ASERS

Theoretical and Practical Research in Economic Fields

Biannually

Volume III

Issue 1(5)

Summer 2012

ISSN 2068 – 7710

Summer 2012
Volume III, Issue 1(5)

ASERS Publishing
http://www.asers.eu/asers-publishing
ISSN 2068 – 7710

Contents:

Call for Papers
Winter_Issue 2012

Theoretical and Practical Research in Economic Fields

Many economists today are concerned by the proliferation of journals and the concomitant labyrinth of research to be conquered in order to reach the specific information they require. To combat this tendency, **Theoretical and Practical Research in Economic Fields** has been conceived and designed outside the realm of the traditional economics journal. It consists of concise communications that provide a means of rapid and efficient dissemination of new results, models and methods in all fields of economic research.

Theoretical and Practical Research in Economic Fields publishes original articles in all branches of economics – theoretical and empirical, abstract and applied, providing wide-ranging coverage across the subject area.

Journal promotes research that aim at the unification of the theoretical-quantitative and the empirical-quantitative approach to economic problems and that are penetrated by constructive and rigorous thinking. It explores a unique range of topics from the frontier of theoretical developments in many new and important areas, to research on current and applied economic problems, to methodologically innovative, theoretical and applied studies in economics. The interaction between empirical work and economic policy is an important feature of the journal.

Theoretical and Practical Research in Economic Fields, starting with its first issue, it is indexed in RePEC, IndexCopernicus, EBSCO, ProQuest and CEEOL databases.

The primary aim of the Journal has been and remains the provision of a forum for the dissemination of a variety of international issues, empirical research and other matters of interest to researchers and practitioners in a diversity of subject areas linked to the broad theme of economic sciences.

All the papers will be first considered by the Editors for general relevance, originality and significance. If accepted for review, papers will then be subject to double blind peer review.

Deadline for submission of proposals:	15th November 2012
Expected Publication Date:	January 2013
Web:	www.asers.eu/journals/tpref/
E-mail:	tpref@asers.eu

To prepare your paper for submission, please see full author guidelines in the following file: TPREF_Full_Paper_Template.doc, then send it via email at tpref@asers.eu.

MODELING UNEMPLOYMENT AND EMPLOYMENT IN ADVANCED ECONOMIES: OKUN'S LAW WITH A STRUCTURAL BREAK

Ivan KITOV
Institute for the Dynamics of the Geopsheres, **Russia**
ivan.O.Kitov@gmail.com
Oleg KITOV
Department of Economics, University of Oxford, **UK**
oleg.Kitov@economics.oxford.ac.uk

Abstract:

Using a modified version of Okun's law, we have modeled the rate of unemployment and the employment/population ratio in several largest developed countries: Australia, Canada, France, Japan, the UK, and the U.S. Our results show that the evolution of the (un)employment rate since the early 1970s can be predicted with a high accuracy by a linear dependence on the logarithm of real GDP per capita. All empirical relationships estimated in this study need a structural break somewhere between 1975 and 1995. We argue that these breaks are of artificial nature and were caused by similar changes in measurement procedures in all studied counties: the deviation between the GDP deflator and CPI and the structural breaks in the modified Okun's law are synchronous. Statistically, the link between measured and predicted rate of (un)employment is characterized by R^2 from 0.84 (Australia) to 0.95 (Japan). The model residuals are likely to be associated with measurement errors.

Keywords: employment, unemployment, real GDP, modeling, Okun's law.

JEL Classification: J65.

1. Introduction

There is an economic problem which is likely felt as superior to all other problems in the socio-economic domain. This problem is employment. At all times, paid jobs are the most important source of income. Unemployment is an issue of the same importance but is rather a complementary part of the employment problem. In the short run, the change in unemployment is practically equal to the change in employment, with the level of labor force, i.e. the net change in unemployment and employment, evolving at a slower pace.

It is instructive to use the trade-off between the rate of unemployment and the employment/population ratio to predict the workforce evolution in developed countries. As we have recently revealed, Okun's law (Okun, 1962) is able to provide a very accurate prediction technique for the rate of unemployment (Kitov, 2011). Therefore, one can test real economic growth, as expressed by the change rate of real GDP per capita, as the driving force behind the employment/population ratio.

2. Modified Okun's Law

Since the quantitative description of unemployment was very successful with only GDP as a predictor, we do not include in our employment model economic, financial, demographic, educational, or any other variables. Hence, we do not use any of the assumptions underlying the dynamic labor market models *introduced and developed by Diamond (2011), Mortensen (2007) and Pissarides (2000) among others. Our model is a parsimonious and purely empirical one.*

We will seek a theoretical explanation in due course. This is a difficult task since the current understanding of the employment market is poor. One may judge the failure of many theoretical models (Zhu, 2008) by the evolution of employment and unemployment in the OECD countries during the 2008 crisis. The OECD (2007) projected the rate of unemployment to fall during 2008 in the OECD area and expected the level of 5.5% in average. Unfortunately for the OECD countries, there was no sign of the approaching failure in any theoretical or empirical model of the labor market.

We start with a modified Okun's law, where real GDP is replaced with per capita GDP. We also extend the modified Okun's law by integration of both sides of the relevant equation. As a result, one obtains a link between the rate of (un)employment and the logarithm of the overall change in real GDP per capita accompanied by a linear time trend with a positive slope. Thus, our model uses levels instead of derivatives.

For our empirical study, we use the most recent data on GDP per capita provided by the Conference Board (2011) and data on the (un)employment rate from the U.S. Bureau of Labor Statistics (2011). For several developed countries, the latter time series are available only from 1970. For the U.S., all variables are available since 1948. We allow for a structural break in the link between the (un)employment rate and real GDP per capita which might manifest artificial changes in definitions of employment and real GDP as well as actual shifts in the linear relationship.

Kitov (2011) has tentatively assessed several quantitative unemployment models based on Okun's law in the biggest developed countries: the United States, the United Kingdom, France, Australia, Canada and Spain. In this article, we enhance these tentative models and the link between employment and real GDP is also studied in the same countries except Spain (BLS does not provide the employment/population ratio). Instead of Spain we included Japan in the list. Our statistical results suggest the presence of a reliable relation between (un)employment and real GDP per capita.

According to the gap version of Okun's law, there exists a negative relation between the output gap, $(Y^p-Y)/Y^p$, where Y^p is potential output at full employment and Y is actual output, and the deviation of actual unemployment rate, u, from its natural rate, u^n. The overall GDP or output includes the change in population as an extensive component which is not necessary dependent on other macroeconomic variables. Econometrically, it is mandatory to use macroeconomic variables of the same origin and dimension. Therefore, we use real GDP per capita, G, and the modified version of Okun's law has the following form:

$$du = a + bdlnG \quad (1)$$

where: du is the change in the rate of unemployment per unit time (say, 1 year);
$dlnG = dG/G$ is the relative change rate of real GDP per capita;
a and b (<0) are empirical coefficients.

The intuition behind Okun's law is very simple. Everybody may feel that the rate unemployment is likely to rise when real economic growth is very low or negative. An economy needs fewer employees to produce the same or smaller real GDP also because of the growth in labor productivity.

When integrated from t_0 to t, equation (1) can be rewritten in the following form:

$$u_t = u_0 + bln\,[G_t/G_0] + a(t-t_0) + c \quad (2)$$

where u_t is the rate of unemployment at time t. The intercept $c \equiv 0$, as is clear for $t=t_0$.

Instead of using the continuous form (2), we calculate a cumulative sum of the annual estimates of $dlnG_i$. As a result, for any time t we need only the initial (G_0) and current (G_t) estimates of real GDP per capita, what ignores the path between these points. By definition, the cumulative sum of the observed du_t (= u_{t+1} -u_t) is the time series of the unemployment rate, u_t: $u_{t+1} = u_t + du_t$. Statistically, the use of levels, i.e. u and G, instead of their differentials is superior due to the effective suppression of uncorrelated measurement errors.

