linear alternative. The derived implication is that the contemporaneous effect of growth on unemployment is asymmetric and significantly higher in recessions than in expansions, whereby shocks to unemployment tend to be more persistent in the expansionary regime. Silvapulle et al. (2004), by applying an asymmetric dynamic model, provide support to the proposition that the output-unemployment relationship as represented by Okun's law is asymmetric. They show that the short-run effects of positive cyclical output on cyclical unemployment are quantitatively different from those of negative ones, the evidence being consistent with the proposition that cyclical unemployment is more sensitive to negative than to positive cyclical output. Holmes and Silverstone (2005) address the asymmetry issue via a Markov switching methodology, by estimating two Okun coefficients for each of the two regimes, expansionary and recessionary, depending on whether cyclical output is above or below trend. They identify the existence of asymmetries both within and across regimes. The detected two forms of asymmetry imply (a) that a given increase in cyclical output during the 'unemployment lies above trend' regime has a smaller impact on the cyclical unemployment

rate than a decrease in cyclical output of equal absolute magnitude and (b) that the unemployment rate is more sensitive to movements in cyclical output in the recessionary regime. Knotek (2007) uses the rolling regressions technique to investigate the stability of the postulated relationship between GDP and unemployment. His results indicate that part of the variation of Okun's law over time is related to the state of the business cycle, with the relationship between output and unemployment being different in recessions and expansions.

In the aftermath of the experience of the Great Recession and in connection with the issue of jobless recoveries, Owyang and Sekhposyan (2012) examine the historical performance of Okun's law by considering three alternative specifications and augmenting, among other things, the benchmark specifications with recession dummies. They provide evidence of a great degree of instability and argue that the detected breakdowns in Okun's law seem to be highly correlated with the business cycle. Pereira (2013) estimates asymmetries in Okun's law across the business cycle using, in a first approach exogenously determined breaks based on the NBER recession dates and using, in a second approach, endogenously determined break points through the estimation of a Markov switching model. He provides evidence supporting the hypothesis of asymmetries in Okun's law, with a structural feature of the law being the weaker relationship between GDP growth and unemployment during periods of economic expansion. This relation coupled with the phenomenon of weak economic performance in recent decades is seen to relate to the phenomena of jobless recoveries.

No evidence of non-linearity for the USA is found in one of the more recent applications (using annual data) by Ball et. al (2013), who estimate separate coefficients for positive and negative output gaps in the levels and positive and negative output growth in the changes equation in order to check for the validity of Okun's law.

Another class of papers investigating the asymmetry issue refers to groups of countries and, as one would expect, evidence provided by the application of various methodologies is not always unanimous, although there are mostly significant indications on asymmetric effects. Lee (2000) investigates the stability of the properties, and in particular the existence of asymmetries, in Okun's law for the 1955-1996 time period and 16 OECD countries. The Okun equations are augmented to allow for different effects between non-negative and negative values in the unemployment data, by incorporation of the Heaviside indicator. While the provided evidence is far from being conclusive since it varies across countries, there are some indications for

asymmetric effects in certain cases. Harris and Silverstone (2001) argue that failure to take account of asymmetries would see a rejection of the hypothesis that there exists a long-run relationship between unemployment and output in certain cases. In their application to seven countries for the period starting in 1978Q1 and ending around 1999 (depending on availability) and by use of an asymmetric error-correction model on the basis of a Heaviside indicator function, they establish cointegration. They show that, in almost all cases, short run output and unemployment adjustments to disequilibrium differ according to whether upturns or downturns in the business cycle are considered. Döpke (2001) analyzes the question whether the Okun relationship is different during expansions and recessions in seventeen selected OECD countries for the period 1971-1999. He includes a Heavyside function in the estimated relation and also conducts a test for asymmetry. His findings are rather ambiguous, since there does not appear to be a clear-cut pattern across the countries under investigation, even though the null hypothesis of no asymmetry is rejected in several cases.

Virén (2001) analyses the relationship between output and unemployment in order to find out whether it is linear in terms of the cyclical situation of the economy. On the basis of an error correction model for unemployment, he investigates the relationship in 20 OECD countries for the time period 1960-1997 (with minor exceptions). He provides support for the existence of non-linearities in terms of the output growth effects, with output growth having a strong effect on unemployment when unemployment is low and output is high, and vice versa. In a more direct approach, Lang and de Peretti (2009) derive a theoretical framework, encompassing the role of past history and a remanence effect, which is then implemented empirically. It allows for the construction of hysteretic variables within Okun's relation to test whether this version out-performs the standard, linear alternative. The authors use quarterly GDP and unemployment data for a selection of seven countries starting at the earliest available point in time for each individual country and ending in 2007Q4. Even though results are mixed, empirical evidence consistent with hysteresis is found for several of the investigated countries. Finally, in an application to the USA and Canada, Beaton (2010) uses a time varying parameter approach to investigate the stability of Okun's law both in terms of the existence of potential structural changes and differences over the course of the business cycle. On the basis of quarterly data from 1961Q1 to 2009Q2 for Canada and 1948Q1-2009Q2 for the USA, she finds that the unemployment rate typically increases by more during recessions than it falls during expansions, confirming the argument of Okun' law instability across the state of the business cycle.

## 3. Hidden co-integration and the crouching error correction models

The *asymmetric* Error Correction Model (AECM)[2], the LSE–Hendry general-to-specific Model (GETS)[3] and the Threshold Error Correction Model (TECM), are some of the main econometric methodologies implemented for testing asymmetries.

Within the same symmetric/asymmetric framework lies the CECM, actually derived from the hidden co-integration approach by Ganger and Yoon (2002). This model is more flexible than the TECM, as it is not limited to two (or more) regimes and allows the investigation of all possible combinations of co-integration between data components. Additionally, it resembles more the AECM & GETS approaches than the TECM since it initially presupposes an *ex-ante* positive and negative disaggregation of the data and then a cumulative aggregation of these two parts in the Data Generation Process (DGP). Consequently, the hidden co-integration approach allows for distinct co-integrating relationships between subcomponents (positive and negative) of two time series even when co-integration between them is not identified at the aggregate level. This flexibility in the use of data might a) offer a better insight into the asymmetry both in the long run and short run level and b) enable the implementation of a CECM.

As already mentioned, the Granger and Yoon (2002) hidden co-integration approach aims to identify the dynamics between cumulative positive and negative changes of data components. If any of these components of the data series (negative or positive) are co-integrated, then the data are hidden co-integrated. The concept behind the hidden co-integration approach is quite simple.

Suppose $X_t$ and $Y_t$ are two random walk time series described by:

$$X_t = X_{t-1} + \varepsilon_t = X_0 + \sum_{i=1}^{t} \varepsilon_t \quad , \tag{1a}$$

$$Y_t = Y_{t-1} + \eta_t = Y_0 + \sum_{i=1}^{t} \eta_t \quad , \tag{1b}$$

where, $X_0$, $Y_0$ denote initial values and $\varepsilon_i$ and $\eta_i$ are mean zero white noise disturbance terms. In the Granger and Yoon (2002) methodology we define positive and negative shocks as

[2] In fact it was Von Cramon-Taubadel and Loy (1997) and Von Cramon-Taubadel (1998) who actually introduced the *symmetric/asymmetric* ECM approach through an *ex-ante* disagreggation of the data.

