ÇANKAYA UNIVERSITY
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MASTER THESIS

A REINVESTIGATION OF THE HYSTERESIS HYPOTHESIS IN THE OECD COUNTRIES

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Title of the Thesis: **A Reinvestigation of the Hysteresis Hypothesis in the OECD Countries**

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ABSTRACT

A Reinvestigation of the Hysteresis Hypothesis in the OECD Countries

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This study re-investigates the hysteresis hypothesis in unemployment for 24 OECD countries. The results obtained in the literature are quite mixed for the OECD countries, with the findings highly sensitive to the econometric methodology applied and data used. Therefore, to shed some light on this debate in addition to the conventional unit root tests, a variety of other tests that allow for asymmetric adjustment, structural breaks or both simultaneously are also considered. Our results show that the hysteresis effect in unemployment was confirmed for most of the countries studied according to all tests applied. Thus, the labor markets of the OECD countries calls for urgent reform, especially if they want their jobless rates to return to their pre 2008-2009 global financial crisis levels.

Keywords: Hysteresis in unemployment, Nonlinear unit root test, Unit root test with structural break, Unit root test with both structural break and asymmetric nonlinearity.

ÖZ

İşsizlik Histerisinin OECD Ülkelerinde Yeniden İncelenmesi

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Bu çalışmada işsizlikte histeri hipotezi İktisadi İşbirliği ve Gelişme Teşkilatı (OECD) üyesi 24 ülke üzerinde yeniden incelenmiştir. Literatürde OECD ülkeleri üzerinde yapılmış çalışmalar uygulanan ekonometrik metotlara ve kullanılan verilere aşırı hassasiyet gösterdiği için oldukça karışık sonuçlar vermiştir. Bundan dolayı, bu konuya bir açıklık getirebilmek adına klasik birim kök testlerinin yanında asimetrik ayarlama, yapısal kırılma veya ikisine birden izin veren testler değerlendirilmiştir. Uygulanan testlere göre incelenen ülkelerin çoğunda işsizlikte histeri etkisi kanıtlanmıştır. Bu yüzden, OECD ülkelerinin emek piyasaları, özellikle işsizlik oranlarının 2008-2009 küresel finansal kriz öncesi seviyelerine gerilemesi için, acil reformlara ihtiyaç duymaktadır.

Anahtar Kelimeler: İşsizlikte histeri, Doğrusal olmayan birim kök testi, Yapısal kırılmalı birim kök testi, Doğrusal olmayan yapısal kırılmalı ve asimetrik birim kök testi.

To My Dear Family

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ABBREVIATIONS

ADF : Augmented Dickey Fuller

AR : Auto- Regressive

DF : Dickey Fuller

EG : Enders and Granger

ESTAR: Exponential Smooth Transition Autoregressive

HUR : Harmonized Unemployment Rate

KSS : Kapetanios, Shin, Snell

LM : Lagrange Multiplier

LNV : Leybourne, Newbold, Vougas

LP : Lumsdaine – Papell

NAIRU: Non-accelerating Inflation Rate of Unemployment

NLS : Nonlinear Least Square

OECD : Organisation for Economic Co-operation and Development

OLS : Ordinary Least Square

STR : Smooth Transaction Regression

SURADF: Seemingly Unrelated Regression Augmented Dickey Fuller

UO : Uçar - Omay

ZA : Zivot-Andrews

CHAPTER 1

1. INTRODUCTION

Unemployment is one of the primary issues in an economy. Since the unemployment rate is relevant to the welfare of a society, governments pursue policies aiming to reduce it. The studies on unemployment are quite essential to guide these policies, as it would be a hopeless effort for the governments to take actions in the right way against unemployment without knowing the dynamics of the issue. As in our case, it is crucial to know the persistency of the effect of a shock in the economy on unemployment rates to take precautions, or to address the problem properly. For instance, if the effect of the shock does not persist after the shock fades there is no need for extreme precautions or actions since the unemployment rate would go back to its initial rate all by itself. This particular situation is known as the natural rate hypothesis in the literature. On the other hand, if the effect of the shock persists even after the shock fades then the unemployment rate would remain high instead of going back to its initial value. In this case, the economy would be in a much direr situation and it would demand extreme actions or precautions in order to reduce the unemployment rate back. This exact opposite situation is called hysteresis in unemployment.

There are numerous studies in the literature on this subject. We divided them into three groups according to their results as studies in favor of the natural rate hypothesis, studies with hysteresis results, and studies with mixed results. First, we reported the studies with natural rate results (e.g. Camarero et al., 2006; Lee et al. (2009); and Çınar et al., 2014). In these studies the applied methods were mostly Panel data and time series tests. Then, we listed the studies with hysteresis results (e.g. Romero-Ávilaand Usabiaga, 2008; Yılancı, 2009; and Niclas, 2012). The most preferred method in these studies were Panel unit root tests. Finally, we analyzed the studies with mixed results (e.g. Camarero and Tamarit, 2004; Yılancı, 2008; Chang

and Lee, 2011; Furuoka, 2012; and Bolat et al., 2014). Studies with mixed results were the majority of the studies on this subject in the literature. There is not a method or test that stands out in these studies as the most commonly used one. Multivariate ADF test, new unit root test developed by KSS (2003), nonlinear panel unit root test, SURADF test were some of the tests that were conducted in these studies.

The aim of this thesis is to re-analyze the hysteresis effect in unemployment. To this end, we studied 24 OECD (Organisation for Economic Co-operation and Development) countries and conducted various tests on the unemployment rate data of these countries. These 24 OECD countries are Australia, Austria, Belgium, Canada, Chile, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, Norway, Poland, Portugal, Spain, Sweden, and the US. We used monthly data of the period April 1998 to September 2013. The tests that has been applied are Augmented Dickey Fuller (ADF) test, Leybourne, Newbold, Vougas (LNV) test, Enders and Granger (EG) test, and lastly Sollis (2004) test.

The Augmented Dickey Fuller (ADF) test verified the hysteresis effect in unemployment for most of the OECD countries considered. Also, there was a nonlinear unit root test used in this paper, which was the Enders and Granger (EG) test. Nonlinearity in unemployment may arise due to business cycle asymmetries, with unemployment rising more sharply during recessions than they fall during expansions. In addition, Cross (1994, 1995) show that current unemployment may display nonlinear behavior due to adjustment costs. To this end, the KSS test can be used to test the unit root hypothesis against stationary exponential smooth transition autoregressive (ESTAR) nonlinearity. However, an implicit assumption behind the ESTAR model is symmetric adjustment towards equilibrium (Sollis, 2009). Since this assumption will be very restrictive when studying unemployment rates because of cyclical asymmetries, we considered the EG test which allows for asymmetric mean reversion. The results of the EG test provided enough evidence to accept the presence of the hysteresis effect in the unemployment rates of the majority of the OECD countries.

To allow for the presence of structural breaks we further applied the Leybourne, Newbold, Vougas (LNV) unit root test, which employs a smooth transition autoregressive (STR) model to allow for smooth structural breaks. We analyze whether allowing for structural breaks could shed some light on the apparent hysteresis behavior in the OECD unemployment rates. It is demonstrated in the literature that ignoring structural breaks may highly exacerbate unemployment persistence (see Bianchi and Zoega, 1998; Papell, Murray, and Ghiblawi, 1999). However, the LNV test conclusively rejected the natural rate hypothesis for all the OECD countries included in this thesis. In other words 100% of the countries had hysteresis effect according to this test.

Lastly, to test for hysteresis in OECD unemployment we implemented the Sollis (2004) unit root test that allows for both smooth structural breaks and nonlinearity simultaneously. By employing the Sollis (2004) test we aimed to analyze whether combining cyclical asymmetries and structural breaks may account for the hysteresis behavior in the unemployment data. However, Sollis (2004) test, just like LNV test, verified the hysteresis effect for almost all of the OECD countries included in this thesis, except for only one country which was proved to have natural rate in unemployment according to the F test.

The rest of this paper is organized as follows: Chapter 2 firstly clarifies what unemployment and unemployment rate are, then introduces natural rate hypothesis and hysteresis hypothesis, and finally examines the situation of the labor markets and the employment of the OECD countries. In Chapter 3, the empirical literature surrounding the two unemployment hypotheses is surveyed and each study is explained briefly. Also, the results are divided into 3 groups and tables involving the studies of each group are given in this chapter in order to make the results easier to follow. Chapter 4 gives information regarding the methodology and explains each test that was applied in this paper in detail. Chapter 5 presents the empirical results. The data set is also mentioned shortly in this chapter. Finally, Chapter 6 is reserved for the conclusion.

CHAPTER 2

2. THEORETICAL ISSUES AND STYLIZED FACTS

In this chapter general information about unemployment will be given. Firstly, unemployment will be defined, and then the economic theories of unemployment dynamics will be explained in detail. Lastly, we will examine the labor market conditions and the unemployment experiences of the OECD countries based on the OECD employment outlook reports and unemployment rate history of the OECD countries.

2.1 Unemployment Hypotheses

The right to work is a human right that takes part in the Universal Declaration of Human Rights, stating everyone has the right to work, to free choice of employment, to just and favourable conditions of work and to protection against unemployment. The situation of not being able to get a job for an individual at working age who is trying to be employed is defined as unemployment. The unemployment number is generally represented as a percentage and it is the ratio of the people who are unemployed to the total work force. Unemployment is one of the most basic and long term issues in economy due to its negative economic and social effects. The rate of unemployment is often considered directly related with the welfare of a society both in economic and social perspectives. Naturally, there is always a struggle to decrease this rate in economies. As for the efforts to minimize the unemployment rate, it is important to understand the dynamics of unemployment like how does it react to shocks such as crises. A shock in the economy could cause an immensely high increase in unemployment rates. The issue is to understand how persistent such effects are supposed to be. There are two main theoretical views on this topic in the literature, the natural rate hypothesis and hysteresis hypothesis.