Figure 1 depicts the evolution of annual increments in the rate of unemployment, du, in the U.S. and that of the employment/population ratio, e, with a negative sign, $-de$. Both curves evolve practically in sync from 1949 to 2010 with the du series demonstrating a slightly higher volatility. A linear regression gives for the curves in Figure 1 a slope of 1.24 and R^2=0.88. It is an important observation that du almost coincides with – de in amplitude after 1985. The higher level of correlation between these variables allows formulating quantitatively a modified Okun's law for de:

$$de = \alpha + \beta dlnG \quad (3)$$

where β should be a positive constant. Equation (3) is the sought functional dependence between the first differences of the rate of employment and the growth rate of real GDP per capita.

When integrated, relationship (3) has the following form:

$$e_t = e_0 + \beta ln[G_t/G_0] + \alpha(t-t_0) \quad (4)$$

In this study, we use (2) and (4) for the estimation of all coefficients by a standard *LSQ* method. We seek the best fit between the measured and predicted rate of (un)employment.

Kitov (2011) has shown the necessity of a structural break in (1). Figure 1 also suggests that the link between *de* and *dlnG* might change around 1985 because the relationship between *du* and *de* also changes. Therefore, we introduce a structural break with floating timing in (2) and (4). Due to the difference in characteristics of the measurement noise between employment and unemployment, the years of the sought structural breaks, which have to be estimated by the best fit method, may differ by a few years. The measurement noise also includes all changes in definitions which make the time series of (un)employment quantitatively incompatible in time, as the BLS explicitly reports.

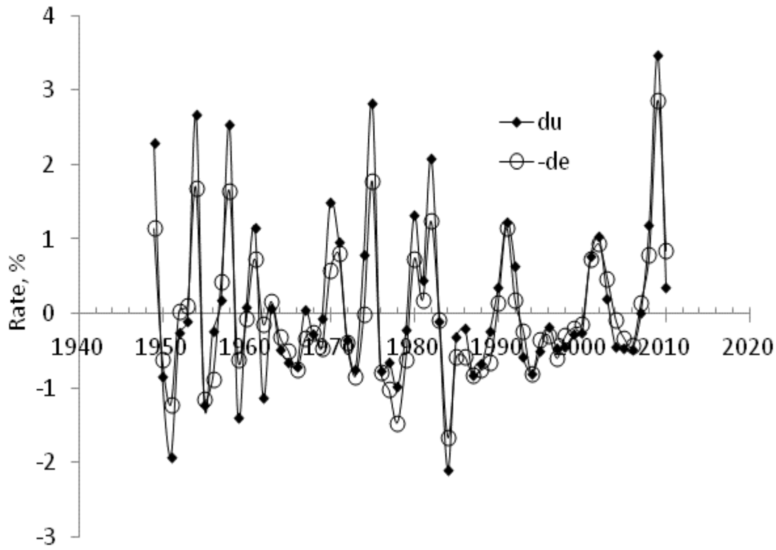

Figure 1. The evolution of *du* and *–de* in the U.S. between 1949 and 2010

For the U.S., we allow the break year to vary between 1975 and 1995. Thus, relationship (4) should be split into two segments:

$$e_t = e_0 + \beta_1 ln[G_t/G_0] + \alpha_1(t-t_0),\ t<t_s$$
$$e_t = e_s + \beta_2 ln[G_t/G_{ts}] + \alpha_2(t-t_s),\ t \geq t_s \qquad (5)$$

where e_0 is the measured employment/population ratio at time t_0; e_s is the predicted employment/population ratio at the time of structural break t_s; α_1 and β_1, α_2 and β_2 are empirical coefficients estimated before and after the structural break, respectively. The integral form of the modified Okun's law for unemployment should be also split into two time segments:

$$u_t = u_0 + b_1 ln[G_t/G_0] + a_1(t-t_0),\ t_0<t<t_s$$
$$u_t = u_s + b_2 ln[G_t/G_{ts}] + a_2(t-t_s),\ t \geq t_s \qquad (6)$$

In the next Section, we estimate all coefficients and timing of structural breaks in (5) and (6). All time series are obtained from the same sources. Thus, we avoid, in part, the incompatibility of measuring procedures and definitions in different countries. Twenty years ago almost all developed countries had different definitions of unemployment and employment. Moreover, these internal definitions were subject to numerous revisions which made these domestic time series incompatible over time. Apparently, these incompatibility problems in (un) employment time series cannot be resolved at all since the appropriate measurements were not conducted. Therefore, one should not exclude the possibility of structural breaks in some labor force series, which might be synchronized with the breaks in real GDP per capita.

3. Empirical results

We start with the case of the U.S. Since we have already estimated a preliminary empirical relationship for the rate of unemployment using only the best visual fit (Kitov, 2011), it is important to re-estimate Okun's law using a reliable statistical procedure. The method of least squares applied to the integral form of Okun's law (6) results in the following relationship:

$$\begin{aligned} du_p &= -0.406dlnG + 1.095, \; 1979 > t \geq 1951 \\ &\quad [0.04] \qquad [0.07] \\ du_p &= -0.465dlnG + 0.895, \; 2010 \geq t \geq 1979 \\ &\quad [0.04] \qquad [0.06] \end{aligned} \tag{7}$$

where du_p is the predicted annual increment in the rate of unemployment, *dlnG* is the (measured) relative change rate of real GDP per capita per one year.

There is a structural break in 1979 which divides the whole 60-year interval into two practically equal segments. In 1979, the slope changed from -0.406 to -0.465 and the intercept from 1.095 to 0.895. Instructively, the ratio of the slopes is (0.465/0.406=) 1.15 with the ratio of the respective intercepts (0.895/1.095=) 0.81 ~ 1/1.15.

The deviation between the observed and predicted values is very sensitive to all coefficients since the cumulative sums multiply any static error by the number of samples and an error of 0.01 in the intercept rises to 0.5 in 50 years. Not surprisingly, both intercepts are reliable with the standard error of 0.007 and p-value of 10^{-9}. Both slopes are also reliably estimated with the standard error of 0.04 and p-value of 10^{-11}. Since all models in this study have reliable coefficients we skip the results of significance testing.

Here it's worth emphasizing again that the current rate of unemployment depends on its initial value many years ago and the cumulative change in real GDP per capita. Therefore, the uncertainty of coefficients in (7) is defined by the net growth in *G* over the sixty year period, which is measured much more accurately than its annual change in the original version of Okun's law. This also means that the current rate of unemployment has to remember its initial value in 1951 (the start point of our model for the U.S.) and even earlier. Hence, the difference in the initial rates of unemployment in developed countries may partly explain the current difference. Obviously, this effect is directly implied by Okun's law.

Figure 2 (left panel) displays the measured and predicted rate of unemployment in the U.S. since 1951; the latter is obtained using the integral form of the modified Okun's law with the *G* estimates from 1951 to 2010. The agreement between these curves is excellent with the standard error of 0.55%. The time series of model error is displayed in the right panel of Figure 2. The average rate of unemployment for the same period is 5.75% with the mean (absolute) annual increment of 1.1%. All in all, this is a very accurate model of unemployment with R^2=0.89. Hence, the model (the integral Okun's law) explains 89% of the variability in the rate of unemployment between 1951 and 2010.