[3] The GETS methodology was introduced by Hendry, Pagan, & Sargan, 1984; Hendry, 1987; Hendry and Krolzig, 2005. This methodology was substantially evolved by Bachmeier and Griffin (2003) and Rao and Rao (2008).

follows:

$\varepsilon^+ = \max(\varepsilon_i, d)$, $\varepsilon^- = \min(\varepsilon_i, d)$, $\eta^+ = \max(\eta_i, d)$ and $\eta^- = \min(\eta_i, d)$, where $d$ stands for an unknown threshold value (with $d$ = 0 as the most popular choice).

Then equations 1a and 1b are transformed to:

$$X_t = X_{t-1} + \varepsilon_t = X_0 + \sum_1^t \varepsilon^+ + \sum_1^t \varepsilon^- \quad (2a)$$

and,

$$Y_t = Y_{t-1} + \eta_t = Y_0 + \sum_1^t \eta^+ + \sum_1^t \eta^- \ . \quad (2b)$$

Following the Granger and Yoon (2002) approach, we can simplify to:

$X_t^+ = \sum_1^t \varepsilon_i^+$, $X_t^- = \sum_1^t \varepsilon_i^-$, $Y_t^+ = \sum_1^t \eta_i^+$, $Y_t^- = \sum_1^t \eta_i^-$ .

Thus we get that $X_t = X_0 + X^+ + X^-$ and $Y_t = Y_0 + Y^+ + Y^-$,

and it follows that $\Delta X_t^+ = \varepsilon^+$, $\Delta X_t^- = \varepsilon^-$, $\Delta Y_t^+ = \eta^+$, $\Delta Y_t^- = \eta^-$.

In empirical terms, we calculate the first difference (e.g. $\Delta X_t = X_t - X_{t-1}$) for both of the time series $\{X_t, Y_t\}$ and sort the resulting observations according to positive and negative movements (e.g. $\Delta X_t^+, \Delta X^-$, $\Delta Y_t^+, \Delta Y^-$). Then, we calculate the cumulative sum of positive (and negative) changes at a given time for all (four) variables (e.g. $X_t^+ = \sum \Delta X^+$, $X_t^- = \sum \Delta X^-, Y_t^+ = \sum \Delta Y^+$, $Y_t^- = \sum \Delta Y^-$).

Next, we move to the presentation of the alternative long run co-integration hypotheses which can be tested between the four different components of the two time series (e.g. $X_t^+, X_t^-$, $Y_t^+, Y_t^-$).

***The alternative long run hypotheses***

Two variables $\{X_t, Y_t\}$ are hidden co-integrated if their positive and/or negative components are co-integrated. According to Granger and Yoon (2002) and Honarvar (2009), we might have one of following four alternative hypotheses between the pre-selected pairs of $X_t$ and $Y_t$ {e.g. $X_t^+, Y_t^+$ and $X_t^-, Y_t^-$}:

*Hypothesis 1:* Neither $\{X_t^+, Y_t^+\}$ nor $\{X_t^-, Y_t^-\}$ are hidden co-integrated.

*Hypothesis 2:* Either $\{X_t^+, Y_t^+\}$ or $\{X_t^-, Y_t^-\}$ but not both, are hidden co-integrated. In this

case, $X_t$ and $Y_t$ are subject to positive or negative shocks.

*Hypothesis 3:* Both $\{X_t^+, Y_t^+\}$ and $\{X_t^-, Y_t^-\}$ are hidden co-integrated, but with different co-integrating vectors. In this case, the common shocks of $X_t$ and $Y_t$ are not co-integrated.

*Hypothesis 4:* Both $\{X_t^+, Y_t^+\}$ and $\{X_t^-, Y_t^-\}$ are hidden co-integrated. In this case, $X_t$ and $Y_t$ are co-integrated with the same co-integrating vector.

In the following, we present the dynamic EC model which is differentiated in accordance with the prevailing long run hypothesis. Granger and Yoon (2002) refer to the ECM implied by hidden co-integration as the "Crouching Error Correction Model". The CECM is based on the Engle–Granger two-step procedure. The structure of this specific ECM varies in accordance with the three long run alternative *hypotheses* between the components of $X_t$ and $Y_t$ . Thus, in line with these aforementioned *hypotheses*, we can derive the following alternative CECMs.

***The alternative CECMs***

For *Hypothesis 1,* there is no any CECM representation as no pair of components is co-integrated.

For *hypothesis 2,* we assume that $\{X_t^+, Y_t^+\}$ are the only components that are co-integrated with a co-integrating vector of $(1,-1)$ for convenience. Then the CECM model can be specified as[4]:

$$\Delta X_t^+ = \delta_0 + \sum_{i=1}^{k1} \delta_{1t} \Delta Y_{t-i}^+ + \sum_{i=1}^{k2} \delta_{2t} \Delta X_{t-i}^+ + \psi_2 (X_{t-1}^+ - Y_{t-1}^+) + \eta_t \qquad (3)$$

If alternatively $\{X_t^-, Y_t^-\}$ are the co-integrated components then we can derive the CECM for negative movements.

For *hypothesis 3,* we assume that $\{X_t^-, Y_t^-\}$ are co-integrated components as well with a co-integrating vector of $(1,-k)$, where $k \neq 1$. Then we have the following CECM:

$$\Delta X_t = \delta_0 + \sum_{i=1}^{k1} \delta_{1t} \Delta Y_{t-i}^- + \sum_{i=1}^{k2} \delta_{2t} \Delta X_{t-i}^- + \sum_{i=1}^{k3} \delta_{3t} \Delta Y_{t-i}^+ + \sum_{i=1}^{k4} \delta_{4t} \Delta X_{t-i}^+ +$$

[4] The Ganger &Yoon (2002) paper provides also the reverse CECM between $X_t$ and $Y_t$ because it examines the causality among them as well (e.g. $\Delta Y_t^+ = \beta_0 + \sum_{i=0}^{j1} \beta_{1t} \Delta Y_{t-i}^+ + \sum_{i=0}^{j2} \beta_{2t} \Delta X_{t-i}^+ + \psi_1 (Y_{t-1}^+ - X_{t-1}^+) + \xi_t$).

$$\psi_3 ( X_{t-1}^{+} - Y_{t-1}^{+} ) + \psi_4 ( X_{t-1}^{-} - kY_{t-1}^{-} ) + \eta_t \quad (4)$$

Finally, for *hypothesis 4*, we assume the existence of a common co-integrating vector (1,−1) and that $X_t$ and $Y_t$ have the following *standard* ECM:

$$\Delta X_t = \delta_0 + \sum_{i=1}^{k1} \delta_{1t} \Delta Y_{t-i}^{-} + \sum_{i=1}^{k2} \delta_{2t} \Delta X_{t-i}^{-} + \sum_{i=1}^{k3} \delta_{3t} \Delta Y_{t-i}^{+} + \sum_{i=1}^{k4} \delta_{4t} \Delta X_{t-i}^{+} +$$

$$\psi ( X_{t-1}^{+} - Y_{t-1}^{+} ) + \psi ( X_{t-1}^{-} - Y_{t-1}^{-} ) + \eta_t \quad (5)$$

with $\psi = \psi_3 = \psi_4$ (from equation 4). Additionally, the coefficients associated with $\Delta X_{t-i}^{-}$ and $\Delta X_{t-i}^{+}$ should be the same. The same holds for $\Delta Y_{t-i}^{+}$ and $\Delta Y_{t-i}^{-}$.