2.1.1 Natural Rate Hypothesis

The natural rate hypothesis, also known as the non-accelerating inflation rate of unemployment (NAIRU) hypothesis was firstly proposed by Phelps (1968) and Friedman (1968). The natural rate of unemployment is the equilibrium unemployment rate in the long run. In their simultaneous and independent studies Phelps (1968) and Friedman (1968) claimed that the shocks that happened in the economy can increase the unemployment rate for a period, but effects of the shock cannot persist through time and the unemployment rate will eventually revert back to the actual natural rate of unemployment. In other words, the effects of the shocks on the economy are temporary and the unemployment rate is mean-reverting. Therefore the unemployment series do not follow a random walk, which means they are stationary and do not contain a unit root.

2.1.2 Hysteresis Hypothesis

In the late 1970s, the high and persistent unemployment rates in European countries caused questioning and the reevaluation of the natural rate hypothesis (Saraç, 2014). This lead to the suggestion of the hysteresis hypothesis. The term hysteresis is originally an Ancient Greek word, which means "state of being behind or late". It was first coined by the Scottish physicist Sir James Alfred Ewing for scientific purposes. However, the term was first used in economics literature by Phelps (1972). Later, Blanchard and Summers (1986) were the first ones to come up with an econometric model to test the hysteresis hypothesis in unemployment.

This concept suggests that after the temporary shocks in the economy fades the equilibrium unemployment rate that has been increased due to the effect of the shock would not go back to its former rate. In other words, even though the shocks are temporary, their effects on the unemployment rate persist even after they fade and the unemployment rate remains at this increased level.

According to Blanchard and Summers (1986) one of the main reasons of the hysteresis effect in unemployment is the power of labour unions. They called this the insider-outsider model, with the insiders being the union member workers and

outsiders being the unemployed people. This theory suggests that in the event of a shock in the economy the insiders would enforce the wage negotiations in their best interest using strike as a threat. Considering the strike threat and the high costs of hiring and training new workers, the employers would have to agree on the wage level that the unions demand. This would prevent the wages to drop and thereby cause the unemployment rates to remain high. Thus, the unemployment rate cannot go back to its equilibrium rate and it would become persistent.

The hysteresis in unemployment approach states that the unemployment rates follow a random walk and do not exhibit mean reverting behavior. So, in case of a shock or disturbance the series will not revert back to their mean. This means that the unemployment rate series are non-stationary, and they contain a unit root.

2.2 Labor Markets and Employment in the OECD Countries

The Organization for Economic Co-operation and Development (OECD) is an organization which defines its goal so as to promote policies that will improve the economic and social well-being of people around the world. The organization brings governments together and works with them to seek solutions to common problems. They try to understand what causes economic, social and environmental changes. They also measure productivity and global flows of trade and investment, and analyze and compare data to predict future trends.

One of the main problems that OECD is trying to understand and come up with policies to solve is unemployment. To this end, OECD collects the unemployment data of all of its member countries to analyze and compare them. Annually, OECD publishes reports in order to inform the economy society about the results of their analyses, their predictions about the future of unemployment, and their suggestions to governments. In this chapter, we will look into the OECD Employment Outlook reports, mostly the latest ones, and then we will give detailed information about some of the major OECD countries, and analyze the unemployment rate history of all 24 OECD countries that we are investigating.

2.2.1 Employment Outlook Reports of OECD

In the 2014 employment report of OECD a critical question was asked about the countries where unemployment rates were still above their pre-crisis levels. It was asked whether the unemployment rates were high due to a cyclical increase or a structural increase which is rather permanent. This question is highly critical in order to address it in the right way since each option requires a different counteraction. The cyclical increase would perish as the economy recovers. As for the structural increase, however, many years of work might be necessary even after the economy fully recovers. One way to determine if the unemployment is structural or not is to check the non-accelerating inflation rate of unemployment (NAIRU). As mentioned both in our paper before and in OECD 2014 report, natural rate is the rate which the increased unemployment rate is expected to go back to after the shock in the economy fades. As an example, the following graph from the report represents the change in the estimated NAIRU along with the change of actual unemployment rate after the 2008 global crisis,

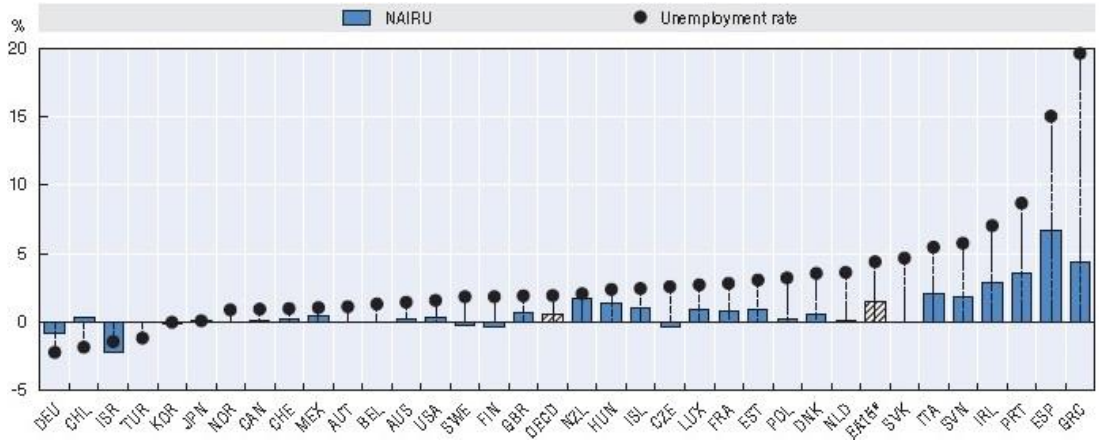

Figure 1. Percentage-points change in the NAIRU since the start of the global financial crisis, 2008-13 (*Source: OECD calculations based on OECD Economic Outlook)*

We can say that according to this graph the change in unemployment is mostly cyclical; however there is a structural increase as well since the NAIRU has also increased. In other words, it is not expected for most of the countries' unemployment

rates to go back to their pre-crisis levels, since most of them have a new estimated natural rate level. It is noted in the report that the most significant increases happened in Greece, Spain and Portugal by 3 percentage points or more. Other noteworthy increases happened in Hungary, Iceland, Ireland, Italy, New Zealand and Slovenia, between 1 and 3 percentage points.

These results fired up the debate over hysteresis in unemployment for OECD countries. The potential hysteresis effect was predicted by Ball in the 2009 report of OECD. The 2009 report was almost completely about the 2008 global crisis. The report referred to the crisis as the worst financial and economic crisis of the past 50 years. Moreover, they reported that the economic crisis rapidly transformed into a job crisis as it lead to sharp falls in employment and steep hikes in unemployment. The unemployment rate was at 5.6% in 2007, which was the lowest level experienced in 25 years. After the crisis the rate has risen to 8.3% in June 2009. This meant 15 million people lost their jobs in the post-crisis period. Furthermore, the OECD unemployment rate was projected to rise over 10% in 2010 which meant a total of 57 million unemployed people in OECD countries. This numbers meant a new postwar high rate.

In the 2012 report, the post-crisis recovery was considered to be weak or uneven across the OECD countries, and some countries even have returned into recession period. The recovery in OECD-wide economic growth was similar in strength to the 1990s and 2000s recessions in the beginning. Then the economic growth slowed down eventually and became by far the weakest recovery of the past four decades. It is also noted that the 3 years long recovery was not strong enough as the unemployment rate dropped by just 0.6% from 8.5% in October 2009, to 7.9% in May 2012.

The labour market performance was remarkably diverse across OECD countries. The unemployment rate stayed between 3.5-5.5% in Australia, Austria, Japan, Korea, Luxembourg, Mexico, Netherlands, Norway and Switzerland. Germany was the only country managed to decrease its unemployment rate from 8.2% at the beginning of the global crisis, December 2007, to 5.6% in May 2012. On the other hand, nine countries remained at double-digit drastic rates in May 2012. These countries were Estonia, France, Greece, Hungary, Ireland, Italy, Portugal, the Slovak

Republic, and Spain. The United States managed to decline its unemployment rate, while the European Union failed to prevent the rise in its unemployment rates.

In the report of 2013, it has been reported that even after five years, the weak and uneven recovery was not strong enough to generate enough jobs to decrease unemployment for most of the OECD countries. By April 2013, 48 million people were without a job, which represented 8% of the total population of the OECD countries. This means more than 16 million people lost their jobs since 2007. The employment growth in the United States in 2013 could be encouraging if the Eurozone unemployment rates had not risen to a new record of 12.1% in April 2013 as a result of the returning recession.

Another notable point according to the report is that the unemployment rates were extremely high among young people. Especially in some of the European countries young people faced record unemployment levels. For instance, Greece had more than 60%, Spain had more than 55%, Italy and Portugal had more than 40% young unemployed population.

In the report of 2014, it is stated that the labour market recovery in OECD area as a whole was subdued. However, the situation was not the same for all countries. Moreover, even with the slight recovery the OECD still had a job deficit. Employment growth decreased the unemployment rate only 2 percentage points below the level at the beginning of the crisis. While most of the Eurozone countries had the highest unemployment level since the onset of the crisis, seven other OECD countries had lower rates in contrast with the Eurozone countries. In the United States, the crisis caused a major decline in labour force participation. According to the report, this was the real reason behind the persistent shortfall in jobs in the US. The US employment rate decreased by 5 percentage points from 72% in 2007 to 67% in 2010, and remained determinedly close to its post-crisis level.

Unemployment rate in the OECD decreased slightly to the 7.4% level after remaining unchanged at around 8% for three years. This rate was below the post-war high of 8.5% in October 2009 by 1.1 percentage points; however it was still above the pre-crisis by 1.8 percentage points. Nearly 45 million citizens of the OECD countries

were without a job, which was 12.1 million more than the pre-crisis number. According to the report, this slight decline was mostly driven by the United States, and slightly by the euro area and Japan.

By May 2014, the highest unemployment rates were recorded in Greece (26.8%, March 2014), Spain (25.1%), Portugal (14.3%), the Slovak Republic (13.9%), Italy (12.6%), Ireland (12%), and France (10.1%). The lowest were those of Norway (3.3%, April 2014), Japan (3.5%), Korea (3.7%), Austria (4.7%), Switzerland (4.8%, Q1 2014), Mexico (4.9%), and Germany (5.1%).