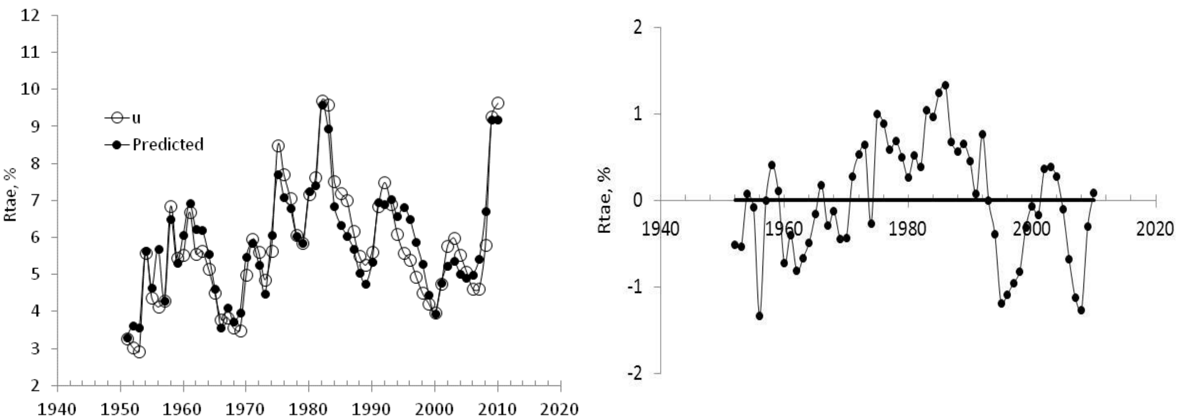

Figure 2. Left panel: The observed and predicted rate of unemployment in the USA between 1951 and 2010. Right panel: the model error with the regression line coinciding with the x-axis

Both variables in (7) are measured with some uncertainty. The rate of unemployment is estimated in the Current Population Surveys which are conducted every month by the Census Bureau for the Bureau of Labor Statistics. The Bureau of Labor Statistics (2006) describes non-sampling and sampling errors associated with unemployment measurements in the CPS and multiple revisions to unemployment definition and procedures (e.g. a major revision in 1978). Considering all these factors, the inherent uncertainty in the (annualized) rate of unemployment might be crudely estimated as 0.2% to 0.4%. The level of real GDP per capita is also subject to measurement uncertainty. The accuracy of annual estimates could be roughly estimated as 0.5 to 1.0 percentage points. With the empirical slope in (7) of ~0.5, the uncertainty in *G* is transformed in the uncertainty of 0.2% to 0.4% in the rate of unemployment. Thus, the model error of 0.55% is likely wholly related to the measurement errors. Statistically, there is almost no room for any other macroeconomic variables to influence the rate of unemployment, except they are affecting the real GDP per capita.

In (7), the rate of real GDP growth has a threshold of (0.895/0.465=) 1.92% per year for the rate of unemployment to be constant. When $dlnG > 0.0192$, the rate of unemployment in the U.S. decreases. Figure 3 displays the evolution of *dlnG* since 1979. On average, the rate of growth was 1.65% per year, i.e. slightly lower than the threshold and the rate of unemployment has been increasing since 1979.

Empirical model (7) suggests a tangible shift in slope and a significant change in intercept around 1978. This is a very important finding. There are two terms in (7) which define the evolution of the unemployment rate: real economic growth counteracts the positive linear time trend. Figure 4 depicts both components. The difference or the distance between $a(t-t_0)$ and $-bln(G_t/G_0)-u_0$ in Figure 4 is the rate of unemployment.

We have mentioned already that the 1979 break is associated with artificial changes in measurement units. Let's, however, assume that the structural break in 1979 was related to a true change in the macroeconomic behavior. The result of this "true" change is obvious when we extend the trend $a_1(t-t_0)$ observed before 1979. The distance would have been much larger with the old trend after 1979, i.e. the rate of unemployment would have been also higher than that actually measured. If to extrapolate the current time trend and the dependence on *G* one can project the rate of unemployment. Figure 4 also depicts such a projection through 2050. Without a new structural break, the rate of unemployment in 2050 will be near 25% (like in Spain). It would be good if the U.S. is currently struggling through a transition to a new relation in (7) which will be able to keep the rate of unemployment below 10%. In any case, the growth rate of real GDP per capita has to be much higher than 2% per year in order to reduce the current rate of unemployment to the level of 5%.

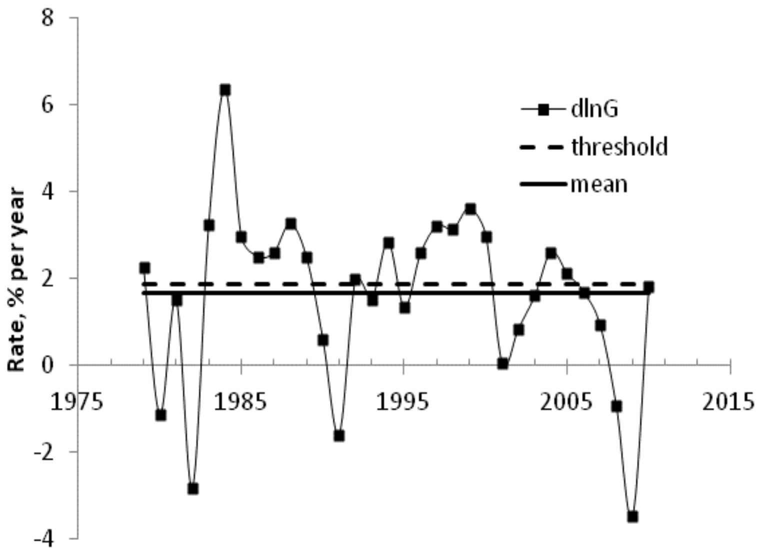

Figure 3. The growth rate of real GDP per capita, *dlnG*, as a function of time
Also shown is the threshold rate of 1.92% per year and the mean growth rate 1.65% per year

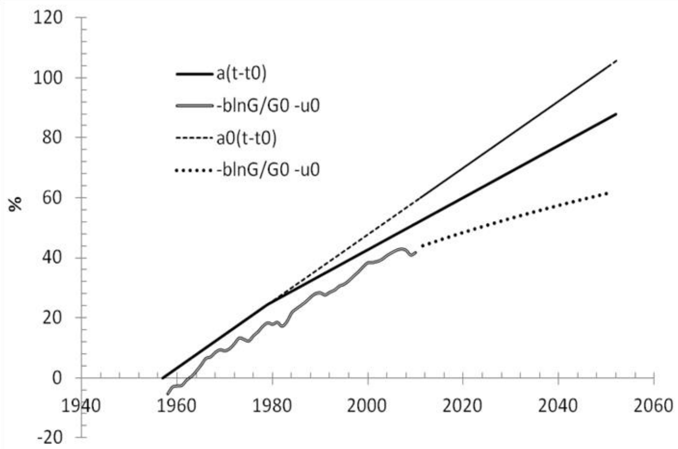

Figure 4. The evolution of two components in (7) defining the unemployment rate

In the above paragraph, we assumed constant increment of real GDP per capita when extrapolating its evolution into the future. For a constant annual increment, one obtains a logarithmic time trend which follows from our model of economic growth (Kitov, 2009). We have introduced an inertial growth component, $(dlnG/dt)_i$, which is inversely proportional to the attained level of real GDP per capita:

$$(dlnG/dt)_i = C/G \quad (8)$$

where C is an empirically estimated constant. The term *C/G* represents the inertial rate of growth. Figure 5 demonstrates the observed evolution of *G* since 1950 and gives two projections: a linear one with an annual increment *C*=\$591.5 (2010 U.S. dollars) and an exponential growth following the trend observed before 2010. The deviation between these projections is fast and the next few years should help to distinguish between them.

After obtaining relationship (7) with a high predictive power for the rate of unemployment we have estimated (using the integral form) a modified Okun's law for the employment/population ratio:

$$de = 0.277dlnG - 0.457,\ 1983 > t \geq 1951$$
$$de = 0.496dlnG - 0.870,\ 2010 > t \geq 1983 \quad (9)$$

Figure 6 compares the observed and predicted change in the employment/population ratio. Figure 7 shows the cumulative curves for both time series in Figure 6. It also provides some hints on the nature of the break near 1983. The difference between 1979 and 1983 as the estimated break years might be related to the effect of measurement noise on the results of the least squares method: even small deviations in noise may affect the RMS error and the break year shifts. In reality, the employment/population ratio jumped from ~57% in 1982 and ~63% in 1989. The change in slope in (7) and (9) is rather similar: both the rate of employment and unemployment is more sensitive to the rate of change in GDP after the break.