The main arising advantage from implementing the Ganger and Yoon (2000) hidden co-integration methodology is that this kind of model specification allows for distinct co-integrating relationships between subcomponents of time series even when co-integration between two aggregate time series is not identified. As Honarvar (2009) underlines, one of the advantages of the hidden co-integration approach over, for instance, the standard asymmetric ECMs in the literature, is that it investigates all possible combinations of co-integration between data components. The CECM methodology contains all the advantages of the LSE–Hendry general to specific (GETS) methodology (as we can simultaneously estimate the short-run and long–run coefficients in the same dynamic model and can test for the existence of any asymmetric effects) and optionally allows for cumulative, positive and/or negative, long run estimators to be embedded in its structure.

## 4. Data and empirical results

### 4.1. Data

We use OECD unemployment rate and GDP data for six selected advanced economies, including Greece. One aspect of the present application is to investigate the existence of asymmetric responses of unemployment to changes in output for the USA, in order to compare the results obtained by use of this novel approach with the existing literature. At the same time, we are interested in examining the existence of potential asymmetries for other countries as well and will attempt to provide suitable interpretations. Moreover, we chose to include Greece, due to the recent period of deep recession the country experienced and the still pertaining extraordinary high unemployment rates related to this long-lasting and severe recessionary regime. The provision of evidence, for example, in favour of asymmetries and in

particular in favour of the assertion that unemployment is less responsive during expansions than during recessions could have extremely important implications with respect to the expected path towards lower unemployment rates and potential necessary policy actions.

The investigated countries are Australia, Canada, Germany, Greece, Japan and the USA. The referred time period, and basically the starting point, varies depending on data availability and ends in the second or third quarter of 2014 (for Australia the examined time period starts in 1966Q1 to 2014Q2, for Canada, from 1960Q1 to 2014Q2, for Germany, from 1962Q1 to 2014Q2, for Greece, from 1990Q1 to 2014Q2, for Japan, from 1960Q1 to 2014Q2 and finally for the USA, from 1960Q1 to 2014Q3). The unemployment rate data originate from the OECD short-term Labour Market Statistics, for all persons aged 15 and over, and are seasonally adjusted. GDP data refer to volume estimates in millions with OECD reference year, and are seasonally adjusted as well.

We first decompose our data series to obtain separate series for cumulative sums of positive and negative components. These are depicted in Appendices 1 and 2 for the unemployment and the GDP series separately for all countries under investigation. Additionally, we present the graphs between positive components of GDP and negative components of unemployment (Appendix 3) and between negative components of GDP and positive components of unemployment (Appendix 4). We then proceed with the succeeding steps of our estimation procedure in order to implement the hidden cointegration approach, which includes testing for unit roots and then for co-integration and finally estimating the CECMs. All CECM are estimated with OLS.

### 4.2. Empirical results

Before the implementation of the proposed methodology, we proceed with the derivation of the order of integration of the variables. To do that, we initially conduct ADF unit root tests in order to check for stationarity. With respect to the aggregate unemployment rate and GDP series we find that in almost all cases the series are integrated of order one. With reference to the decomposed series (positive and negative), we again uncover that in almost all cases the series are I(1).

Then, as a first step, we check for the existence of a long-run relation between the investigated variables, both in aggregate and decomposed forms. In order to be able to establish more robust

evidence on that issue, we apply both OLS-based and Johansen-procedure pair wise cointegration tests. As indicated in Tables 1a and 1b, for a number of countries and in particular when applying the OLS-based cointegration tests, we cannot reject the hypothesis of no cointegration in the aggregated series in all but one cases (USA). However, when conducting the tests for the decomposed series, we observe the existence of hidden cointegration in a number of cases. This outcome strengthens the argument for the application of the hidden cointegration approach.

**Table 1a: Pair wise hidden co-integration tests (OLS results)**

| Dep. Vs. Indep. | Australia | Canada | Germany | Greece | Japan | US |
|---|---|---|---|---|---|---|
| **U vs. Y** | -3.01 | -2.96 | -2.57 | -2.64 | -1.48 | -3.24 |
| **$U^+$ vs. $Y^-$** | -2.77 | -1.02 | -3.22** | -3.13** | -1.75 | -3.57*** |
| **$U^-$ vs. $Y^+$** | -1.96 | -2.14 | -2.24 | -3.44*** | -0.03 | -1.77 |
| **$Y^+$ vs. $U^-$** | -2.61 | -2.00 | -4.11*** | -2.14 | -2.52 | -0.26 |
| **$Y^-$ vs. $U^+$** | -2.67 | -2.05 | -4.12*** | -3.36** | -0.12 | -3.39** |

Granger & Yoon (2002) critical values: (-3.80, -3.35 at 5% with trend and without trend respectively).

**Table 1b: Pair wise hidden co-integration tests (Johansen results)**

| Dep. Vs. Indep. | Australia | Canada | Germany | Greece | Japan | US |
|---|---|---|---|---|---|---|
| **U vs. Y** | Yes | No | No | Yes | Yes | Yes |
| **$U^+$ vs. $Y^-$** | No | No | Yes | Yes | No | No |
| **$U^-$ vs. $Y^+$** | Yes | Yes | Yes | Yes | Yes | Yes |

*Eigen values* and *Trace tests* have been implemented for all cases (results upon request). Yes: implies that there is a co-integrating vector (r=1). No: implies the opposite (r=0 or 2).

Therefore, as a second step, we proceed with the implementation of the dynamic model by estimating the CECMs (Table 2). Before analyzing the details of the estimates of the individual dynamic models, it is worth mentioning that in almost all cases of the long-run relationships, the coefficients on the GDP series exhibit the appropriate negative sign, as indicated by economic theory.