2.2.2 Employment Analyses of OECD Countries

Along with the general employment outlook reports, OECD also prepares reports for its countries specifically. In this section, we will first analyze the 2015 mid-year reports and the unemployment rate history of 14 countries (Australia, Austria, Canada, Chile, France, Germany, Greece, Italy, Japan, Korea, Mexico, Portugal, Spain, and the US), and then we will observe the unemployment rate history of the remaining countries (Belgium, Denmark, Finland, Hungary, Ireland, Luxembourg, Netherlands, Norway, Holland, Sweden) which do not have country specific OECD reports.

Australia:

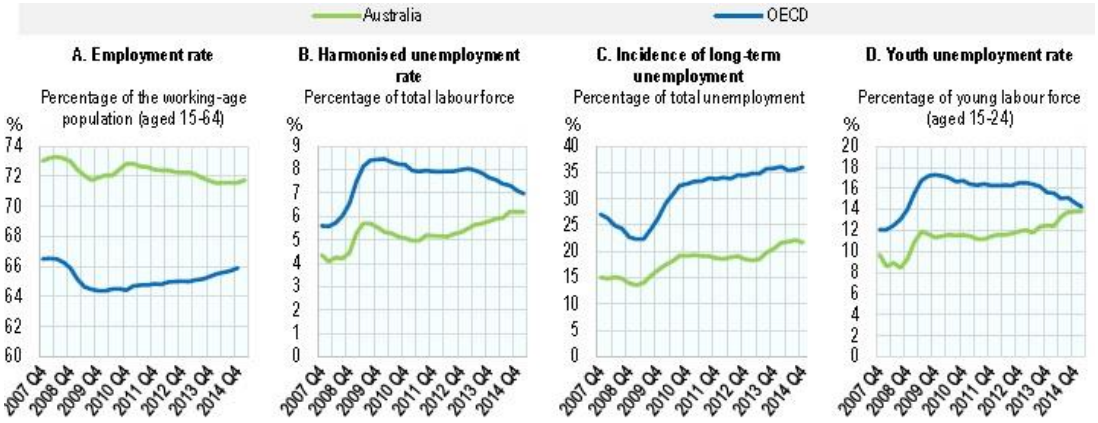

Figure 2. Australia's employment outlook compared to OECD *(Source: OECD employment outlook 2015)*

As we can see in the first graph of Figure 2, Australia's employment rate is quite above the OECD average, which means Australia is doing better in terms of dealing with the unemployment problem. Its employment rate for 15-64 year-olds was 71.8%, which is 5.8 percentage points (ppts) above the OECD average, in the first quarter of 2015. Inspite of this positive outlook, the status of labour market have not been well for the last four years. Accordingly, Australia lost its position among the best performing countries in the OECD.

The harmonized unemployment rate in Australia increased by 1.2 percentage points in four years to the level of 6.2% in the first quarter of 2015. Despite this increase, it is still 0.8 percentage points below the OECD average as can be seen from the second graph in Figure 2. The youth unemployment rate (15-24 year-olds) was 13.8% in the first quarter of 2015, this means the youth unemployment rate also increased by 2.3 percentage points in four years. However, there was a 5.2 percentage points of difference between Australia's and OECD's youth unemployment rate was in 2011, and that difference narrowed down to 0.5 percentage points in 2015.

The unemployment rate history of Australia is shown in the following figure:

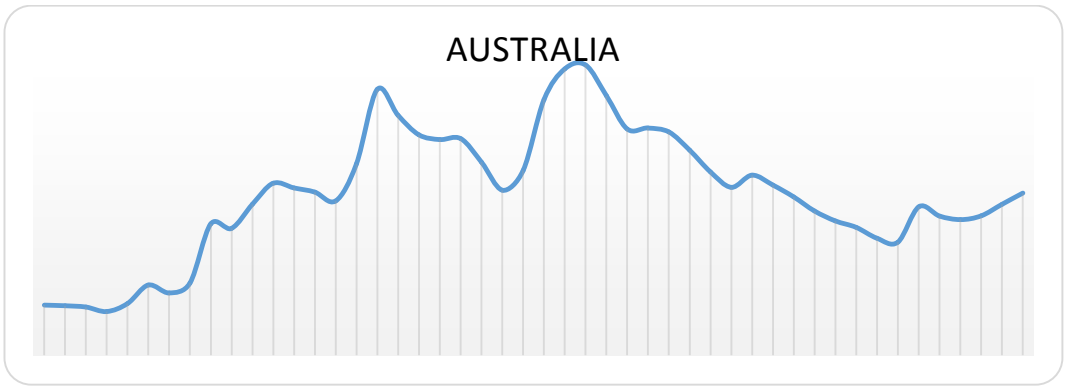

Figure 3. History of Australia's unemployment rate according to OECD data

Austria:

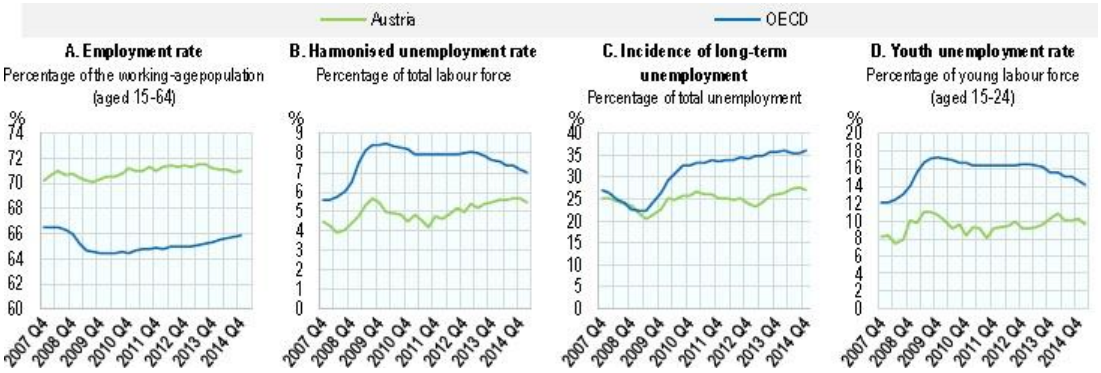

Figure 4. Austria's employment outlook compared to OECD *(Source: OECD employment outlook 2015)*

Austria faced a renewed deterioration in its labour market between mid-2011 and late-2014, due to the increased unemployment rates. However, the recent changes indicate a slow recovery. Both the general and youth unemployment rates fell in the first quarter of 2015. Accordingly, the employment numbers also rose. Inspite of these good indicators, the mid-term outlook for Austria remains bleak since the unemployment rate is expected to increase in the second half of 2015 and then to fall barely in 2016. The gap between Austria and the OECD average is narrowing down due to the faster recovery in the other OECD countries compared to Austria.

The history of Austria's unemployment rate is shown in the following figure:

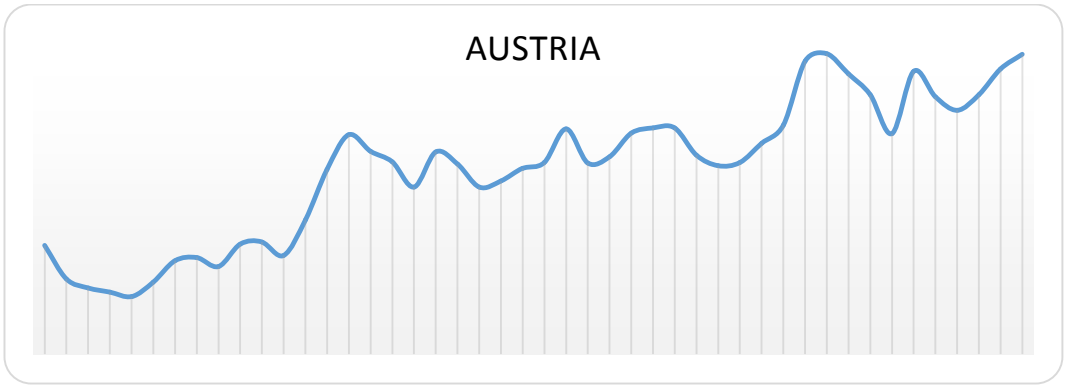

Figure 5. History of Austria's unemployment rate according to OECD data

Canada:

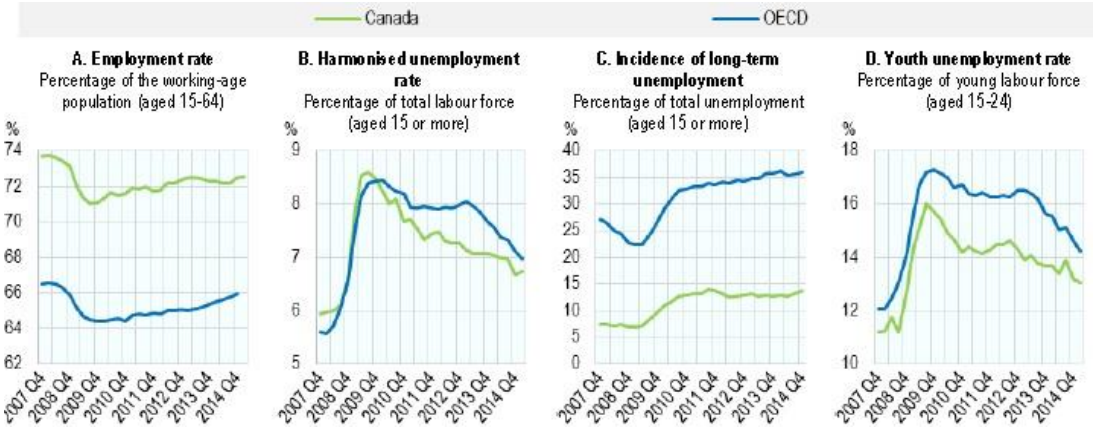

Figure 6. Canada's employment outlook compared to OECD *(Source: OECD employment outlook 2015)*

Canada is one of the countries who experienced a solid labour market recovery after the global crisis. The overall employment rate (15-64 year-olds) in Canada, which was 72.5%, was only 1.2 percentage points below its pre-crisis level in the first quarter of 2015. This means Canada recovered about half of the drop observed due to the global recession. The unemployment rate in Canada was 6.7% in the first quarter of 2015. This rate is only 0.8 percentage points above the pre-crisis level. It is expected to be reduced to 6.4 by the end of 2016. The unemployment among the youth also decreased in Canada. It increased by 4.8 percentage points after the global recession

and hit 16.0% level; however it dropped back by 3 percentage points and ended up at 13.0% in the first quarter of 2015.

