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Unemployment convergence analysis for Nordic countries: Evidence from linear and nonlinear unit root tests

Burak GÜRIŞ
Istanbul University, Istanbul, Turkey
bguris@istanbul.edu.tr
İpek M. YURTTAGÜLER
Istanbul University, Istanbul, Turkey
ipeksa@istanbul.edu.tr
Muhammed TIRAŞOĞLU
Istanbul University, Istanbul, Turkey
muhammed.tirasoglu@istanbul.edu.tr

Abstract. *The purpose of this study is to analyze the unemployment convergence in the NORDIC countries. The linearity test developed by Harvey et al. (2008) was used, the Sollis (2009) nonlinear unit root test was used for the countries the nonlinearity of which have been identified and the Narayan and Popp (2010) test was used for the series the linearity of which have been identified. As a result of the analysis, it was found out that the unemployment rates in Finland, Norway and Sweden converged to the NORDIC mean whereas the unemployment rates in Denmark and Iceland did not converge to the NORDIC mean. Based on this result, it could be said for Denmark and Iceland that the shocks to unemployment rate differentials are persistent.*

Keywords: Convergence, Nonlinear Unit Root Test, Linear Unit Root Test, Linearity, Unemployment Rate.

JEL Classification: C22, J64.

1. Introduction

The concept of convergence has been one of the topics frequently discussed in the mainstream literature of economy since the end of 1980s. The discussion is around to what extent these existing differences of international societies, countries or regions with different distribution of natural resources and different income levels would continue. In other words, the topics on in which direction inequalities between economies would change constitute the basis of convergence discussions.

The validity of the contemporary economic growth models in the most general terms is tested against the concept of convergence; in other words, the differences between the characteristics of the Solow type of growth model and the endogenous growth models are made clear (Jones, 2002). The convergence hypothesis which assumes that the differences between per capita income levels in different countries or regions of similar type in terms of economic choices and technology will decrease in time is based on the neoclassic growth model of Solow (1956). According to this model, if the GDP levels of the countries or regions studied start to look similar in time, then it could be said that poor countries have the tendency to grow faster when compared with that of developed countries (Sala-i-Martin, 1996). So, it is observed that the per capita income and production levels of countries converge. According to Barro and Sala-i-Martin (1992), if economies are in a position lower than stationary levels, then their per capita parameters tend to grow faster and this indicates the existence of convergence (Barro and Sala-i-Martin, 1992).

The concept of convergence was first introduced by Baumol (1986) and was divided into two as beta (β) and sigma (σ) convergences. After Baumol's study, the studies of Barro and Sala-i-Martin (1991-1992) and Sala-i-Martin (1996) hold an important place in the literature of convergence and its types. In most general terms, the β convergence defines the negative relationship between the income level at the start and the income growth rate later (Paas et al., 2007). In other words, it is the type of convergence that designs the type of relationship in which poor countries show the tendency of growing faster than rich countries. The σ convergence introduced into literature based on the Galton's fallacy in the study by Quah (1993), on the other hand, is the type of convergence that shows the decrease of cross-sectional dispersion of per capita income or production level in time. In other words, if the speed of increase of per capita income in a given economy can be investigated and predicted that it would reach the mean of per capita income in general, then this means that it is about the β convergence. On the other hand, it is about the σ convergence if the study is about how the per capita national income distribution was in the past and how it will be in the future (Barro and Sala-i-Martin, 1991).

Although the literature has mainly focused on the β and σ types of convergence, the concept of convergence also involves other different types. These types could be classified as convergence within one economy and between economies, convergence in growth rate and income level, conditional and unconditional convergence, convergence of income and total factor efficiency, deterministic and stochastic convergence (Islam, 2003).

In convergence analysis, definitions based on horizontal section regression were replaced in time by linear and nonlinear time series methods and panel data analysis. This development in literature has brought with it the creation of a differentiation between deterministic and stochastic convergence. Quah (1993), Bernard and Durlauf (1991, 1995, 1996), Evans (1998), Binder and Pesaran (1999) were especially the ones who used the time series analyses in their studies shedding light on the concept of stochastic convergence. The nonlinear time series techniques were used in this study to investigate the presence of stochastic convergence in the unemployment levels in the NORDIC countries.