**Table 2: The CECM results**

| | Australia | Canada | Germany | Greece† | Japan | US |
|---|---|---|---|---|---|---|
| **Long run Regression: U+ = constant + $\beta$ *GDP-** | | | | | | |
| **C** | 0.08 | 0.10 | 0.04 | -0.005 | 0.04 | 0.11 |
| | (2.54) | (3.49) | (2.80) | (-0.06) | (4.43) | (4.20) |
| **ECT $_{-1}$** | -0.05 | -0.01 | -0.03 | -0.12 | -0.04 | -0.05 |
| | (-3.48) | (-0.82) | (-3.62) | (-4.00) | (-2.90) | (-2.44) |
| **$\Delta U^{+}_{-1}$** | 0.48 | 0.58 | 0.49 | 0.36 | 0.34 | 0.67 |
| | (6.79) | (8.34) | (7.27) | (2.75) | (5.09) | (9.58) |
| **$\Delta U^{+}_{-2}$** | 0.04 | -0.12 | 0.20 | 0.47 | 0.04 | -0.10 |
| | (0.73) | (-1.83) | (3.05) | (3.82) | (0.62) | (-1.60) |
| **$\Delta GDP^{-}_{-1}$** | -2.16 | -2.31 | -2.20 | 1.71 | -0.73 | -3.83 |
| | (-1.25) | (-1.16) | (-2.27) | (0.37) | (-1.50) | (-2.11) |
| **$\Delta GDP^{-}_{-2}$** | -0.95 | -2.85 | 0.00 | 1.16 | -0.48 | -4.31 |
| | (-0.56) | (-1.43) | (0.00) | (0.39) | (-0.99) | (-2.35) |
| **$R^2$** | 0.35 | 0.33 | 0.48 | 0.61 | 0.20 | 0.49 |
| **Long run Regression: U- = constant + $\phi$ *GDP+** | | | | | | |
| **C** | -0.02 | -0.02 | -0.02 | -0.005 | -0.03 | -0.02 |
| | (-1.11) | (-1.24) | (-1.58) | (-0.06) | (-4.27) | (-1.54) |
| **ECT $_{-1}$** | -0.02 | -0.03 | -0.02 | -0.15 | -0.003 | -0.02 |
| | (-2.05) | (-2.47) | (-2.42) | (-1.91) | (-0.29) | (-1.76) |
| **$\Delta U^{-}_{-1}$** | 0.22 | 0.16 | 0.30 | 0.21 | -0.005 | 0.36 |
| | (3.08) | (2.37) | (4.61) | (0.75) | (-0.08) | (5.12) |
| **$\Delta U^{-}_{-2}$** | 0.11 | 0.08 | 0.27 | -0.03 | 0.18 | 0.04 |
| | (2.30) | (1.28) | (4.25) | (-0.11) | (2.62) | (0.60) |
| **$\Delta GDP^{+}_{-1}$** | -2.99 | -4.75 | -0.61 | -0.31 | 0.12 | -2.16 |
| | (-2.65) | (-3.38) | (-0.65) | (-0.09) | (0.29) | (-1.55) |
| **$\Delta GDP^{+}_{-2}$** | -1.56 | -2.97 | -0.77 | -1.39 | 0.14 | -2.75 |
| | (-1.38) | (-2.06) | (-0.83) | (-0.46) | (0.33) | (-1.98) |
| **$R^2$** | 0.15 | 0.17 | 0.26 | 0.61 | 0.03 | 0.23 |

Note: t-statistics in parentheses ($\pm$ 1.98, at 5%). †. The CECM of hypothesis 3 is applied in Greece. In all other cases (countries) hypothesis 2 is implemented.

***Australia***

For the case of Australia, we estimate both CECMs with the positive and negative decomposed unemployment rate series as the dependent variable and the negative and positive GDP series, respectively, as the independent variable. In both cases we obtain a negative and significant error correction term. This implies that there exists a long-run linkage in both directions, indicating the presence of symmetry. In other words, unemployment seems to respond symmetrically to negative and positive changes in output.

***Canada***

In estimating the corresponding CECMs for Canada, again with the positive and negative decomposed unemployment rate series as the dependent variable, we derive some interesting results. When estimating the model with the positive unemployment rate series as the dependent variable and the negative GDP series as the independent one, we obtain a negative

but non-significant error correction term. This implies that there does not seem to exist a long-run linkage between falling GDP and increasing unemployment rate. However, we obtain a negative and significant coefficient when estimating the reverse relationship, meaning that there is a long-run linkage between increasing GDP and falling unemployment rate. Overall, our results for Canada indicate the existence of asymmetry, confirming the assertion that there is an asymmetric response in unemployment rate to changes in output.

***Germany***

For Germany, when estimating both CECMs with the positive and negative decomposed unemployment rate series as the dependent variable and the negative and positive GDP series, respectively, as the independent variable, we derive in both cases a negative and significant error correction term. This presents evidence for the existence of a long-run linkage in both directions, indicating at the same time the presence of symmetry. In other words, unemployment seems to respond symmetrically to negative and positive changes in output.

***Greece***

For the case of Greece, we also obtain evidence for the existence of asymmetry. More specifically, we estimate both CECMs with the positive and negative decomposed unemployment rate series as the dependent variable and derive a negative and significant error correction term when estimating the model with the positive unemployment rate series as the dependent variable. The opposite, regarding the error correction term significance, is the case when estimating the equation in the other direction (even though marginally). As a result, we can say that whereas there appears to exist a long-run linkage between falling GDP and increasing unemployment rate, increasing GDP and falling unemployment rate do not seem to be linked in the long-run. Again, we confirm for the case of Greece the existence of an asymmetric response in unemployment rate to changes in output.

**Japan**

For the case of Japan, we estimate both CECMs with the positive and negative decomposed unemployment rate series as the dependent variable and obtain evidence for the existence of asymmetry. In more detail, while we derive a negative and significant error correction term when estimating the model with the positive unemployment rate series as the dependent variable and the negative GDP series as the independent one, the opposite is the case when estimating the equation in the other direction. Our results, hence, imply that whereas there

appears to exist a long-run linkage between falling GDP and increasing unemployment rate, increasing GDP and falling unemployment rate do not seem to be linked in the log-run. All in all, we confirm for the case of Japan the existence of an asymmetric response in unemployment rate to changes in output.

**USA**

For the case of the USA, we again derive an asymmetric response in unemployment rate to changes in output, confirming the evidence provided by Granger and Yoon (2002). More particularly, we estimate both CECMs with the positive and negative decomposed unemployment rate series as the dependent variable and obtain a negative and significant error correction term when estimating the model with the positive unemployment rate series as the dependent variable and the negative GDP series as the independent one. The same does not hold in the opposite direction. Our results, hence, imply that whereas there appears to exist a long-run linkage between falling GDP and increasing unemployment rate, increasing GDP and falling unemployment rate do not seem to be linked in the long-run.

Overall, the above analyzed results indicate that in four out of six of the investigated countries we find clear evidence of existing asymmetries in the unemployment rate response to changes in output. This important result enforces the necessity to investigate the potential existence of an asymmetric relationship between output and the unemployment rate. It, hence, follows that the hidden cointegration approach presents a very useful econometric tool towards that aim.

## 5. Discussion

This paper raises some interesting questions: why unemployment's responsiveness to output changes is higher during recessions and lower during economic expansions? Additionally, what might explain the observed variation over the symmetry issue across countries?