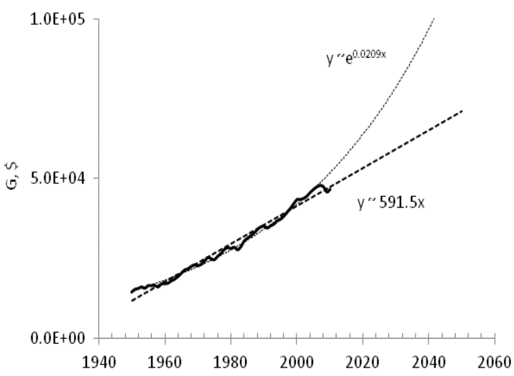

Figure 5. The evolution of *G* over time with a projected linear trajectory for *C*=\$591.5 and an exponential trajectory $G_t=G_0 exp(0.0209t)$,
where the exponent corresponds to that obtained for the period between 1950 and 2010

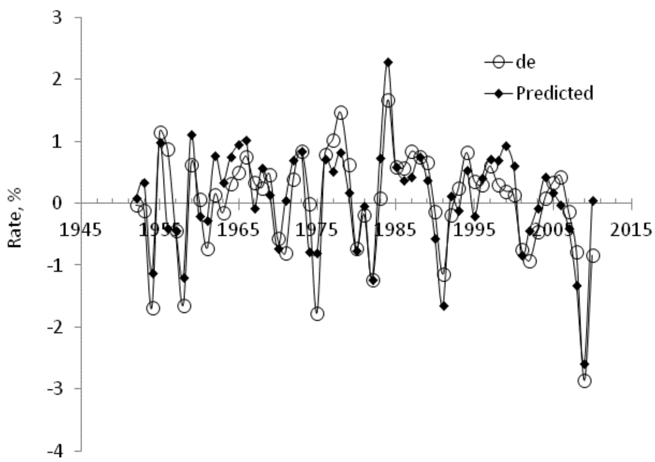

Figure 6. The observed and predicted change in the employment/population ratio, *de*

The next country to model is the United Kingdom. The change in the unemployment rate is also highly correlated with the change in employment/population ratio, R^2=0.79. Figure 8 shows both curves between 1972 (the employment rate estimates are available since 1971) and 2010. As expected, the change in the rate of unemployment is more volatile. The best fit models for the rate of (un)employment in the UK is as follows:

$du_t = -0.63dlnG_{t-1} + 1.35$, $1987 > t > 1965$
$du_t = -0.39dlnG_{t-1} + 0.63$, $2010 \geq t \geq 1988$

$de_t = 0.41dlnG_{t-1} - 1.11$, $1983 > t > 1971$
$de_t = 0.41dlnG_{t-1} - 0.81$, $2010 \geq t \geq 1983$ (10)

where $dlnG_{t-1}$ is the change rate of real GDP per capita one year before, i.e. the predicted curve leads by one year. Figure 9 shows the cumulative curves for the time series in (10). The agreement between the curves is excellent with R^2=0.89. The standard error is 0.47% between 1972 and 2009. There is a large deviation from the measured employment/population ratio after 2008. This deviation is consistent with the difference between *de* and –*du* in 2009.

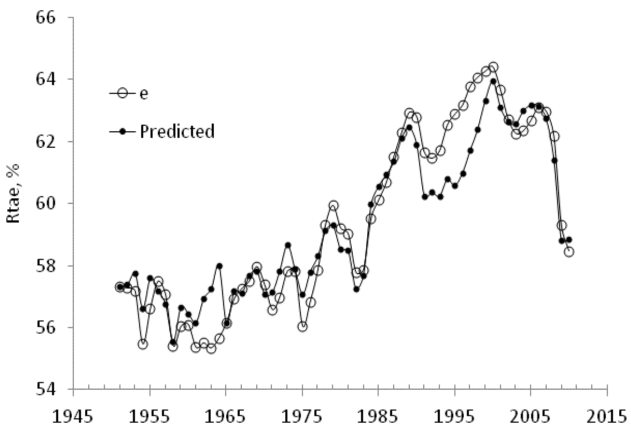

Figure 7. The cumulative curves for the observed and predicted change in the employment/ population ratio in the U.S.

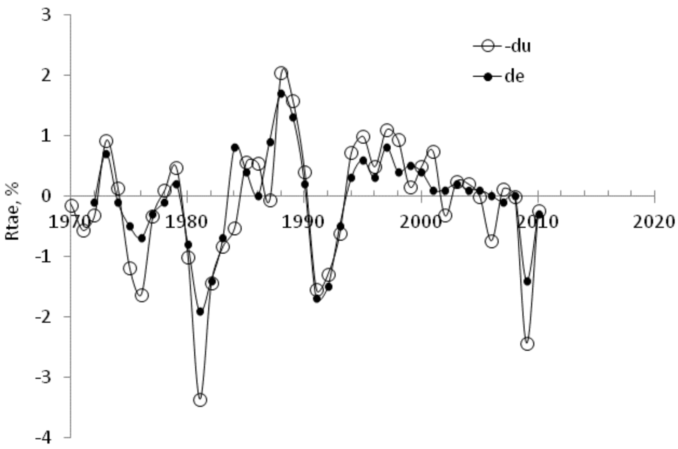

Figure 8. The (negative) change in the rate of unemployment, *-du*, compared to the change in the rate of employment in the UK

There is a structural break near 1983 (1987 for unemployment) which is expressed by a significant shift in intercept without any change in slope. The employment/population ratio varies around 58%; between 54.3% in 1982 and 61% in 1972. After 1983, relationship (10) implies that the UK needs the rate of GDP growth above (0.81/0.41=) 1.97% per year to increase the employment rate. However, the discrepancy between the measured and predicted curves after 2008 may manifest the start of a transition to a new dependence in (10), with a lower sensitivity of the employment rate to the change in GDP. When of artificial nature, this discrepancy also affects all coefficients in (10).

For the rate of unemployment, the threshold is 1.65% per year after 1987. Therefore, the rate of employment is slightly harder to rise with real economic growth. In the U.S., the situation is apposite. Considering the uncertainty in all coefficients, the hypothesis that both thresholds for a given country are equal cannot be rejected.

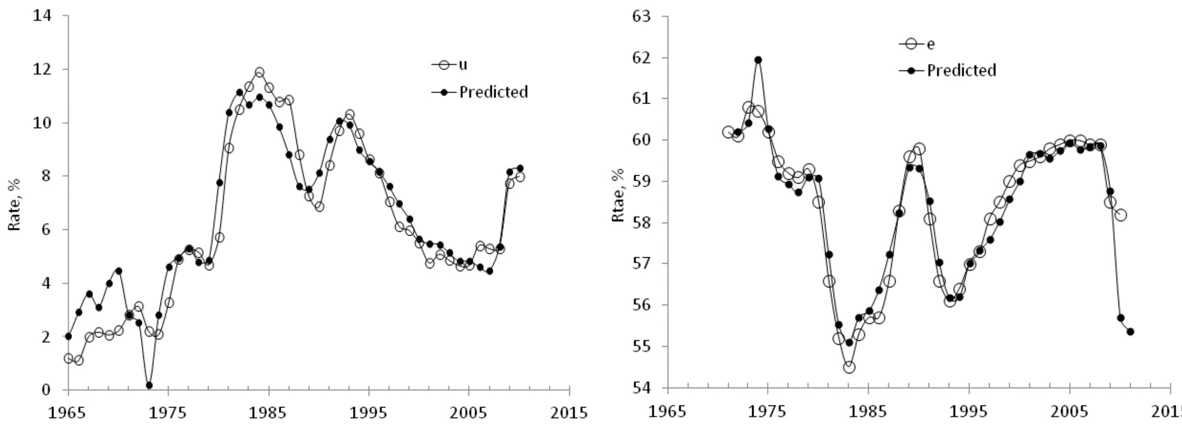

Figure 9. The cumulative curves for the observed and predicted change in the rate of unemployment and employment/ population ratio in the UK

In Canada, the change in the rate of employment, *de*, and the rate of unemployment, *du,* are well correlated (R^2=0.76) as Figure 10 demonstrates. As in other developed countries, the rate of unemployment is more volatile. For Canada, the following best-fit models have been obtained by the least-squares (as applied to the cumulative sums):

$du_t = -0.39 dlnG_t + 1.16,\ 1983 > t > 1970$
$du_t = -0.28 dlnG_t + 0.30,\ 2010 \geq t \geq 1983$

$de_t = 0.40 dlnG_t - 0.67,\ 1984 > t > 1970$
$de_t = 0.44 dlnG_t - 0.56,\ 2010 \geq t \geq 1984$ (11)

Figure 11 shows the cumulative curves for all involved time series in (11). For the rate of employment, the overall fit is very good with R^2=0.84 and the standard error of 0.83% between 1971 and 2010. Before 1984, the predicted curve is likely leading the measured one by 1 year. It is important that the most recent period is well described and the fall in the employment rate in 2009 was completely driven by the drop in real GDP per capita.