Stochastic convergence investigates, in essence, whether there is any relationship between the permanent movements in per capita production of a country with the permanent movements in production of another country (Bernard and Durlauf, 1991). The very first interpretation was developed by Carlino and Mills (1993) and was expressed as the logarithm of per capita income level in an economy in a stationary state with respect to the economy that it is compared with. Bernard and Durlauf (1995) developed an alternative interpretation in their study and came to the conclusion that two economies would converge if there is cointegration with the [1 -1] vector (Fleissig and Strauss, 2001).

Stochastic convergence has been defined in two different ways by Bernard and Durlauf (1996). If it is expected to see a decrease as a value in per capita production levels in the given t period according to the first definition, then this means that the Countries i and j will converge between t and t+T periods. When $y_{i,t}$ and $y_{j,t}$ symbolize the logarithm of per capita production levels of country i and country j and ξt symbolize that the existing information at time t. The stochastic convergence is expressed as follows,

$$\mathrm{E}\left(y_{i,t+T} - y_{j,t+T}\ |\xi_t\right) < y_{i,t} - y_{j,t} \qquad (1)$$

According to the second definition, the Economies i and j converge when the predictions with respect to the per capita production level logarithms for both countries are equal to each other in a given t time:

$$\lim_{k \Rightarrow \infty} \mathrm{E}\left(y_{i,t+k} - y_{j,t+k}\ |\xi_t\right) = 0 \qquad (2)$$

Both definitions reflect the inferences of the neoclassic growth model from the perspective of empirical studies (Bernard and Durlauf, 1996).

Although the concept of convergence is addressed via income convergence due to its appearance, numerous studies have focused on the topic for different countries and regions taking into account different macroeconomic variables such as unemployment, labor efficiency and inflation.

There are studies in literature that investigated unemployment and especially labor efficiency convergences of different regions or country groups. The most important reason for doing so is the effort to try to understand existing economic inequalities between regions. As long as the inertia in regional unemployment differences could be understood, it could also be identified whether regional policies are effective or not.

Blanchard and Katz (1992) emphasized the importance of the convergence of regional unemployment rates in order to create a long term balance in labor market (Katrencik et al., 2008).

Although there are numerous empirical studies that analyze GDP convergence especially at the economic unions level, there are relatively less studies on unemployment convergence. The fact that there is no analysis testing unemployment convergence empirically in the NORDIC countries was the reason why this study was conducted. On the other hand, there is only a limited number of empirical analyses on unemployment convergence of different economic unions that the NORDIC countries are part of. Carrera and Rodríguez (2009) conducted a study on thirteen European countries covering the period between 1984 and 2005 and reached at the conclusion that their unemployment rates converged starting from 1993. In countries such as Belgium, Denmark, Germany, Luxembourg, the Netherlands, Portugal and Sweden where the unemployment rate was under the mean of Europe, an increase was seen in unemployment rates after this convergence in 1993 whereas the unemployment rates in Spain, Ireland and Finland where the unemployment rate was over the mean of Europe decreased after this convergence.

Rosiek and Wlodarczyk (2012) investigated the β and σ convergences in the analysis that they carried out in order to test unemployment convergence between 1999-2009 in the EU-27 countries that also include Sweden, Denmark and Finland. As a result of the empirical analysis carried out, the existence of σ convergence was identified in unemployment rates between 1999-2007 and the results also show divergence in unemployment rates in the same regions between 2008 and 2009. On the other hand, from the perspective of the β convergence, they reached at the conclusion that there was a convergence from the regions where the unemployment rates were high towards the regions where the unemployment rates were low.

In their study on Finland, Koskela and Uusitalo (2003) reached at the conclusion that the unemployment rate which was 3% at the beginning of 1990s went up to 18% within four years and then converged to the European mean at 8,5% in 2002. Likewise, Holmlund (2003) investigated the unemployment rate for Sweden which went up quite rapidly at the beginning of 1990s and then followed a downward trend and converged to the European mean. These studies came to the conclusion that if structural problems are solved and if the labor market institutions start to enjoy a more flexible structure, then a faster decrease could be observed in unemployment rates.