One frequently mentioned and perhaps the most plausible answer to the first question is related to the firms' increased cautiousness during the early stages of recoveries. Under uncertainty about future demand, it is not unusual for firms to adjust the working hours of those they already employ (Bloom, 2009) and/or to adopt measures to increase labour productivity before they proceed to new hirings. In some countries, notably in the US, this strategy is favoured by the 'just-in-time hiring' practices which permit firms to postpone new hirings until the pace of recovery is definitely strong (Schreft and Singh, 2003).

Another set of explanations is related to the structural changes economies usually undergo between recessions and expansions. This strand of the literature distinguishes between restructuring across sectors (Lilien, 1982, Grosben and Potter, 2003) and restructuring that takes place within firms (Koenders and Rogerson, 2005). In the first case, restructuring involves costly and time-consuming reallocation of workers from declining industries to more dynamic sectors. In the second case, firms' reorganization may lead to permanent layoffs as a result of their efforts either to eliminate "wasteful employment" (Koenders and Rogerson, 2005) or to reduce unit labour costs through "job offshoring" to low cost economies. The overall effect of restructuring within and across industries is a growing rate of job destruction which seems to be consistent with temporary and sometimes permanent increases in the natural rate of unemployment.

The list of the economic mechanisms that have been proposed to explain the sharp (mild) responses of unemployment to output contractions (expansions) is complemented by the traditional views on the workings of labour market frictions (e.g. wage and employment contracts inflexibility, strong employment protection legislation, etc) and their effects on unemployment dynamics over the various phases of the business cycle (e.g. IMF, 2010; Cazes et al, 2013).

Interestingly, all these explanations are not mutually exclusive. That is not to say, however, that each one of them is equally valid for every country of our sample. For example, while labour market frictions could possibly explain part of the asymmetry in the responsiveness of unemployment to output changes in Greece and Japan, the same explanation is invalid for countries with quite flexible labour markets like the US. Of course, there are cases where the dynamics implied by the above theories interact and reinforce each other. A good example here is the Greek case where a combination of factors – multiple labour and goods market rigidities, firms' slow pace of reorganization during recoveries, low capacity of the economy to adopt structural changes and create new jobs– has acted against the employment intensity of growth.

Regarding the second question about the variation of asymmetries across countries, these could be possibly interpreted as the outcome of structural and institutional differences between economies. The number, the type and the extent of country-specific episodic factors (e.g. financial crises, sectoral shocks, etc) and the national policy responses to such events might

have also played a significant role in shaping the pattern of interactions between unemployment and output changes. In Germany, for example, the relatively smoother employment transitions over the business cycle reflects not only the country's labour market institutions and practices but also the overall capacity of the economy to adjust quickly to changing circumstances and replace lost jobs with new ones. As for Australia, the symmetric responses of unemployment to output changes could be possibly attributed to the fact that the Australian economy has experienced less and smoother business cycles relative to the rest countries of our sample over the examined period.

In closing this section it is worthwhile to note that identifying the causes of asymmetries in the unemployment-output relationship is of particular relevance for policy makers who are interested in increasing the employment density of growth. For instance, if it is poor labour market institutions that disturb the employment-growth link, then labour market reforms could be proved much more efficient than demand management policies in promoting the employment intensity of growth. Needless to say, the question about the exact factors that explain the nature of the unemployment-growth relationship is beyond the scope of the present paper.

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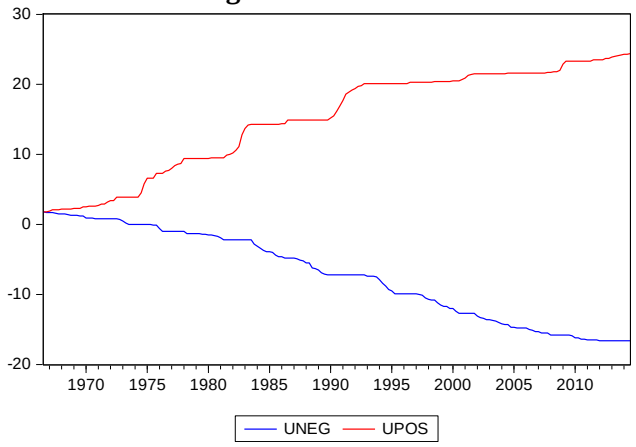
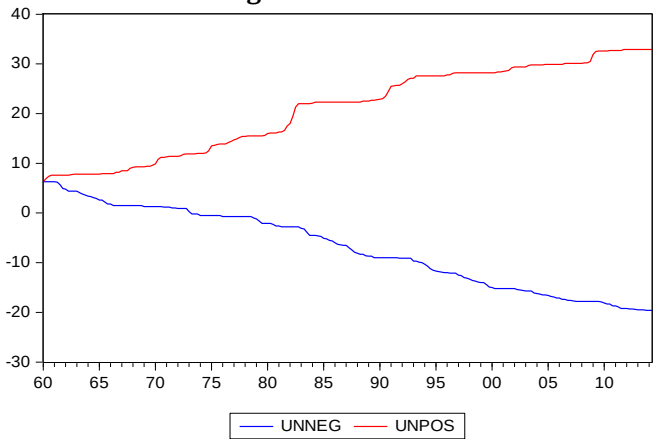
## Appendix 1
## Figures of the cumulative sum of positive and negative components of changes in the unemployment rate