The unemployment rate history of Canada according to OECD data is demonstrated in the figure below:

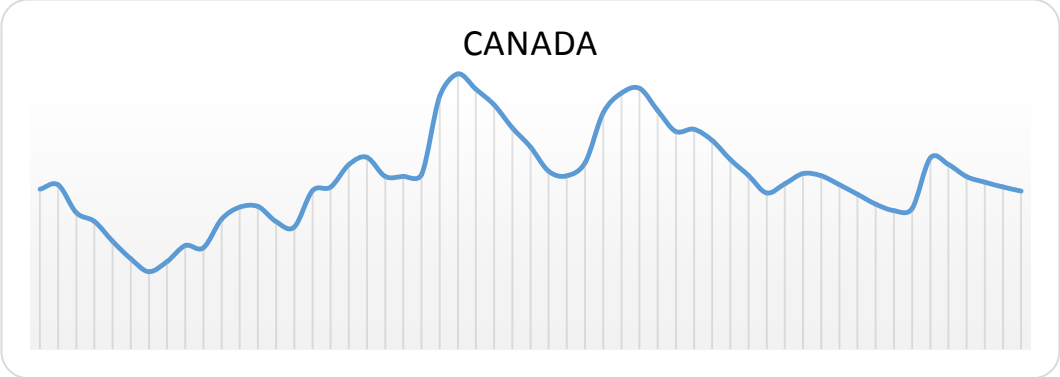

Figure 7. History of Canada's unemployment rate according to OECD data

Chile:

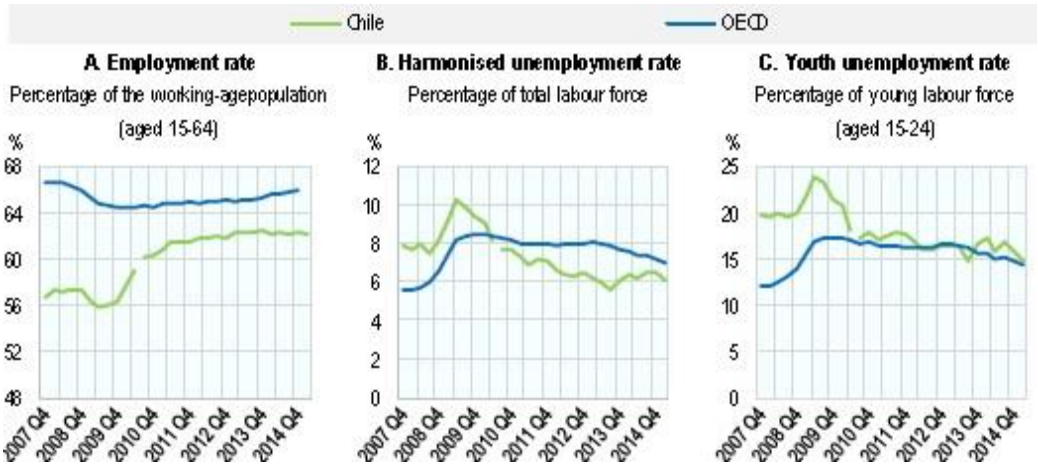

Figure 8. Chile's employment outlook compared to OECD *(Source: OECD employment outlook 2015)*

Unlike most of the countries, it did not take too long for Chile to recover from the global recession. The unemployment rate declined for 0.3 percentage points in one year and hit 6.2% by the first quarter of 2015. Unlike most of the countries, once again,

the unemployment rate is expected rise in Chile, to 6.8% to be specific, by the end of 2016.

The employment rate has been stable at around 62% for 2 years in Chile. This rate is way below the OECD average due to the low female and youth labour force participation rates. In Chile, both youth unemployment rate (14.9%) and youth not in employment, education or training rate (NEETs) are quite high. Especially the NEETs rate is one of the highest in OECD with 19%.

The graph that demonstrates the history of unemployment rate in Chile is shown in the following figure:

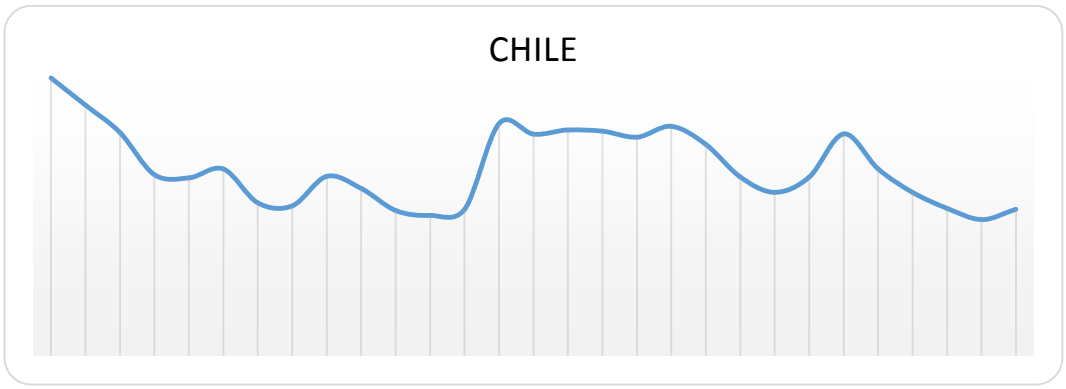

Figure 9. History of Chile's unemployment rate according to OECD data

France:

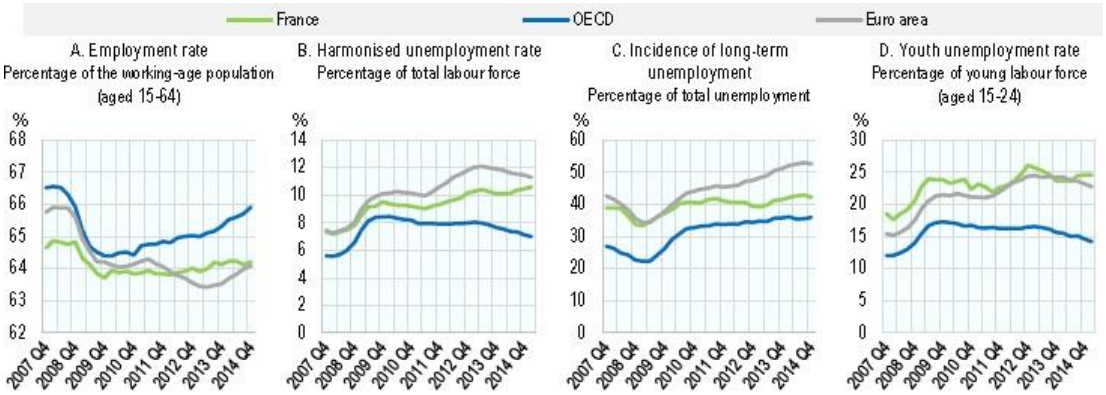

Figure 10. France's employment outlook compared to OECD *(Source: OECD employment outlook 2015)*

France is dealing with one of the highest and most persistent unemployment rates in the OECD area. The unemployment rate of France reached 10.3% in the first quarter of 2015. This rate was way above the OECD average by the first quarter of 2015. The condition in France is not very promising for the youth either. Youth unemployment rate has been decreasing for six quarters in a row. It decreased to 24.7 in the first quarter of 2015. In contrast, both in the OECD area and Euro area youth unemployment continued to recover.

History of France's unemployment rate is shown in the graph below:

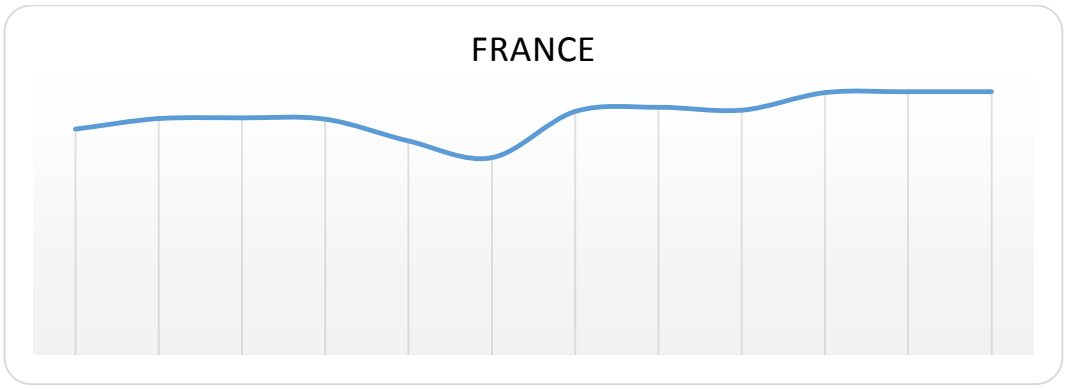

Figure 11. History of France's unemployment rate according to OECD data

Germany:

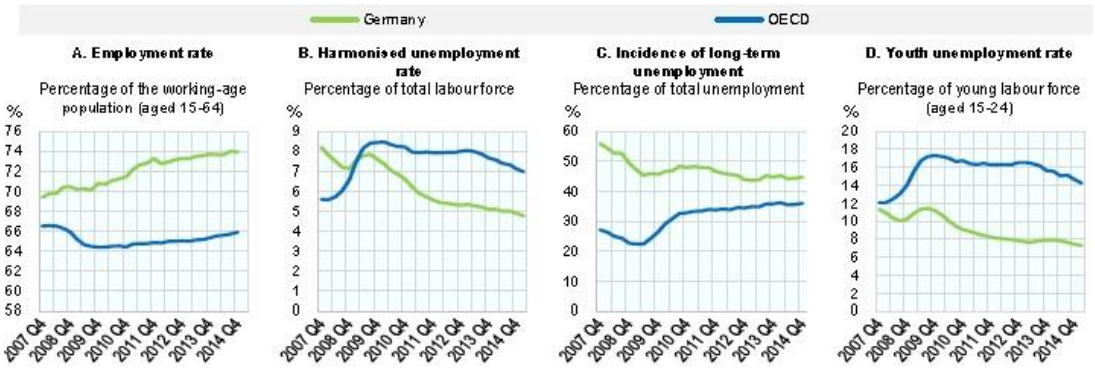

Figure 12. Germany's employment outlook compared to OECD *(Source: OECD employment outlook 2015)*

The German labour market had a pleasing development from 2009 to 2014. The employment rates even reached a historical peak level of 74%. Moreover, both

the overall unemployment and the youth unemployment kept declining. The unemployment rate of Germany was only at 4.7% level in the first quarter of 2015, which is the lowest level in 25 years. This remarkable rate is also among the lowest levels in OECD, and the youth unemployment rate is the third-lowest in OECD.