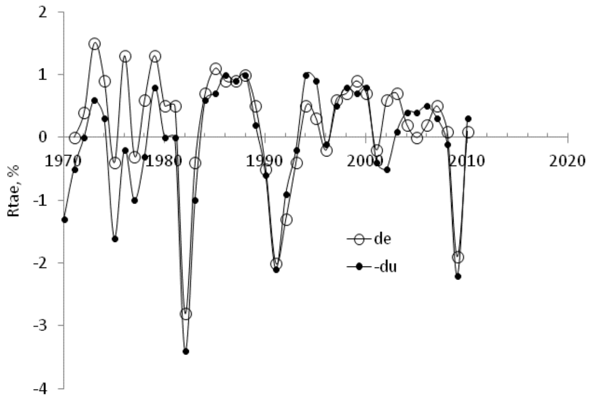

Figure 10. The (negative) change in the rate of unemployment compared to the change in the rate of employment in Canada

There is a structural break near 1984 (1983 for unemployment) which is expressed by a slight shift in the slope and intercept. The employment/population ratio varies between ~54.5% in 1971 and ~64.1% in 2008. For the period after 1984, relationship (11) demands the rate of GDP growth above (0.56/0.44=) 1.27% per year for the employment rate to increase. Otherwise, the employment rate will be falling and the rate of unemployment will be increasing. The rate of unemployment has a threshold of 1.07% per year.

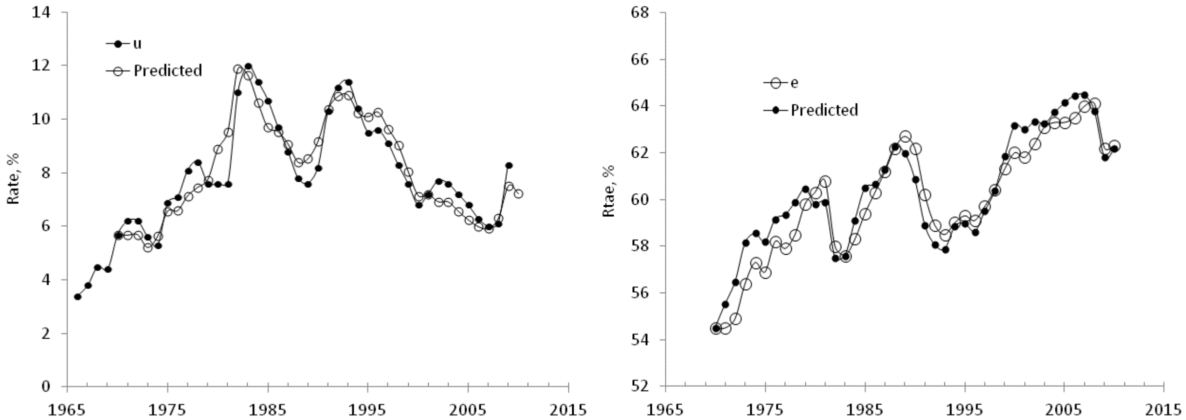

Figure 11. The cumulative curves for the observed and predicted change in the rate of (un)employment in Canada

France gives another example of successful modeling. As expected, the change in the rate of unemployment in Figure 12 is more volatile except the step in the employment rate near 1982. This is a completely artificial break from 53.2% in 1981 to 55.3% in 1982, and we do not need to model it. It is worth noting that *-du* and *de* diverge in 2010. This means that Okun's law for France does not fit observations or the observations are biased.

For France, the best-fit model for the rate of (un)employment is as follows:

$$du_t = -0.155dlnG_t + 0.805,\ 1988 > t > 1970$$
$$du_t = -0.508dlnG_t + 0.710,\ 2010 \geq t \geq 1988$$

$$de_t = 0.155dlnG_t - 0.65,\ 1994 > t > 1970$$
$$de_t = 0.250dlnG_t - 0.30,\ 2010 \geq t \geq 1994 \quad (12)$$

Figure 13 shows the cumulative curves for the time series in (12). There is a structural break near 1994 which is expressed by significant shifts in the slope and intercept. The employment/population ratio varies between ~56% in 1970 and 50.4% in 1992. The agreement is good with R^2=0.91 and the standard error of 0.39% for the period between 1971 and 2010. The rate of employment grows when the rate of GDP growth exceeds (0.30/0.25=) 1.2% per year.

Figure 14 compares the change in the rate of employment and the rate of unemployment, in Australia. The best-fit models are as follows:

$$du_t = -0.69dlnG_t + 1.50,\ 1995 > t > 1975$$
$$du_t = -0.45dlnG_t + 0.75,\ 2010 \geq t \geq 1995$$

$$de_t = 0.50dlnG_t - 0.92,\ 1983 > t > 1970$$
$$de_t = 0.41dlnG_t - 1.08,\ 2010 \geq t \geq 1983 \quad (13)$$

Figure 15 shows the cumulative curves for the time series in (13). For the employment rate, there is a structural break near 1983 which is expressed by tangible shifts in slope and intercept. The employment/population ratio varies between 55% in 1983 and 64% in 2008. The agreement is relatively good with R^2=0.84 and the standard error 1.19% for the period between 1971 and 2010. For the rate of unemployment, the break was in 1995 but is accompanied by a smaller shift in coefficients with a higher R^2=0.87. Figure 15 implies that the rate of employment is overestimated since 1995 and thus the structural break after 1995 is likely a better hypothesis.

We finish modeling the evolution of the employment rate in developed countries with Japan. Figure 16 compares the change in the rate of employment, *de*, and the negative rate of unemployment, -*du*. The latter variable is as volatile as former one and they differ drastically (R^2=0.45) compared to the synchronized evolution of these variables in the U.S. That's why we have failed to obtain a reasonable Okun's law for Japan: the measured rate of unemployment is suspicious and most probably is biased down before 1980.