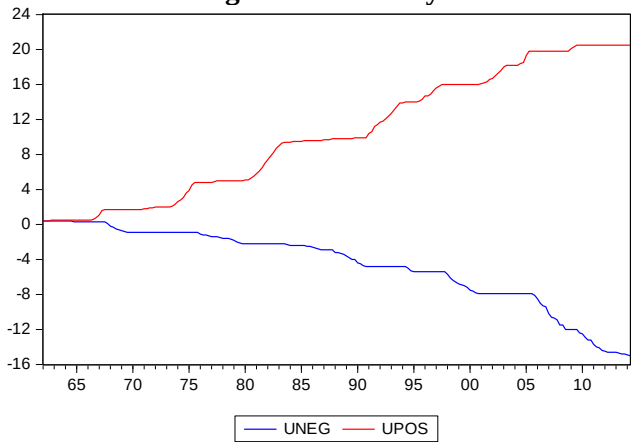
### Figure 1: Australia



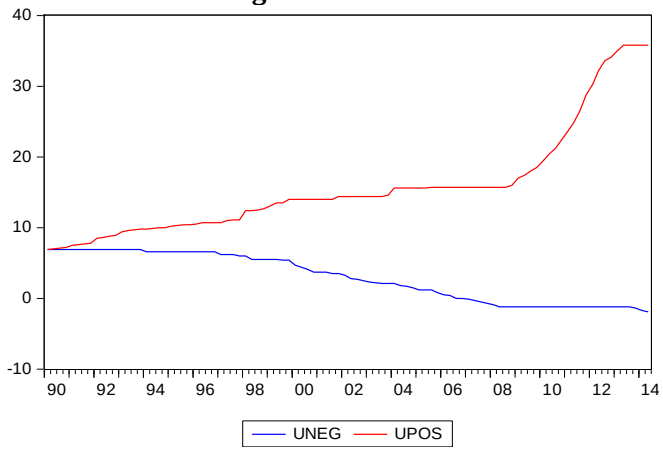

### Figure 2: Canada



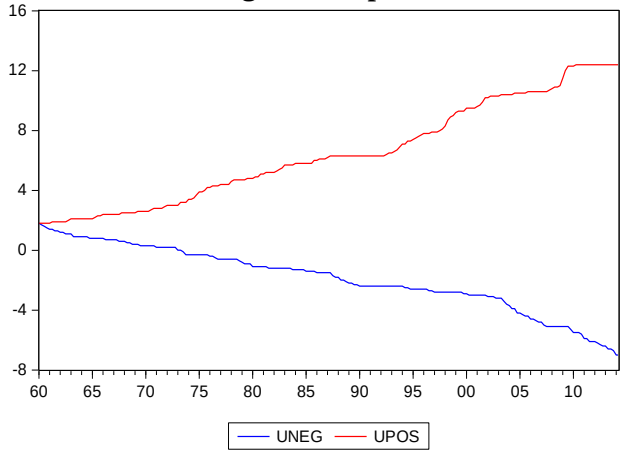

### Figure 3: Germany



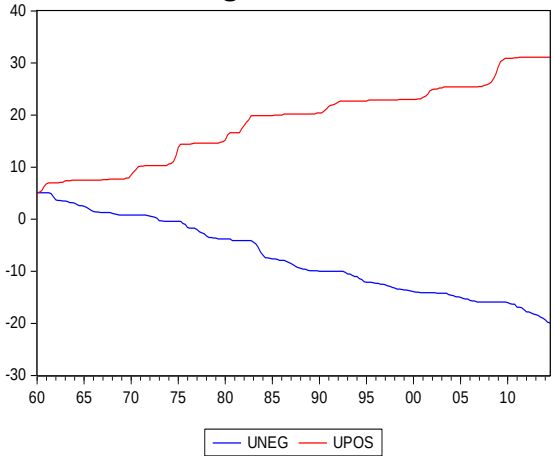

### Figure 4: Greece




### Figure 5: Japan



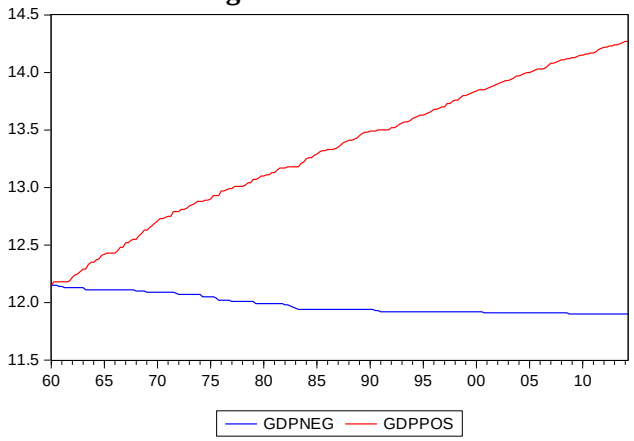

### Figure 6: US



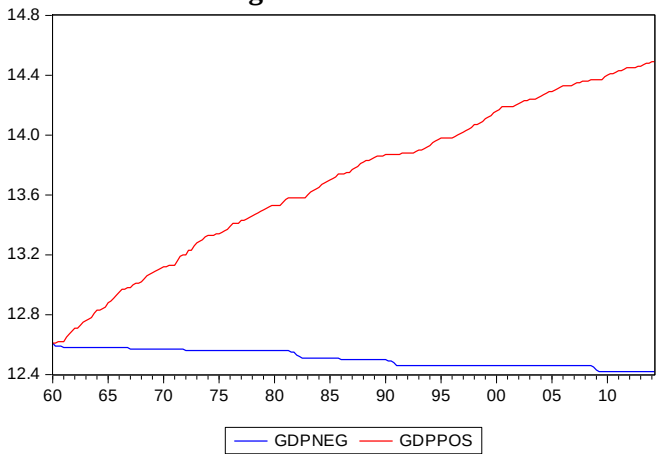
# Appendix 2

## Figures of the cumulative sum of positive and negative components of changes in GDP

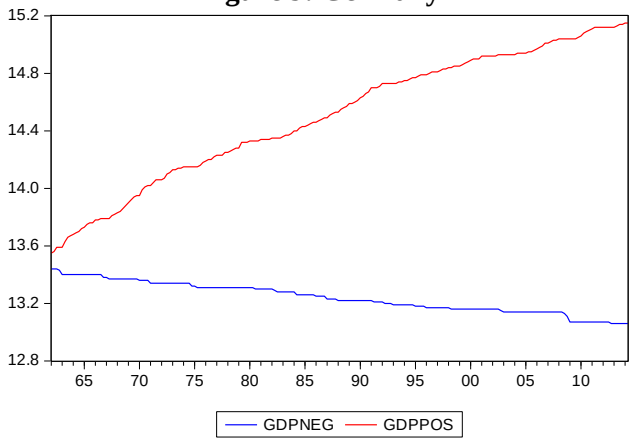
### Figure 7: Australia



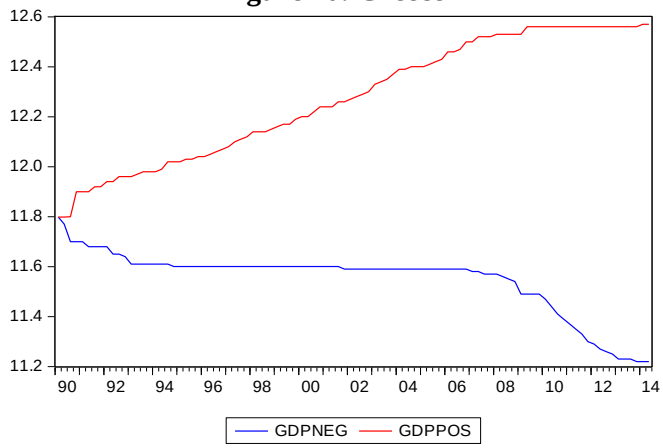

### Figure 8: Canada



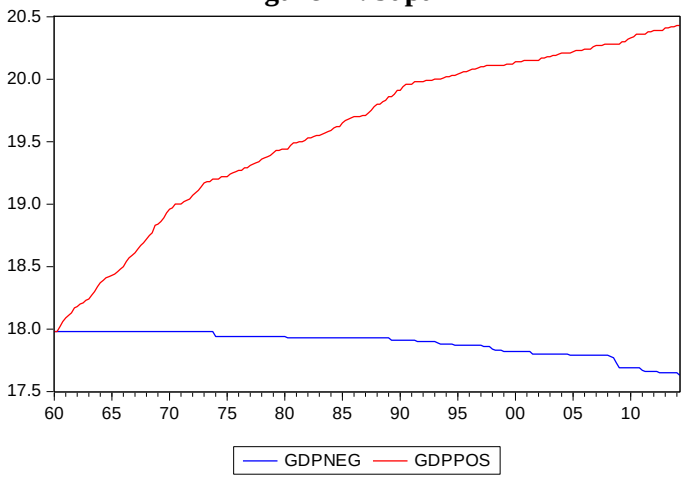