The basic purpose of this study is to contribute to literature since there is no empirical analysis focusing specifically on the NORDIC region with respect to unemployment convergence and to identify the inequalities between unemployment rates in this region. It will be proposed to go for differentiation in the economic policies followed in the countries where convergence has not taken place.

The method frequently used to test empirically stochastic convergence is the use of unit root tests. The basic problem encountered in the studies based on unit root tests is choosing the right test. Different tests chosen produce different results and therefore the results obtained are different from each other.

First of all, a unit root test that is appropriate for the data structure will be chosen first in order to avoid any results with deviations. To achieve this, the nonlinearity test developed by Harvey et al. (2008) will be used to investigate whether the series are linear or not. The reason why this test is preferred is because its variables offer the basic advantage of not being influenced by the levels of stationarity.

The nonlinear unit root tests developed by Sollis (2009) will be used for the series identified to be nonlinear. The reason for preferring these tests is that the transition between regimes considered to be more appropriate for the economic structure is smooth and has a better power than previous tests. This test also allows for symmetric or asymmetric nonlinear adjustments. The unit root test with two structural breaks developed by Narayan and Popp (2010) will be used for the series the linearity of which have been identified. The main advantage of this test is that it allows for structural breaks within the scope of null hypothesis. Narayan and Popp (2013) compared the performances of unit root tests with structural breaks and proved that the Narayan and Popp (2010) test performs better than other tests with structural breaks. This is the reason why this test is preferred.

The second part of the study introduces the dataset methodology used in empirical application and the third part provides information about empirical results. Section 4 presents the summary and policy implications of the study.

2. Data and methodology

Monthly data of the January 2000 – March 2015 period are used in this study that investigates unemployment convergence in the NORDIC countries. The data used are taken from Eurostat.

Stochastic convergence was introduced by Carlino and Mills (1993) and Bernard and Durlauf (1995). According to Bernard and Durlauf (1995), if the logarithm of the analyzed variable y_{ijt}, follows a stationary process, then stochastic convergence occurs.

$$y_{ijt} = logY_{it} - logY_{jt} \quad (3)$$

where y_{ijt} is the analyzed variable, Y_{it} is the variable value for unit i at time t and Y_{jt} is the variable value for unit j at time t.

Carlino and Mills (1993) define deviation series as $Dy_{jt} = \bar{y}_t - y_{jt}$ where y_{jt} is the analyzed variable value for unit j at time t and $\bar{y}$ is the mean value of all units at time t. Rejection of the unit root hypothesis gives evidence of stochastic convergence.

In the light of this article, we used the data as follows:

$$y_{it} = ln\left(\frac{x_{it}}{\bar{x}_t}\right) \quad (4)$$

where x_{it} is unemployment rate of country i, $\bar{x}_t$ is the mean unemployment rate of NORDIC countries.

Linear models have the advantage of being undoubtedly simple and intuitive. However, they also have several limitations, some of which can be overcome via nonlinear modeling. These limitations are as follows: linear models cannot allow for strong asymmetries in data, they are not suitable for data characterized by sudden and irregular jumps, they neglect nonlinear dependence, they are useful for prediction and they are not suitable for series which are not time reversible, respectively. In addition, a failure to recognize and deal with the presence of nonlinearity in the generating mechanism of a time series can often lead to poorly behaved parameter estimates and to models which miss important serial dependencies altogether (Bisaglia and Gerolimetto, 2014, p. 1). Therefore, linear and nonlinear structure should be investigated for the corresponding time series.

In theoretical and empirical econometric studies, investigating linearity is one of the crucial issues. McLeod-Li (1983), Keenan (1985), Tsay (1986) and Brock, Dechert and Scheinkman (1987) improved linearity tests in the past 30 years. The classic linearity tests are based upon the assumption that the variables are $I(0)$ or $I(1)$. In empirical study, this issue is especially problematic. Therefore, in a recent contribution, Harvey et al. (2008) propose a new linearity test which can be applied either to the $I(0)$ or $I(1)$ process. This study proposes a Wald test when the order of integration is unknown, which is a weighted mean of the Wald tests for the null of linearity when the variable is known to have a unit root and when it is known to be stationary (Cuestas, Gil-Alana and Taylor, 2012, p. 9).