History of the unemployment rate of German labour market is given at the figure below:

Figure 13. History of Germany's unemployment rate according to OECD data

Greece:

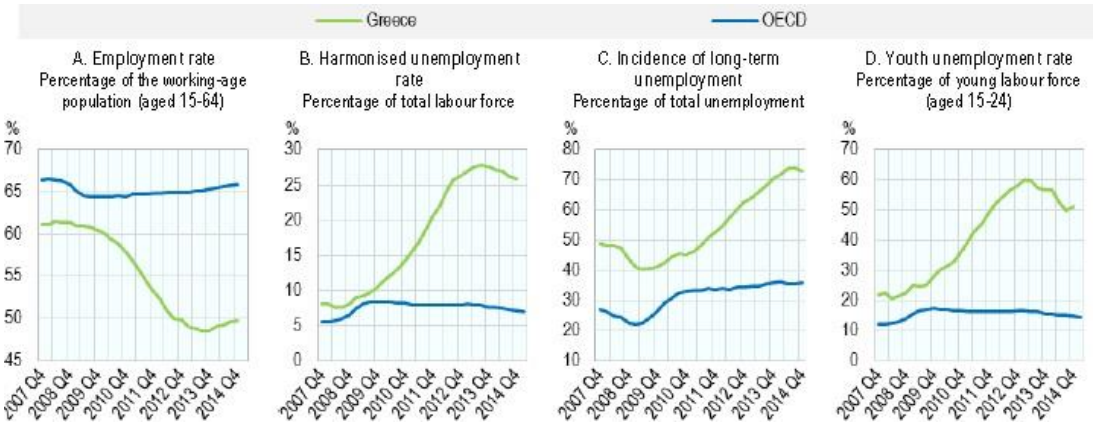

Figure 14. Greece's employment outlook compared to OECD *(Source: OECD employment outlook 2015)*

Greece is probably the worst affected country from the global recession. There have been some recent indications that the situation in Greece has finally begun to recover. Nonetheless, the situation is still dire for Greece. The employment rate was

only 50% in Greece in the first quarter of 2015, which is the lowest in OECD. Accordingly, the unemployment rate is the highest in the OECD with 25.6%. More importantly, every three people out of four have been looking for work for longer than a year. Especially, the youth of Greece have been hit hard by this recession state. Almost 50% of the youth (15-24 year-olds) was unemployed by the end of first quarter of 2015. This is more than three times the OECD average. Moreover, the neither in employment nor in education or training (NEETs) rate for 15-29 year-olds was 27% in the first quarter of 2015. This was 13 percentage points above the OECD average.

The following graph demonstrates the unemployment rate history of Greek labour force:

Figure 15. History of Greece's unemployment rate according to OECD data

Italy:

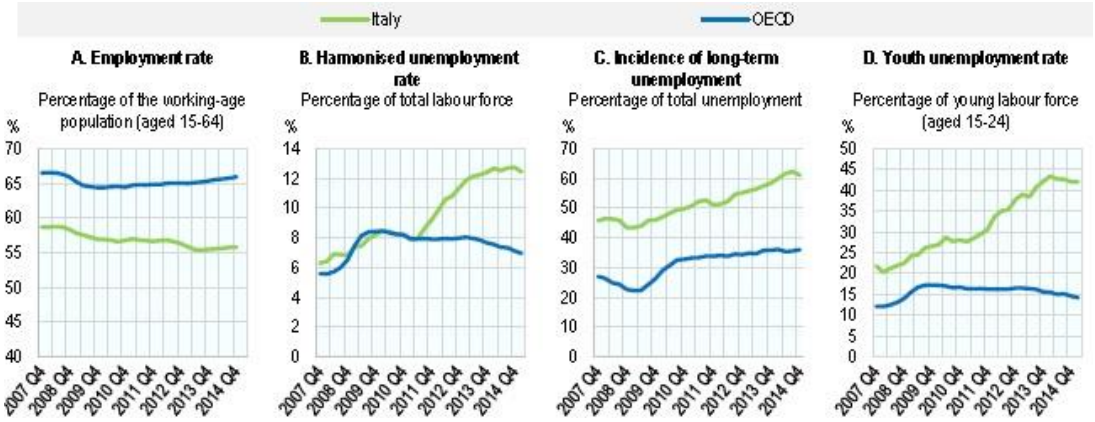

Figure 16. Italy's employment outlook compared to OECD *(Source: OECD employment outlook 2015)*

The unemployment rate in Italy has begun to fall from 13% peak, which was reached in the last quarter of 2014. It has dropped to 12.4% so far in the first quarter of 2015. It is, however, still 1.3 percentage above the unemployment rate of the Euro Area.

History of unemployment rate of Italy is shown in the graph below:

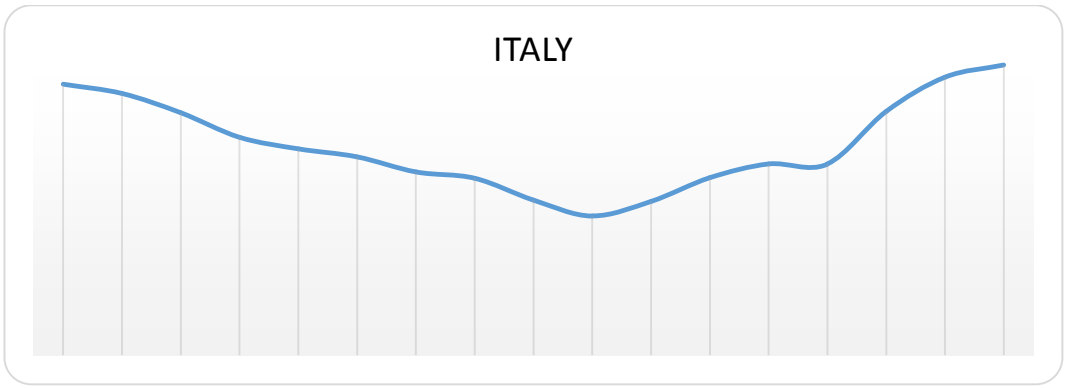

Figure 17. History of Italy's unemployment rate according to OECD data

Japan:

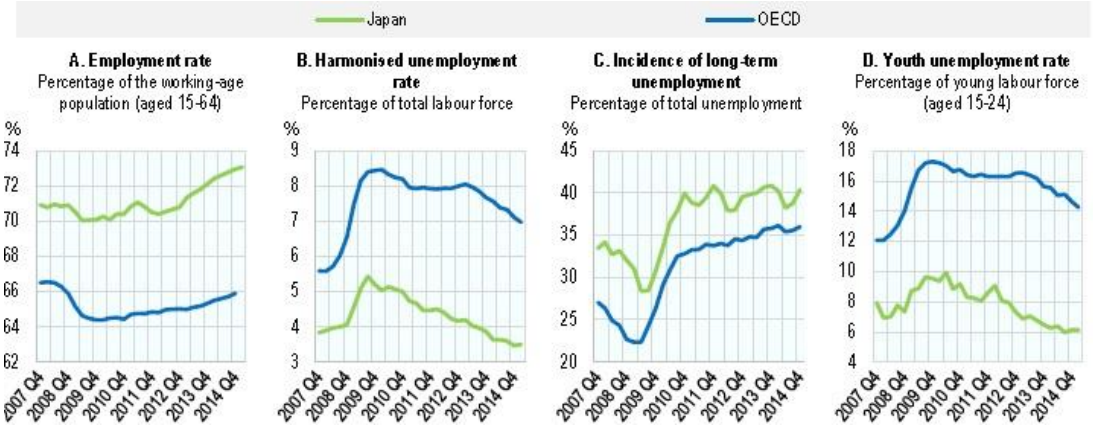

Figure 18. Japan's employment outlook compared to OECD *(Source: OECD employment outlook 2015)*

Japan, thanks to its advanced economy, is one of the countries that handled the global crisis well. When the crisis began, the employment rate of Japan was already 4.4 percentage points above the OECD average. This gap had widen to 7.1 percentage points by the last quarter of 2014, when Japan had 73.0% employed population while

OECD had an average of 65.9%. Japan's unemployment rate was only one-half of the OECD average with 3.5%. This rate is slightly lower than the pre-crisis level for Japan. Unemployment among the youth also decreased and it is one of the lowest ones in OECD. Interestingly enough, the long-term unemployment percentage is quite high in Japan. 40.4% of all unemployed persons had been out of work for a year or longer by the end of 2014.