### Figure 9: Germany



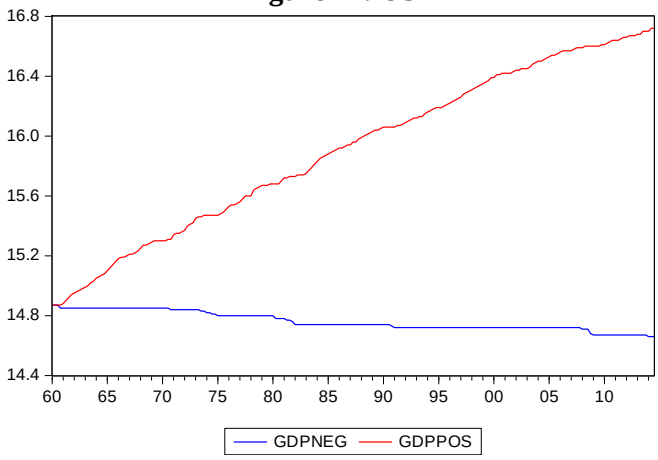

### Figure 10: Greece




### Figure 11: Japan




### Figure 12: US



## Appendix 3
## Figures of the cumulative sum of positive components of changes in GDP and negative components of changes in unemployment rates

**Figure 13: Australia**

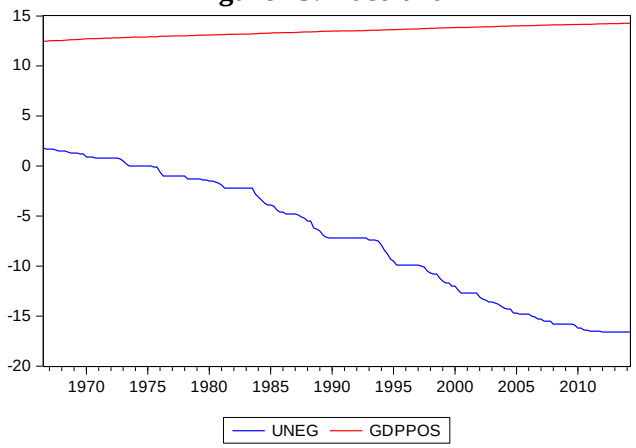



**Figure 14: Canada**

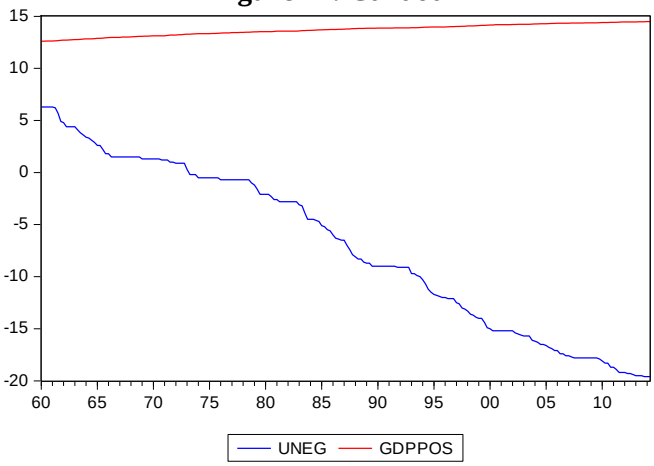



**Figure 15: Germany**

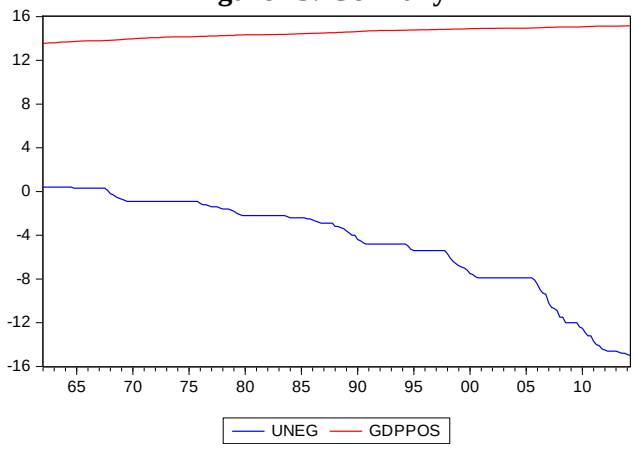



**Figure 16: Greece**

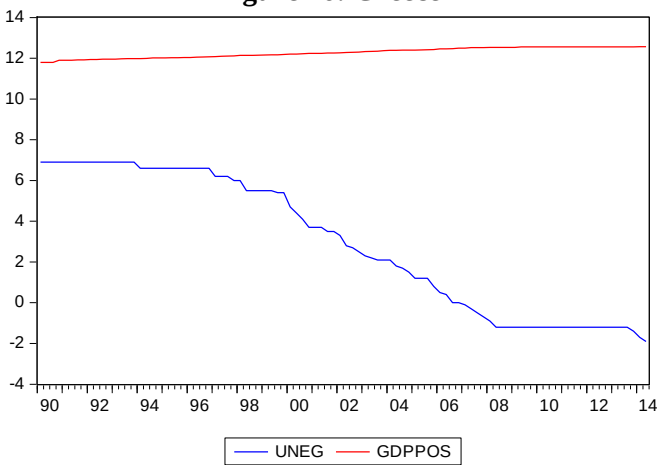



**Figure 17: Japan**

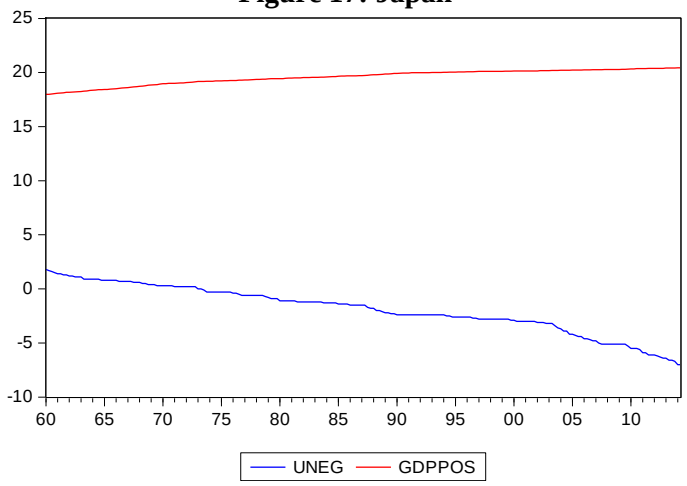
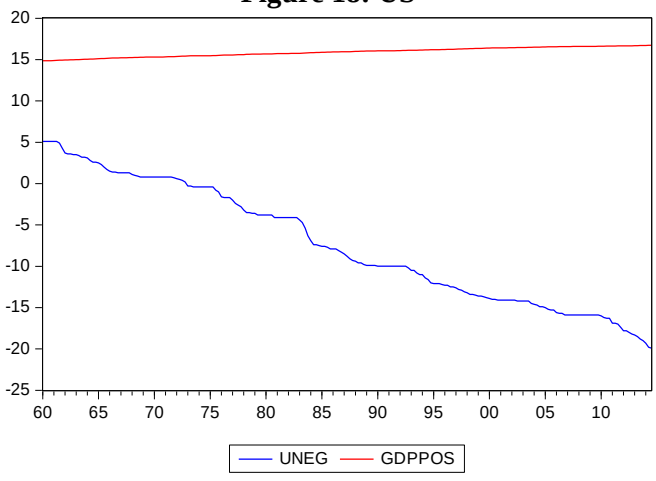