The basic problem experienced in unit root tests is that the correct model specification cannot be determined. Enders and Granger (1998) demonstrate that the standard tests for unit root and cointegration all have lower power in the presence of misspecified model dynamics. Perron (1989) showed that when the existing structural break ignores the conventional unit root tests, it will be biased towards not rejecting a false null of a unit root. A similar phenomenon occurs in nonlinear models. If the data are nonlinear, then the linear unit root tests will face the problem of power. These test results will be the non-rejection of the null hypothesis and biased (Cuestas and Garrant, 2011).

The reason for preferring these tests is that the transition between regimes considered to be more appropriate for the proper economic structures is smooth and has a better power than previous tests.

Kapetanios et al. (2003) propose the implications of the presence of a particular kind of nonlinear dynamics for unit root testing procedures. In addition to this, they provide an alternative framework for a test of the null of a unit root process against an alternative of nonlinear exponential smooth transition autoregressive (ESTAR) process, which is globally stationary.

The KSS test is based on the assumption that the mean reversion is symmetrical at every point. This assumption means that negative and positive deviations have got the same effect. Sollis (2009) extended this assumption and developed a new test that allowed for symmetric or asymmetric nonlinear adjustments. In this test, the speed of mean reversion will be different depending on the sign of the shock, not only the size (Cuestas and

Ramlogan-Dobson 2013). The model to be used for the test based on the asymmetric ESTAR (AESTAR) model proposed by Sollis (2009) is as follows;

$$\Delta y_t = G(\gamma_1, y_{t-1})\{S_t(\gamma_2, y_{t-1})\rho_1 + (1 - S_t(\gamma_2, y_{t-1}))\rho_2\}y_{t-1} +$$

$$+\sum_{i=1}^{k} k_i \Delta y_{t-i} + \varepsilon_i \quad (5)$$

Here $G(\gamma_1, y_{t-1}) = 1 - \exp(-\gamma_1(y_{t-1}^2))$ with $\gamma_1 \geq 0$ and $S_t(\gamma_2, y_{t-1}) = \{1 + \exp(-\gamma_2 y_{t-1})\}^{-1}$ with $\gamma_2 \geq 0$. Just line in the KSS test, the Sollis (2009) model will look like as follows with the use of the Taylor approximations.

$$\Delta y_t = a(\rho_2^* - \rho_1^*)\gamma_1\gamma_2 y_{t-1}^4 + \rho_2^*\gamma_1 y_{t-1}^3 + \eta_i \quad (6)$$

Where ρ_1^* ve ρ_2^* are linear functions of ρ_1 and ρ_2. Where $a = 1/4$, which can be written as:

$$\Delta y_t = \phi_1 y_{t-1}^3 + \phi_2 y_{t-1}^4 + \eta_i \quad (7)$$

Where $\phi_1 = \rho_2^*\gamma_1$ and $\phi_2 = a(\rho_2^* - \rho_1^*)\gamma_1\gamma_2$. An augmented version is

$$\Delta y_t = \phi_1 y_{t-1}^3 + \phi_2 y_{t-1}^4 + \sum_{i=1}^{k} k_i \Delta y_{t-i} + \eta_i \quad (8)$$

Where y_t, a similar KSS test, is raw, demeaned or detrended data. The null hypothesis of nonstationarity is $H_0: \phi_1 = \phi_2 = 0$. Sollis (2009) derives the asymptotic distribution of an F test of $H_0: \phi_1 = \phi_2 = 0$ showing it to be a nonstandard function of Brownian motions. The test statistics can be written as follows:

$$F = (R\hat{\beta} - r)'[\hat{\sigma}^2 R\{\sum_t x_t x_t'\}^{-1}R']^{-1}(R\hat{\beta} - r)/m \quad (9)$$

The critical values of F statistics are tabulated by Sollis (2009). When the null hypothesis is rejected, the null hypothesis of symmetric ESTAR, $H_0: \phi_2 = 0$, can be tested against the alternative of asymmetric ESTAR, $H_0: \phi_2 \neq 0$, by means of standard hypothesis test. For the standard F critical values to be applicable for this test, $\phi_1 < 0$, so that under the null being tested the series is stationary (Sollis, 2009).