The graph that demonstrates the unemployment rate history of Japan is given below:

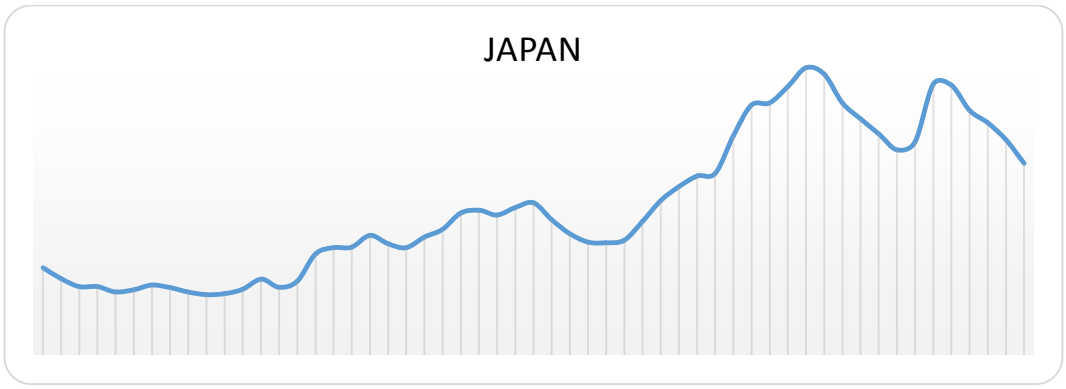

Figure 19. History of Japan's unemployment rate according to OECD data

Korea:

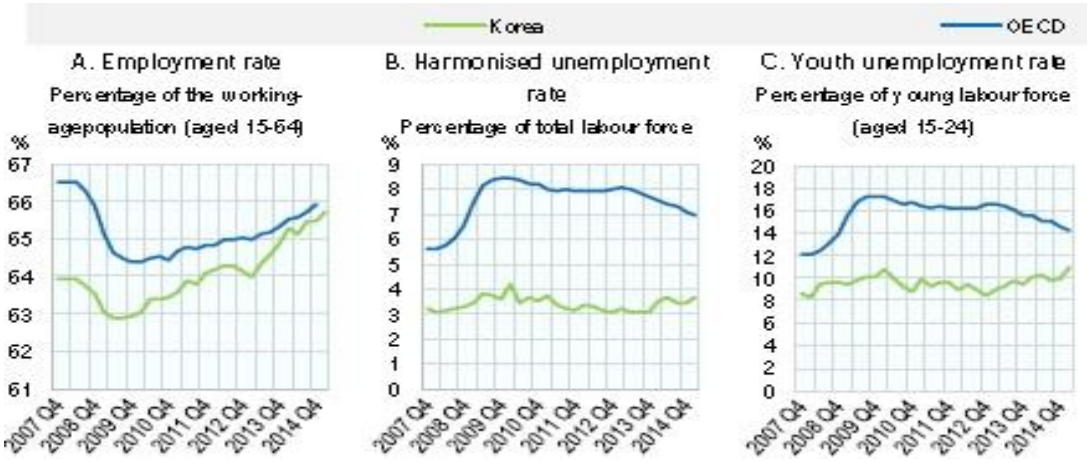

Figure 20. Korea's employment outlook compared to OECD *(Source: OECD employment outlook 2015)*

Korea managed to recover from the recession better than many other OECD countries. Korea was able to increase the employment rate back to its pre-crisis level of 64.0% by 2011. The rate was further increased to 66.1% in the first quarter of 2015. This level was the highest level for Korea since 1982. Korea had the lowest unemployment rate (together with Japan) among OECD countries with 3.7% by the first quarter of 2015. The youth unemployment is considered to be low; however it has risen since the end of 2012. It hit 10.9% in the first quarter of 2015, and exceeded the highest level reached during the recession (10.8%). Korea also had a comparatively high NEETs level. It was 18% of all youth in 2014, which was 4 percentage points above the OECD average.

The unemployment rate history of Korea is shown in the following figure:

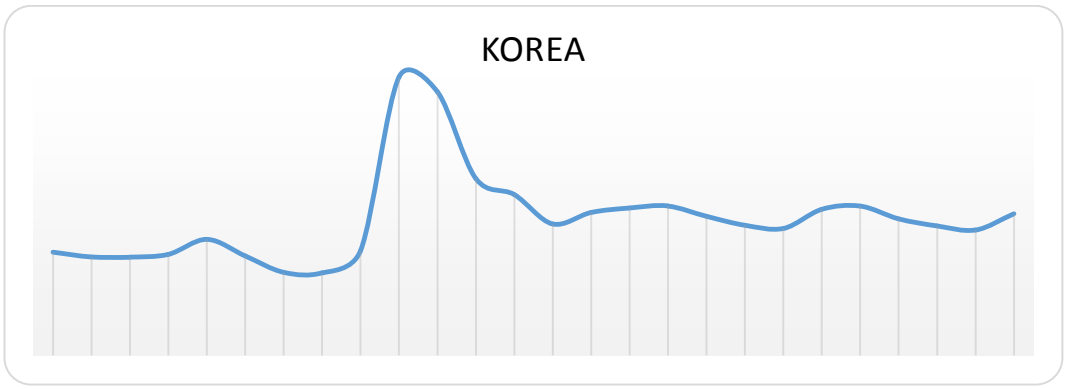

Figure 21. History of Korea's unemployment rate according to OECD data

Mexico:

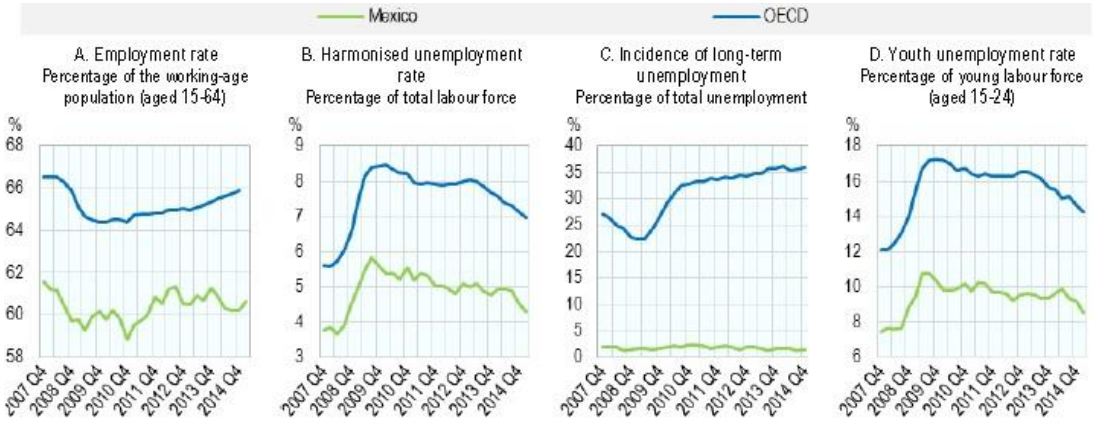

Figure 22. Mexico's employment outlook compared to OECD *(Source: OECD employment outlook 2015)*

Mexico's unemployment rate has been decreasing in recent years. This was no different for the first quarter of 2015, when unemployment rate in Mexico dropped to 4.3%. This was 2.7 percentage points below the OECD average. The youth unemployment rate was at 8.6%, which is also remarkably below the OECD average by 5.6 percentage points. Despite these good numbers, the employment rate in Mexico (60.7%) was relatively lower than the OECD average (65.9%). This has been an ongoing issue for Mexico due to the low participation rates. Furthermore, the NEETs rate was not great in Mexico either. Mexico continued to be among the OECD countries with highest NEETs rate with 22.4%, which was quite above the 14% OECD average.

The history of Mexico's unemployment rate is shown in the figure below:

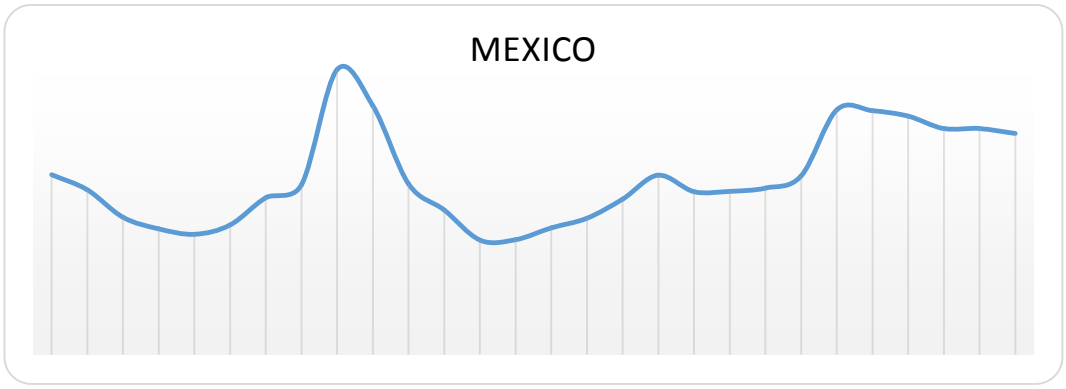

Figure 23. History of Mexico's unemployment rate according to OECD data

Portugal:

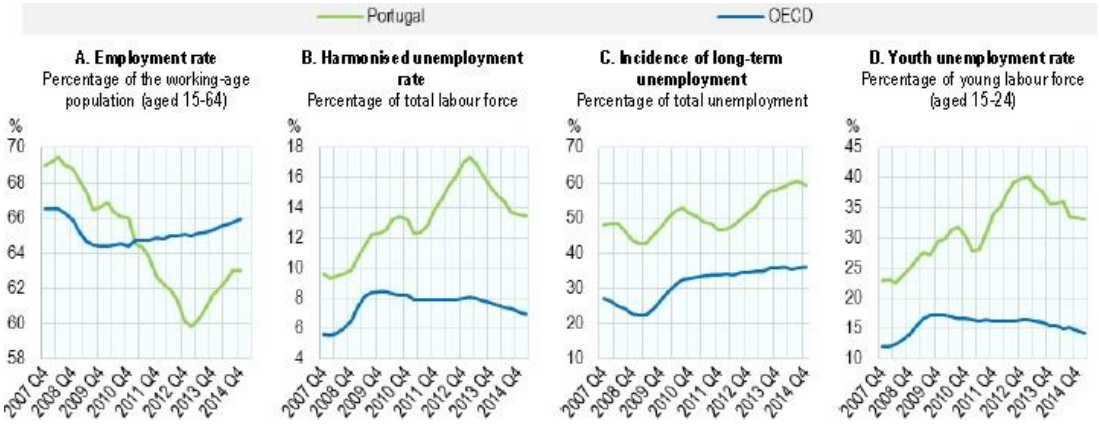

Figure 24. Portugal's employment outlook compared to OECD *(Source: OECD employment outlook 2015)*

Portugal was among the countries who were hit hard by the global crisis. However, there has been a decline in unemployment rates and an increase in employment rates since 2013 for seven quarters in a row. On the other hand, this recovery expected to slow down, but this may only be temporary. The most critical point for Portugal was the youth unemployment rate by the first quarter of 2015 since the rate remains as one of the highest in OECD are with a level of 33.4%.