**Figure 18: US**



## Appendix 4

## Figures of the cumulative sum of positive components of changes in unemployment rates and negative components of changes in GDP

**Figure 19: Australia**

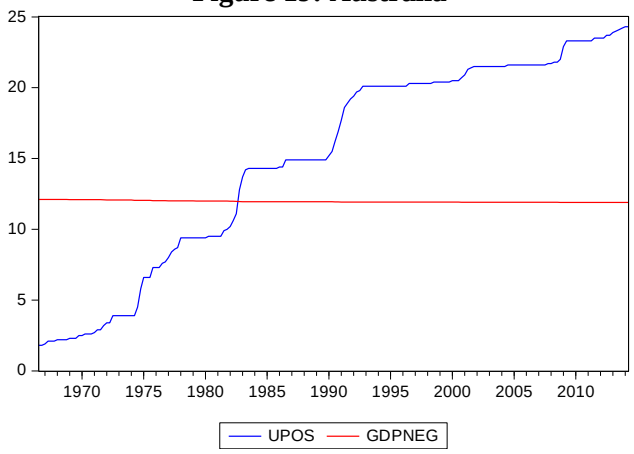



**Figure 20: Canada**

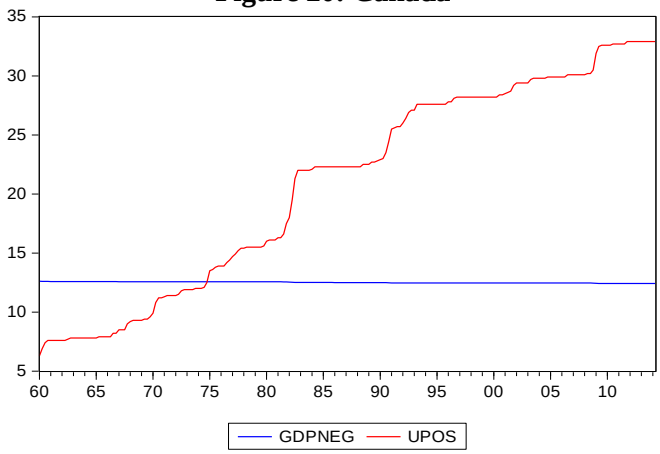



**Figure 21: Germany**

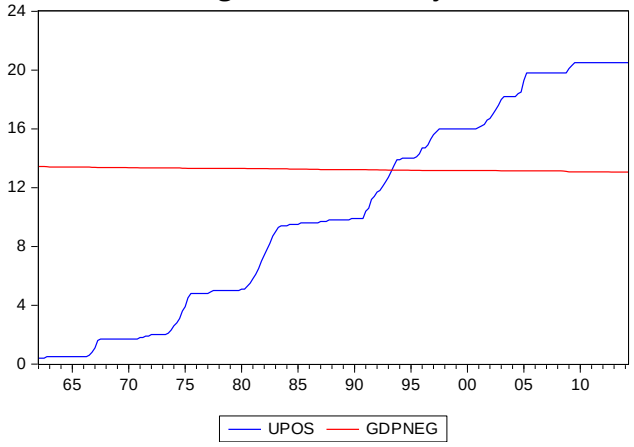



**Figure 22: Greece**

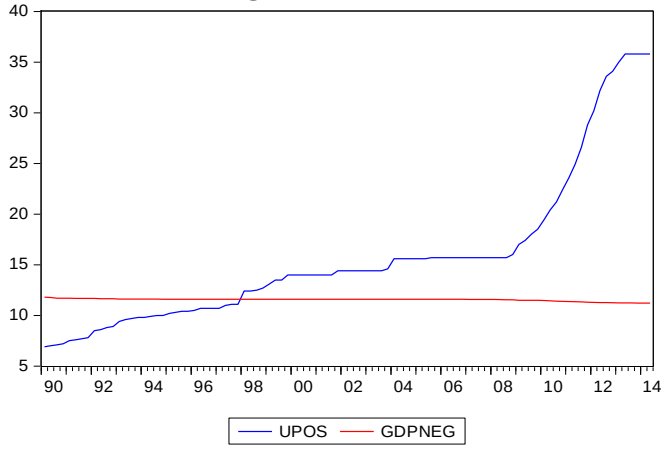



**Figure 23: Japan**

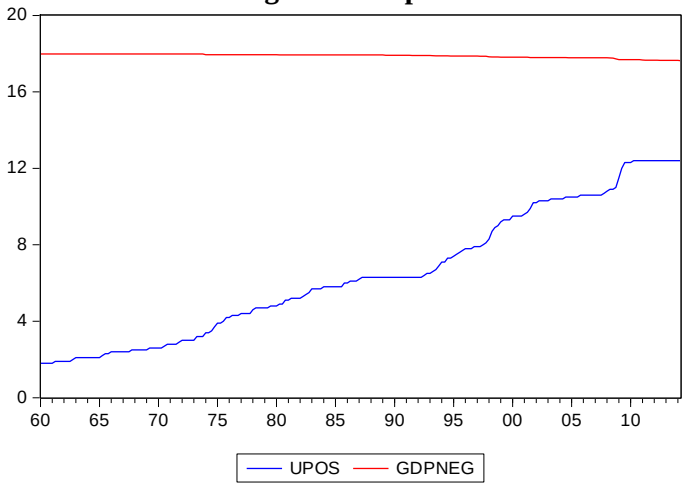
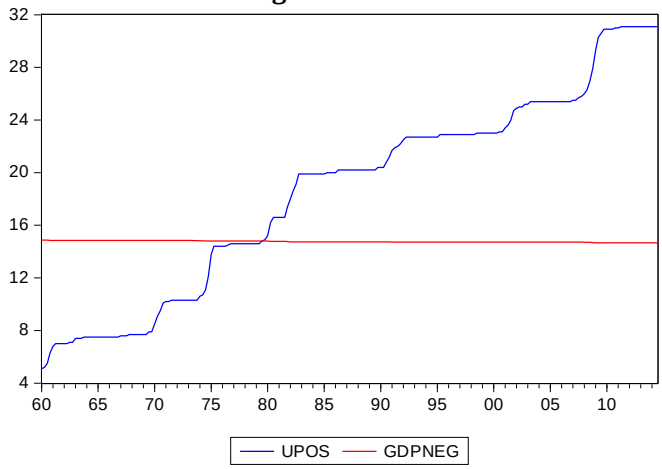



**Figure 24: US**



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