The employment/GDP model for Japan is similar to Okun's law. The best-fit model has been obtained by the least-squares (applied to the cumulative sums):

$$de_t = 0.02dlnG_t - 0.53,\ 1978 > t > 1965$$
$$de_t = 0.14dlnG_t - 0.42,\ 2010 \geq t \geq 1978 \quad (14)$$

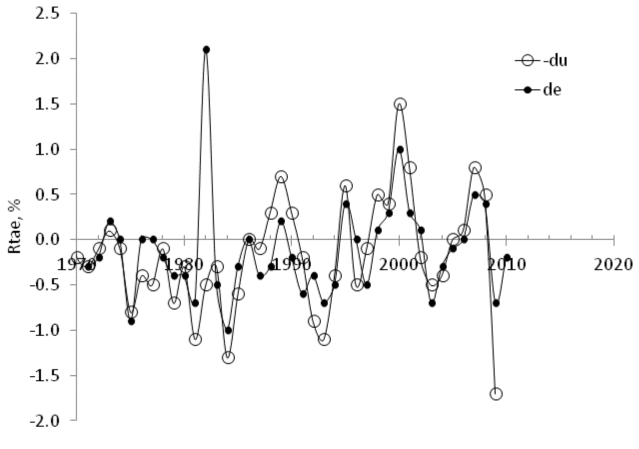

Figure 12. The (negative) change in the rate of unemployment compared to the change in the rate of employment in France

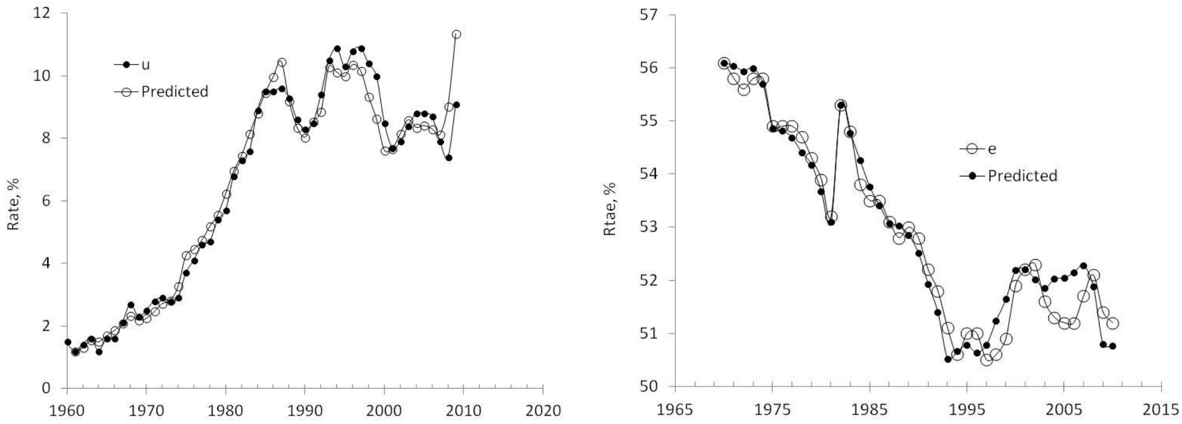

Figure 13. The cumulative curves for the observed and predicted change in the employment/population ratio in France

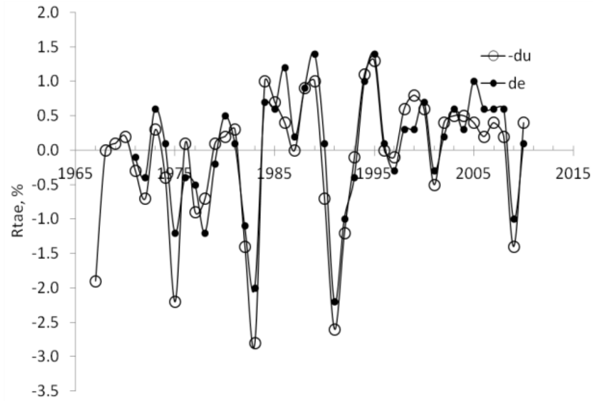

Figure 14. The (negative) change in the rate of unemployment compared to the change in the rate of employment in Australia

Figure 17 shows the cumulative curves for the time series in (14). There is a structural break in 1978 which is expressed by a dramatic shift in slope and a slight break in intercept. The employment/population ratio varies between 64% in 1970 and 56% in 2010. The agreement is excellent with R^2=0.95 and the standard error 0.50% for the period between 1971 and 2010. The coefficient of determination might be biased up when both time series are nonstationary. In the long run, we consider both variables as stationary ones despite the negative trend since 1970.

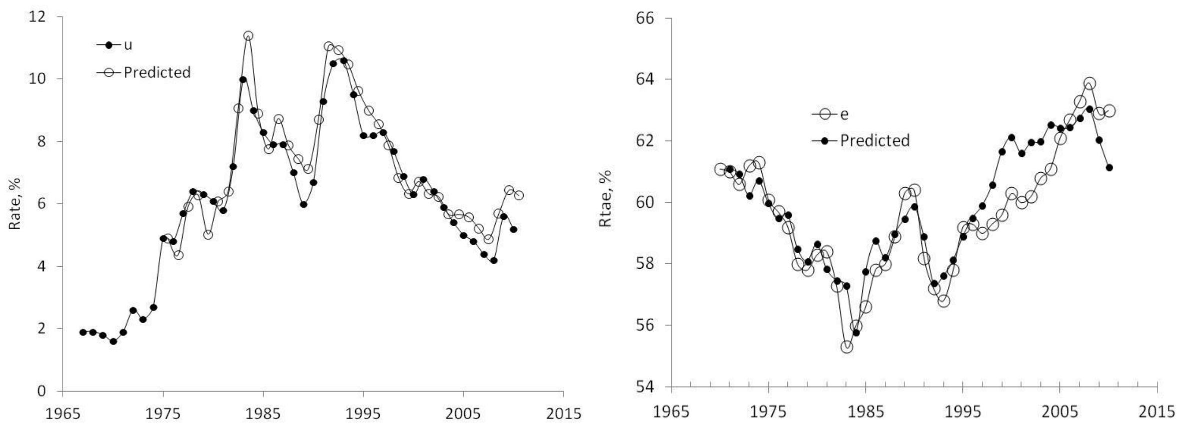

Figure 15. The cumulative curves for the observed and predicted change in the employment/ population ratio in Australia

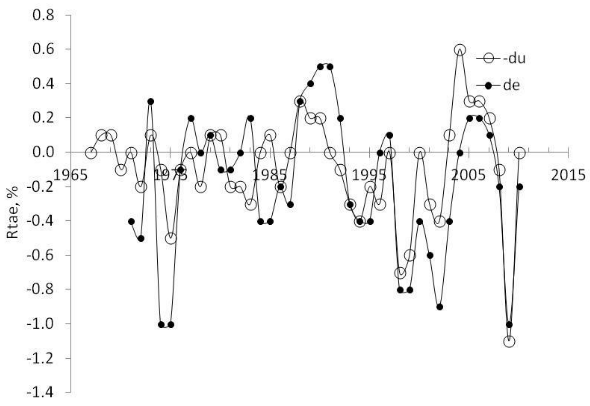

Figure 16. The (negative) change in the rate of unemployment compared to the change in the rate of employment in Japan

In this Section, we have modeled the rate of unemployment and employment in the biggest developed countries. All models include structural breaks, which may differ for unemployment and employment. This difference in timing might be caused by specific properties of measurement noise but the cause of all breaks is likely of the same nature. In the next Section, we present a series of structural breaks in the GDP deflator, which are synchronized with the breaks in the rate of employment.

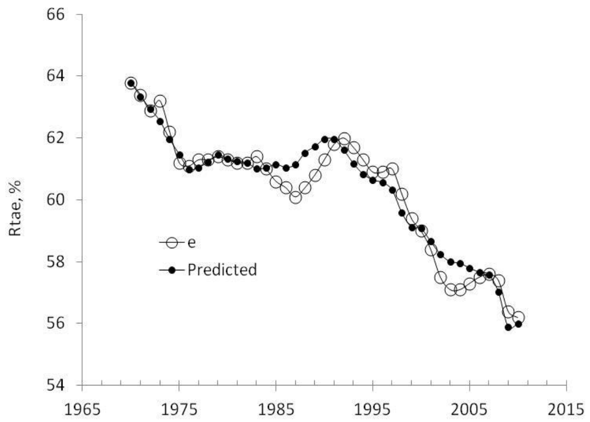

Figure 17. The cumulative curves for the observed and predicted change in the employment/ population ratio in Japan

4. On the Nature of Structural Breaks

We have revealed statistically reliable links between (un)employment and real GDP. However, there is a crucial question on the cause of the structural breaks. There are two possibilities have discussed in Section 2: all structural breaks are of artificial nature (e.g. change in measurement units) or manifests some actual change in the response of employment to GDP. There is a general observation that all breaks coincide in time with the split between the GDP deflator, *dGDP*, and the consumer price index, *CPI*, i.e. with the change in measurement procedures associated with real GDP. Specifically, the GDP deflators and CPIs coincide before the breaks and deviate at different rates after the breaks.