Portugal's unemployment rate history is exhibited in the following graph:

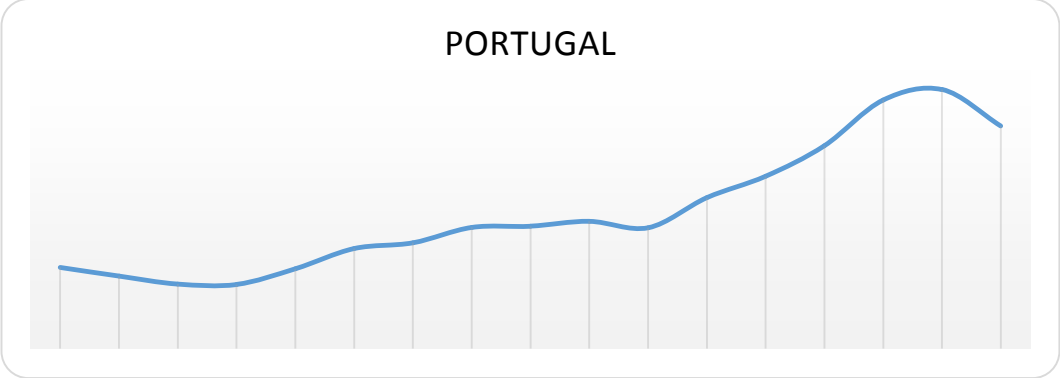

Figure 25. History of Portugal's unemployment rate according to OECD data

Spain:

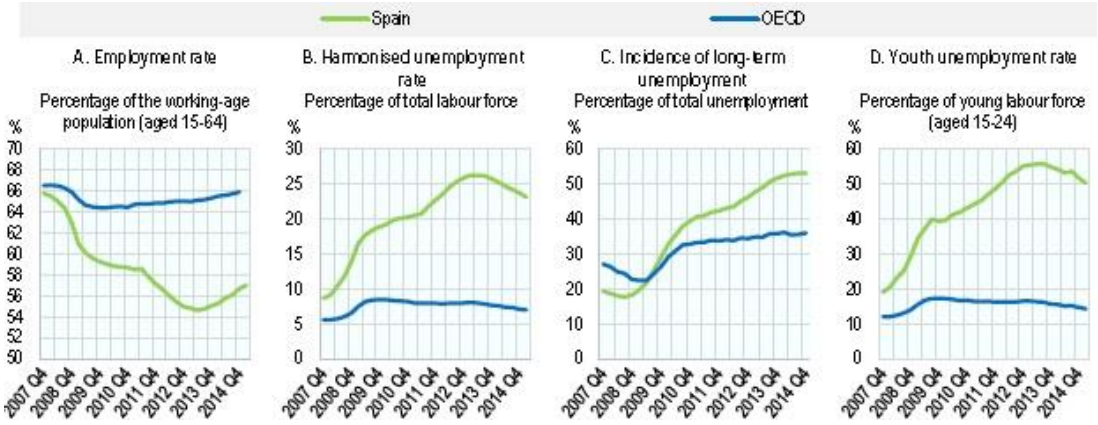

Figure 26. Spain's employment outlook compared to OECD *(Source: OECD employment outlook 2015)*

Spain continued to be one of the countries with extremely critical condition. Both overall unemployment rate and youth unemployment rate were way over the

OECD average, while the employment rate was awfully below the OECD average in the first quarter of 2015. Almost every one of two persons who was unemployed in Spain has been in this situation for over a year. The long-term unemployed rate in Spain was 53% in the last quarter of 2014 which was 17 percentage points above the OECD average.

The history of the unemployment rate of Spanish labour market is displayed in the graph below:

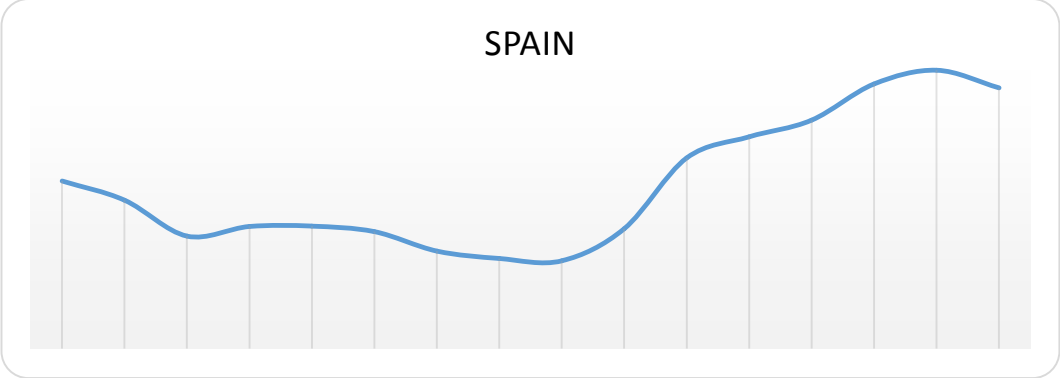

Figure 27. History of Spain's unemployment rate according to OECD data

The United States:

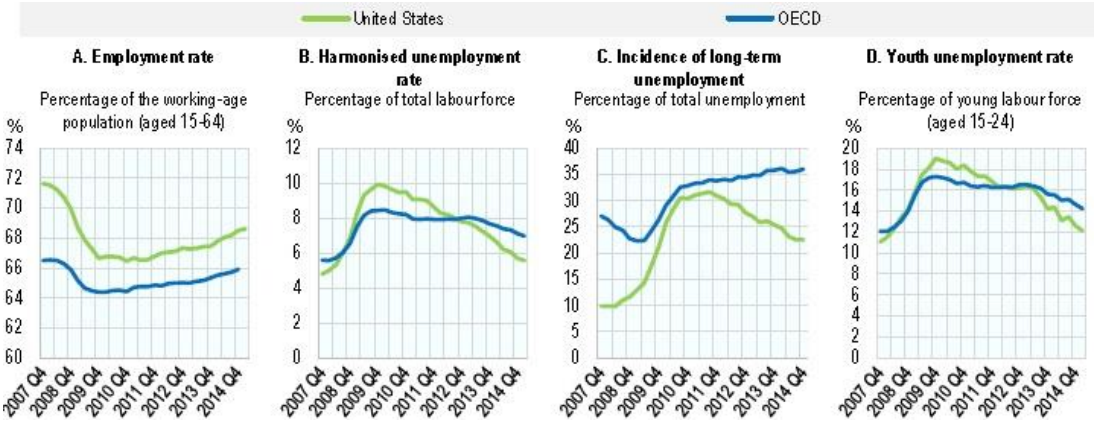

Figure 28. The United States' employment outlook compared to OECD *(Source: OECD employment outlook 2015)*

The US unemployment rate has been in a declining trend for more than five years after hitting a peak level of 10% in 2009. It decreased to a level of 5.3% in the

second quarter of 2015. This level is slightly above the pre-recession level of 4.8%, and quite below the OECD average of 7.0%. The low participation rate explains the decline in the employment rate after the global recession. It was 68.7% in the first quarter of 2015, which was 2.9 percentage points above the pre-crisis level in the last quarter of 2007.

The history of unemployment rate in the US is shown in the figure below:

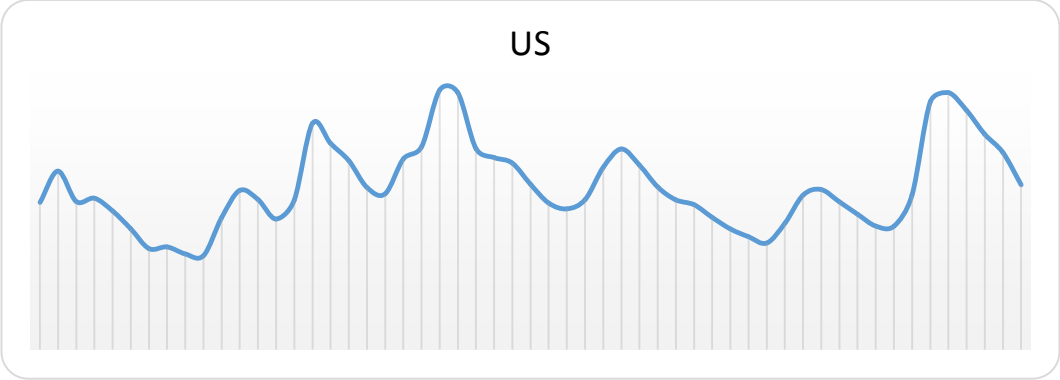

Figure 29. History of the United States' unemployment rate according to OECD data

Graphs that demonstrate the unemployment rate histories of the remaining countries that OECD do not have country-specific reports about are given below:

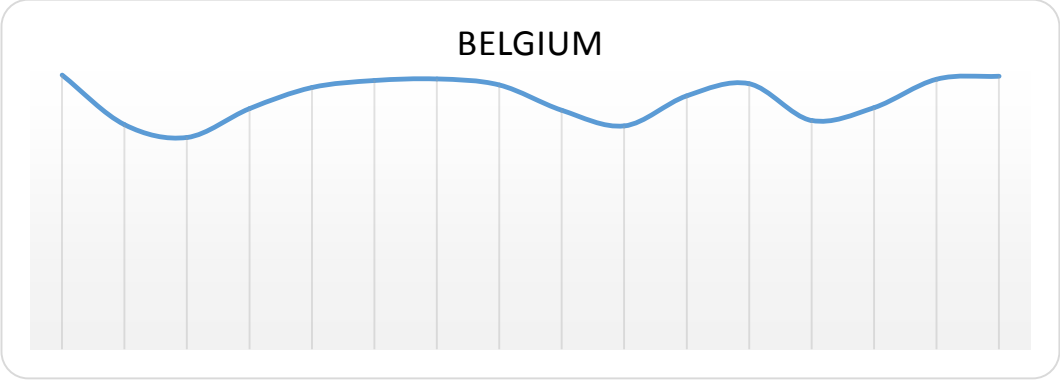

Figure 30. History of Belgium's unemployment rate according to OECD data

As can be seen in the graph, Belgium is among the countries who did not hit hard by the global crisis at all. The unemployment rate in Belgium as the last quarter

of 2014 was 8.52%, which was an only 1.06 percentage point above the pre-crisis level of 7.46%.