In empirical econometrics studies, researchers developed structural unit root tests with different specifications to investigate the presence of unit root. Perron (1989) was the one to generate exogenous structural unit root tests. In the process of time, a lot of different structural unit root tests have been developed. In literature some of the structural unit root tests suffer from severe spurious rejections in finite samples when a break is present under the null hypothesis[(1)]. (Narayan and Popp, 2010, p. 1426)

Narayan and Popp (2010) developed a new unit root test with two structural breaks. Narayan and Popp (2010) unit root test generalizes the one break unit root test by Popp (2008). The Innovational Outlier (IO) type test allows for structural breaks under the null and the alternative hypothesis and is applicable for all model specifications. (Narayan and Popp, 2013, p. 723).

Narayan and Popp (2010) test has two different specifications both for two trending data, one of them allows for two breaks in level (M1) and the other allows for two breaks in level as well as slope (M2). M1 and M2 models specifications differ in how the deterministic component, d_t, is defined,

$$d_t^{M1} = \alpha + \beta t + \Psi^*(L)(\theta_1 DU'_{1,t} + \theta_2 DU'_{2,t})$$

$$d_t^{M2} = \alpha + \beta t + \Psi^*(L)(\theta_1 DU'_{1,t} + \theta_2 DU'_{2,t} + \gamma_1 DT'_{1,t} + \gamma_2 DT'_{2,t}) \quad (10)$$

$$DU'_{i,t} = 1(t > T'_{B,i}), \qquad DT'_{i,t} = 1(t > T'_{B,i})(t - T'_{B,i}), \qquad i = 1,2.$$

where $T'_{B,i}, i = 1,2$ denote the true break dates. θ_i and γ_i indicate the magnitude of the level and slope breaks, respectively. The IO-type test equation for M1 model has the following form,

$$y_t^{M1} = \rho y_{t-1} + \alpha_1 + \beta^* t + \theta_1 D(T'_B)_{1,t} + \theta_2 D(T'_B)_{2,t} + \delta_1 DU'_{1,t-1} +$$

$$+ \delta_2 DU'_{2,t-1} + \sum_{j=1}^{k} \beta_j \Delta y_{t-j} + e_t \quad (11)$$

with $\alpha_1 = \Psi^*(1)^{-1}[(1-\rho)\alpha + \rho\beta] + \Psi^{*'}(1)^{-1}(1-\rho)\beta$, $\Psi^*(1)^{-1}$ being the mean lag, $\beta^* = \Psi^*(1)^{-1}(1-\rho)\beta$, $\phi = \rho - 1$, $\delta_i = -\phi\theta_i$ and $D(T'_B)_{i,t} = 1(t = T'_{B,i} + 1), i = 1,2$. $DU'_{1,t} = 1(t > T'_{B,i}), DT'_{1,t} = 1(t > T'_{B,i})(t - T'_{B,i})$, i=1,2. The IO-type test equation for M2 model is as follows,

$$y_t^{M2} = \rho y_{t-1} + \alpha^* + \beta^* t + \kappa_1 D(T'_B)_{1,t} + \kappa_2 D(T'_B)_{2,t} + \delta_1^* DU'_{1,t-1} +$$

$$+ \delta_2^* DU'_{2,t-1} + \gamma_1^* DT'_{1,t-1} + \gamma_2^* DT'_{2,t-1} + \sum_{j=1}^{k} \beta_j \Delta y_{t-j} + e_t \quad (12)$$

In this equation, κ_i=$(\theta_i + \gamma_i)$, $\delta_i^* = (\gamma_i - \phi\theta_i)$ and $\gamma_i^* = -\phi\gamma_i$ i=1, 2. In order to test the unit root null hypothesis of $\rho = 1$ against the alternative hypothesis of $\rho < 1$, *t*-statistics of $\hat{\rho}$ denote $t_{\hat{\rho}}$. The break dates are selected using the sequential procedure proposed by the Narayan and Popp (2010) test and appropriate critical values as provided in the Narayan and Popp (2010) paper are used to test the hypothesis for unit root. (Salisu and Mobolaji, 2013, p. 172). Narayan and Popp (2010) tabulated their test critical values for M1 and M2 models.