Real GDP is defined as the difference between nominal GDP and the GDP price deflator. The latter is not easy to calculate or even evaluate. Before 1978, there was no practical difference between the cumulative inflation values of the CPI and the GDP deflator in the US, as the left panel of Figure 18 demonstrates. This Figure depicts the cumulative inflation as defined by the GDP deflator (dotted line) and the CPI (solid line). These are the cumulative sums of the annual inflation rates from 1929, which are different from the relevant price indices since they are differently calibrated in the beginning.

Effectively, the *dGDP* and *CPI* curves in Figure 18 coincide before and diverge after 1978. We found no direct statement on the reasons of the change in definitions in the relevant BEA document (2008), but one might guess that this is likely related to the introduction of a new methodology measuring the overall price inflation. This difference has likely affected our analysis of Okun's law and forced the introduction of a structural break in 1978.

Interestingly, the CPI can be represented is a linear function of the GDP deflator after 1978:

$$CPI_t = 1.2dGDP_t \qquad (15)$$

In Figure 18, the *CPI* cumulative curve practically coincides with the *1.2dGDP* curve.

Apparently, before 1978 the CPI was used to estimate of the overall price inflation. Since 1979, the GDP deflator has been used instead of the CPI. In the right panel of Figure 18, we displayed the difference between the *CPI* and *dGDP* cumulative curves. This difference has a clear break in 1978. One should neglect this break in any quantitative analysis involving real GDP: the cumulative change in inflation between 1978 and 2011 is of 22 percentage points. This implies that, when applied to the estimates before 1978, the new concept of the GDP deflator would result in a bigger change in real GDP estimates.

Figure 19 illustrates another unclear feature of the link between the GDP deflator and CPI. Surprisingly, the difference CPI-1.2dGDP varies not randomly but rather oscillates with a changing period. One may expect this difference to rise above the zero line in 2011 and then reach the level of +3 percentage points during the next five years. We have no explanation of this effect.

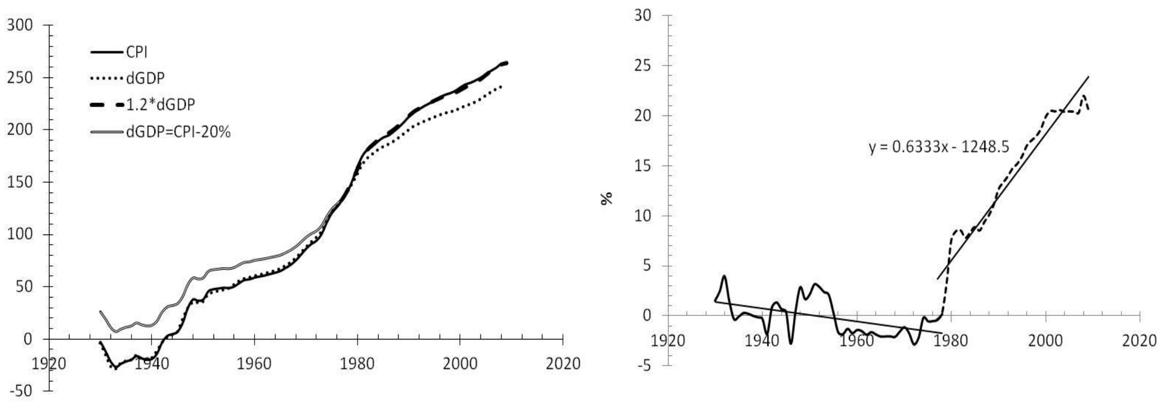

Figure 18. Left panel: Cumulative rates of CPI and dGDP inflation, original and scaled by a factor of 1.2. Right panel: The difference between the original cumulative curves of the CPI and dGDP. The timing of the structural break is obvious

Therefore, we have confirmed the hypothesis that the break in Okun's law is likely of artificial nature and it is associated with the definitions of real GDP rather than with actual process in the U.S. economy. So to say, the U.S. shifted in 1978 from "mph" to "km/h", but still uses the old speed limit as expressed in "mph".

In order to validate this finding we have borrowed data from the OECD and calculated the CPI and dGDP cumulative inflation in Australia, Canada, Japan, France, and the UK, as shown in Figure 20. There are clear breaks in different years. For Australia, the difference is small and starts after 1990. It is worth noting that the slopes in relationship (13) are also close. Apparently, the years of structural breaks in (13) are difficult to estimate due to the measurement noise level.

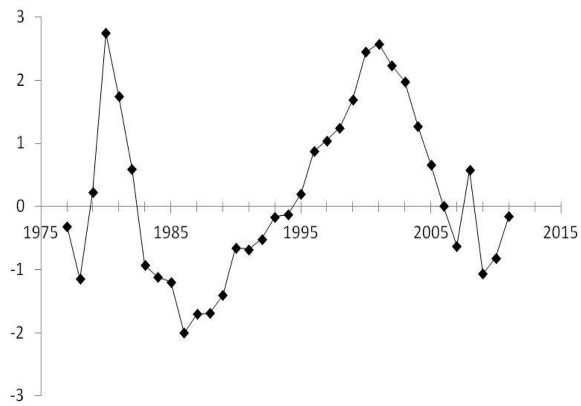

Figure 19. The difference between the cumulative CPI and 1.2dGDP

For Canada, there is a break after 1980 which closely corresponds to the 1983 break in Okun's law (11). The deviation is fast and does not match the small change in the slopes estimated in (11). For the UK, the deviation starts around 1979 (1982 in Okun's law). For some unknown reason, the GDP deflator in the UK rises faster than the CPI. In Japan, the CPI and dGDP diverge since 1974. Considering the accuracy and the length of the initial portion of the time series in Japan since 1971, this year well corresponds to the break in 1978. In France, the discrepancy is marginal and might be dated crudely between 1990 and 1995. This does not contradict the break in 1995, as estimated somewhere between 1988 and 1994 in (12).

Conclusion

We have successfully modeled the evolution of the unemployment rate and employment/ population ratio in a few biggest developed countries using a modified Okun's law with the rate of change of real GDP per capita as the driving force. This model demonstrates an extraordinary predictive power with the coefficient of determination between 0.84 and 0.95. One can accurately describe the dynamics of employment (and thus, unemployment) since 1970. Unfortunately, the OECD does not provide homogenized labor force estimates before 1970 and national data might be biased by severe differences in definitions. The U.S. is the only country we have modeled since 1950. This example shows the accuracy of the model in the past which we could also expect for other developed countries.

Okun's law has been estimated many times for all the studied countries (e.g. Tilleman, 2010; Knotek, 2007; Malley and Molana, 2010; Pierdzioch *et al.*, 2011) but has failed to give more statistically reliable results than those obtained in this study. There are two reasons behind this failure. The original version of Okun's law uses real GDP instead of GDP per capita. This notion has no justification because the rate of unemployment is defined as a portion of the labor force level, i.e. in relative terms independent on the overall population. At the same time, real GDP includes the extensive population growth as a bigger (1% per year in the U.S.) and permanent part of output. In a quantitative model, the extensive part of real GDP introduces a bias proportional to its portion. For the periods of slow growth (e.g. in 2008 and 2009), this portion can be a larger one. As a result, no reliable statistical inference is possible. The use of real GDP per capita removes this bias and all statistical results become reliable.

The second reason is associated with data quality and compatibility over time. The necessity of structural breaks in Okun's law was stressed in many studies (e.g. Huang and Chang, 2005; Marinkov and Geldenhuys, 2007). However, these breaks were considered as related to actual changes in economic behavior. We have shown that all structural breaks in the estimated models of the rate of employment (Okun's law) and the employment/population ratio for the U.S., Japan, Australia, Canada, France, and the United Kingdom are artificial and were forced by the change in real GDP definition in the years of these breaks. Hence, the real GDP estimates are incompatible over the break years and thus biased.