Narayan and Popp (2013) compare the Lumsdaine and Papell (1997), Lee and Strazicich (2003) and Narayan Popp (2010) two structural break unit roots test. Their study show that the Narayan Popp (2010) test has good size and stable power, and identifies the structural breaks accurately in finite samples by using Monte Carlo simulations. According to the findings in their study, the Narayan and Popp (2010) test is significantly superior to the Lumsdaine and Papell (1997) and Lee and Strazicich (2003) two structural break unit root tests.

3. Empirical results

In the first part of this study that investigates unemployment convergence in the NORDIC countries, the series' status of being linear or nonlinear was analyzed based on the test with the null hypothesis advantage developed by Harvey et al. (2008) that is not influenced by the stationarity levels of variables and the results are tabulated in Table 1.

Table 1. *Linearity tests results*

Country	Harvey Statistics
Denmark	3.23
Finland	8.52**
Iceland	0.71
Norway	9.54*
Sweden	30.73*

Note: The symbols *, ** and *** mean rejection of the null hypothesis of linearity at the 1%, 5% and 10% respectively.

According to the test results provided in Table 1, the series of Finland, Norway and Sweden are nonlinear whereas the series of other countries are linear. Based on this basic finding, the nonlinear unit root test developed by Sollis (2009) for nonlinear series was used and the results are tabulated in Table 2.

Table 2. *Nonlinear unit root tests results*

Country	k	$Ho:\phi_1=\phi_2=0$	$Ho:\phi_2=0$
Finland	2	6.132349**	1.206230
Norway	1	13.94348*	0.142894
Sweden	2	6.696475**	0.099006

Note: The symbols *, ** and *** mean rejection of the null hypothesis of unit root at the 1%, 5% and 10% respectively.

According to the results in Table 2, the series for Finland, Norway and Sweden are stationary. We proceed to check whether shocks have symmetric or asymmetric effects for countries in which the unit root is rejected. This is performed by means of testing $Ho:\phi_2=0$ in the equation. These results indicate that the null of hypothesis of symmetric shocks is not rejected for all countries. The Narayan and Popp (2010) unit root test was used for the data of Finland and Iceland identified as linear and the results are tabulated in Table 3.

Table 3. *Linear unit root tests results*

Country	k	t-statistic	TB1	TB2
Denmark	2	-2.852	2006M12	2008M04
Iceland	2	-2.576	2004M04	2005M09

Note: The symbols *, ** and *** mean rejection of the null hypothesis of unit root at the 1%, 5% and 10% respectively.

According to the result of the unit root test with a structural break tabulated in Table 3, Denmark and Iceland unemployment rate series are not stationary.

When the results obtained are evaluated in general, the unemployment rates of Finland, Norway and Sweden converge to the NORDIC mean whereas the unemployment rates of Denmark and Iceland do not converge to the NORDIC mean. Therefore, it could be said that the finding of convergence implies that shocks to unemployment rate differentials are not persistent.

4. Conclusions

The Harvey et al. (2008) test was used in the first part of the study in order to identify whether the series are linear or not and the analysis was carried out by using the Sollis

(2009) nonlinear unit root test for the nonlinear series and the Narayan and Popp (2009) structural break unit root test was used for the stationary series. According to the results, the unemployment rates of Finland, Norway and Sweden converge to the NORDIC mean whereas the unemployment rates of Denmark and Iceland do not converge to the NORDIC mean. Based on these findings, it could be concluded that there are structural differences in the labor markets of the countries examined. As was indicated in the study by Blanchard and Wolfers (2000), the presence of a strong interaction between economic shocks and institutions should be accepted and the shocks experienced could change the negative effects on unemployment. It could then be said that if the structural problems of countries are solved and if the labor market becomes a flexible one, then convergence could take place. On the other hand, it should also be taken into account that the policies implemented against the institutions that cause rigidity in the labor market could have reflections on the neighboring countries with similar economic regimes.

Note

(1) See the Perron (1989), Zivot and Andrews (1992), Lumsdaine and Papell (1997) structural break unit root tests.

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