From the side of (un)employment, there were several significant revisions to the relevant definitions. The BLS (2006) provides a short description of major changes and warns about the overall incompatibility of the labor force data. The OECD (2008) provides the same estimates for other developed countries and also states the overall incompatibility due to revisions to definitions and methodology of estimates. The issue of labor force revisions should be taken into account in quantitative modeling of (un)employment as well. Potentially, these revisions introduce small-amplitude level shifts in the related time series which harm the statistical inferences and the model reliability.

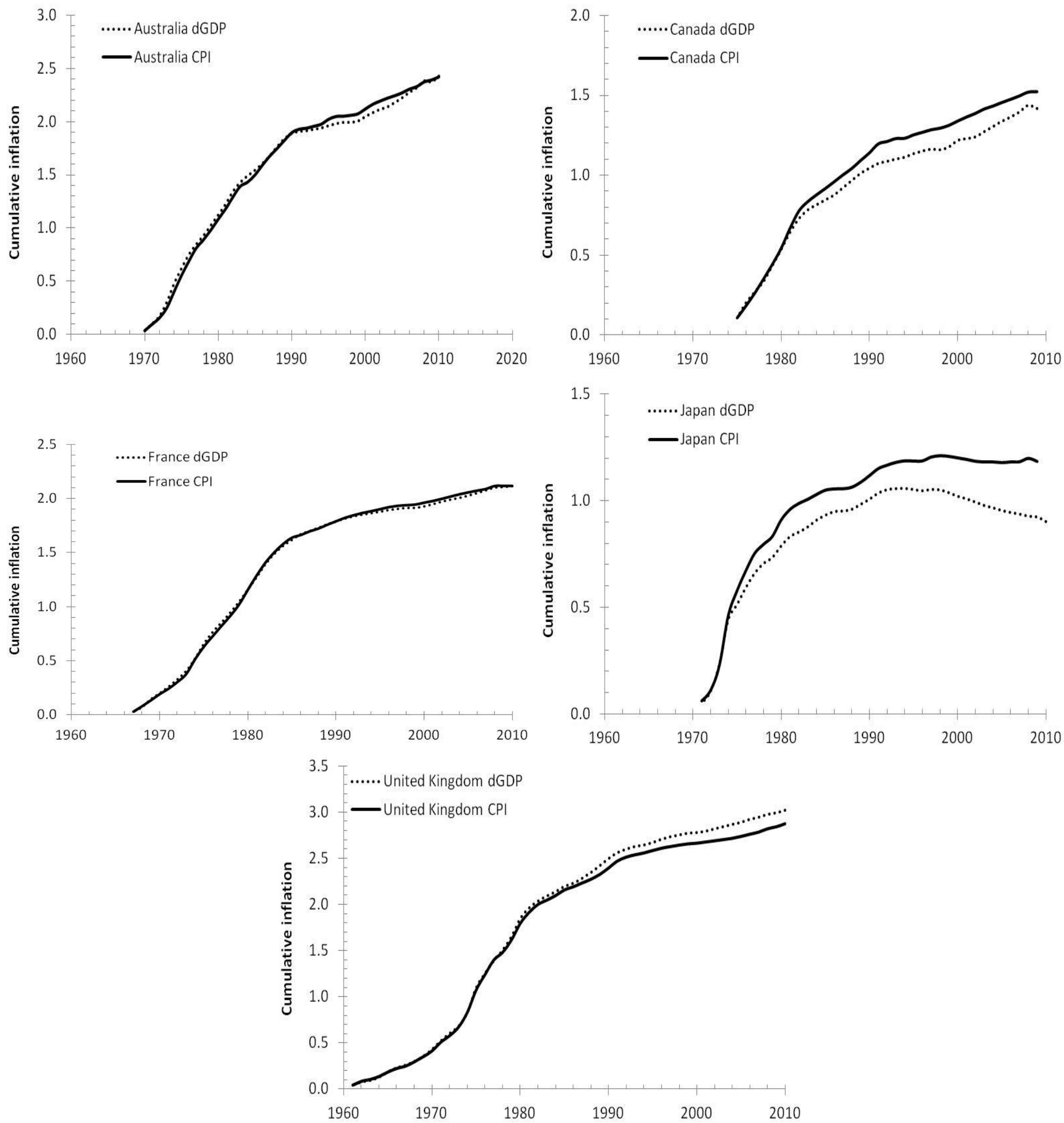

Figure 20. Cumulative values of the GDP deflator and CPI for the studied countries
The years of deviation coincide with structural breaks in Okun's law for the same countries

We have removed both problems in Okun's law and obtained robust quantitative models estimating the evolution of unemployment and employment in the biggest advanced economies. Initially, we revealed modified and integral versions of Okun's law for the United States and then validated the original model by data in Australia, Canada, France, Japan, and the UK. The whole set of modified models should be further validated by new data in the studied economies and data from other developed countries.

References

[1] Bureau of Economic Analysis. 2011. Concepts and Methods of the U.S. National Income and Product Accounts, http://bea.gov/national/pdf/NIPAchapters1-9.pdf.

[2] Bureau of Labor Statistics. 2006. Employment and Earnings, February 2006. Household data, http://www.bls.gov/cps/eetech_methods.pdf.

[3] Bureau of Labor Statistics. 2011. International labor comparisons, retrieved on July 20, 2011 from http://data.bls.gov/.

[4] Conference Board. 2011. Total Economy Database, retrieved on July 20, 2011 from http://www.conference-board.org/data/economydatabase/.

[5] Diamond, P. 2011. Unemployment, Vacancies, Wages. *American Economic Review* 101(4): 1045–72.

[6] Huang, H.C., and Chang, Y-K. 2005. Investigating Okun's law by the structural break with threshold approach: evidences from Canada. Manchester School, University of Manchester 73(5): 599-611.

[7] Kitov, I. 2009. The Evolution of Real GDP Per Capita in Developed Countries, *Journal of Applied Economic Sciences* IV 1(8): 221-234.

[8] Kitov, I. 2011. Okun's law revisited. Is there structural unemployment in developed countries? MPRA Paper 32135, University Library of Munich, Germany.

[9] Knotek, E. S. 2007. How useful is Okun's Law? *Federal Reserve Bank of Kansas City Economic Review* 4th Quarter: 73-103.

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

[11] Marinkov, M., and Geldenhuys, J-P. 2007. Cyclical Unemployment And Cyclical Output: An Estimation Of Okun'S Coefficient For South Africa, South African Journal of Economics, *Economic Society of South Africa* 75(3): 373-390.

[12] Mortensen, D. T. and E. Nagypal. 2007. More on Unemployment and Vacancy Fluctuations, *Review of Economic Dynamics*, 10 (3), pp. 327-347.

[13] OECD. 2007. OECD Employment Outlook, Paris.

[14] OECD. 2008. Notes by Country, http://www.oecd.org/dataoecd/35/3/2771299.pdf.

[15] Okun, A.M. 1962. Potential GNP: Its Measurement and Significance, American Statistical Association, *Proceedings of the Business and Economics Statistics Section*: 98–104.

[16] Pissarides, C.A. 2000. Equilibrium Unemployment Theory, Cambridge: MIT.

[17] Pierdzioch, C., Rulke, J-C., and Stadtmann, G. 2011. Do professional economists' forecasts reflect Okun's law? Some evidence for the G7 countries, *Applied Economics*, v. 43(11), pp. 1365-1373.

[18] Tillemann, P. 2010. Do FOMC members believe in Okun's Law? *Economics Bulletin* 30(3): 2398-2404.

[19] Zhu, Y. 2008. Globalisation, Employment, and Wage Rate: What Does Literature Tell Us? IMK, Working Paper 07/2008.

ASERS Publishing

ASERS

ASERS Publishing
Web: www.asers.eu
URL: http://www.asers.eu/asers-publishing
ISSN 2068 – 7710