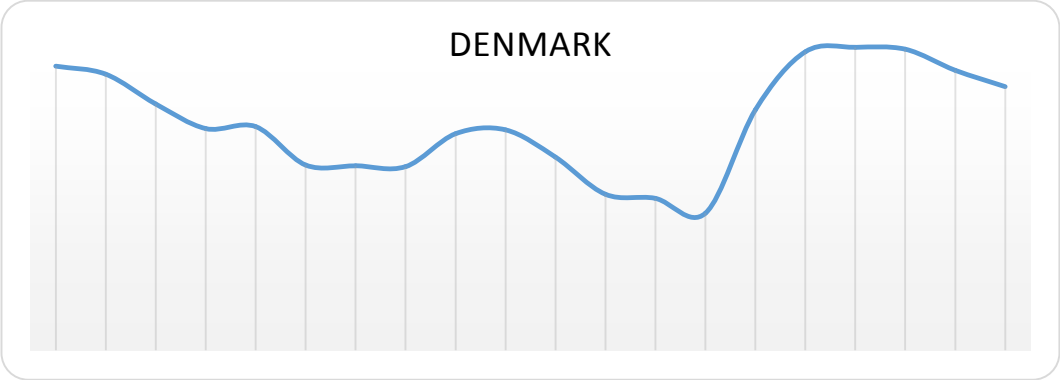

Figure 31. History of Denmark's unemployment rate according to OECD data

Denmark's figure follows the most common pattern, which demonstrates a sharp increase in the unemployment rate, in the post-recession period. The unemployment rate in Denmark went from 3.8% in 2007 to 6.59% in 2014. Interestingly enough, Denmark had its historical bottom level of 3.43% right after the global recession hit in 2008.

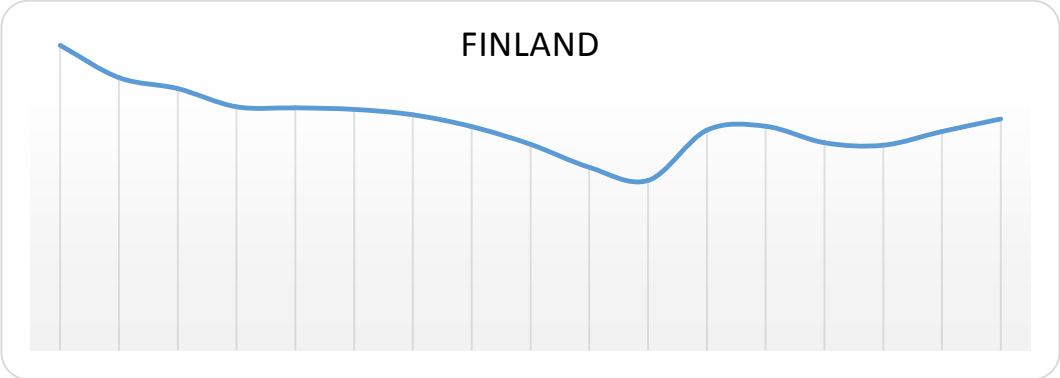

Figure 32. History of Finland's unemployment rate according to OECD data

Just like Denmark, Finland also had its lowest unemployment rate in its history at the beginning of the post-crisis period. However, at the end of the 2014 the unemployment rate in Finland was at 8.66%, 1.81 above the pre-crisis level.

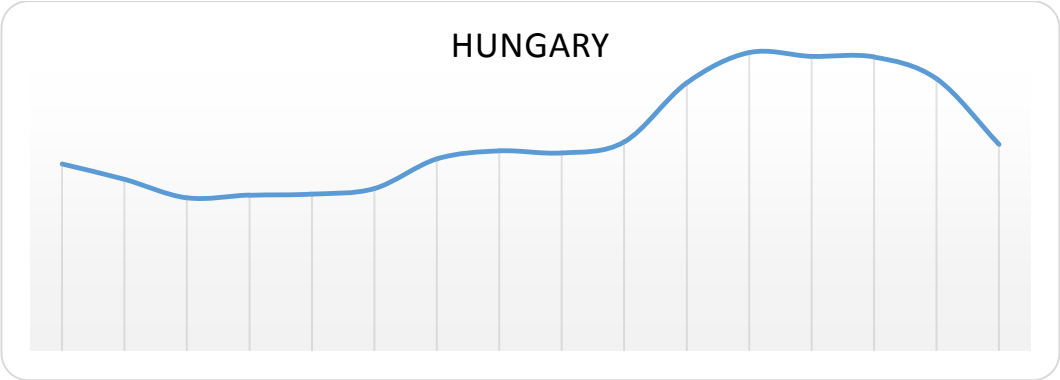

Figure 33. History of Hungary's unemployment rate according to OECD data

Although there has been a recent recover in the labour market of Hungary, it has the same post-recession period pattern that we mentioned before as well. The unemployment rate in Hungary skyrocketed from 7.41% in 2007 to a historical peak of 11.17% in 2010. However, after a favorable recovery the unemployment rate was almost back to its pre-recession level with a rate of 7.73% in the last quarter of 2014, only 0.32 percentage points above the pre-recession level.

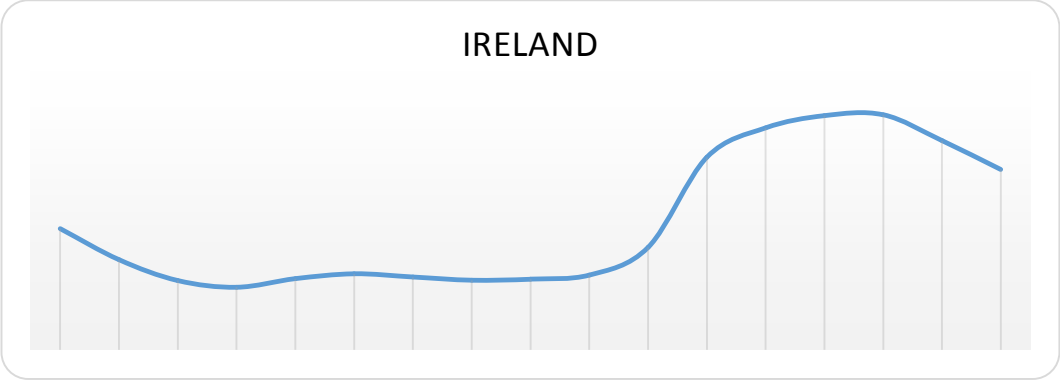

Figure 34. History of Ireland's unemployment rate according to OECD data

Ireland is also among the countries which have the common post-crisis pattern. Ireland's unemployment rate was 4.67%, which was a remarkably low percentage, in 2007. It hit a historical peak in 2012, with a level of 14.67%. With a slight recovery, the rate dropped to 11.26% in the last quarter of 2014.

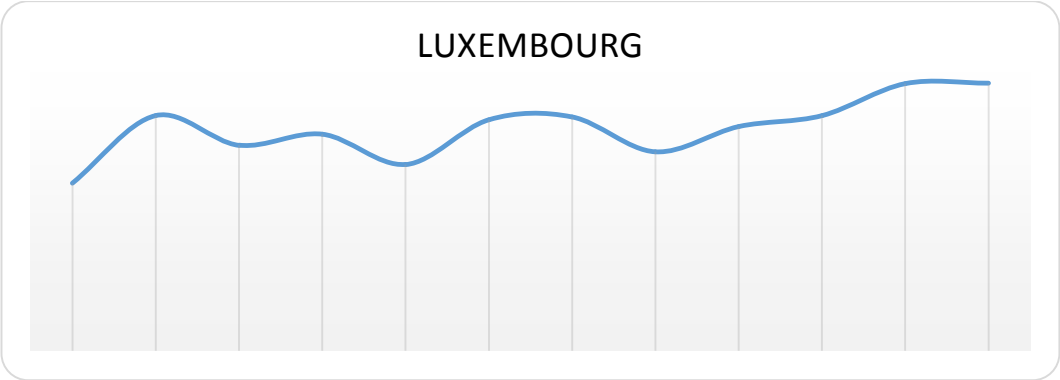

Figure 35. History of Luxembourg's unemployment rate according to OECD data

Luxembourg's labour market has always been one of the best performing countries among OECD countries. The crisis affected the unemployment rate of Luxembourg slightly. The rate increased from a 4.07% pre-recession level in 2007 to 5.85% by the last quarter of 2014. However, this slight increase cost Luxembourg its historical peak unemployment level by the end of 2014.

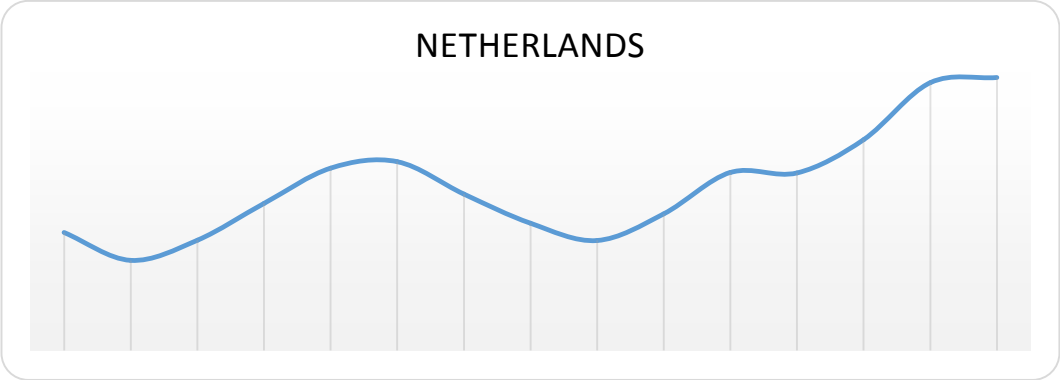

Figure 36. History of Netherland's unemployment rate according to OECD data

Netherlands was somewhat hit hard by the global crisis. Its unemployment rate was more than doubled in 2014 (6.82%, the historical peak) compared to its pre-crisis level in 2007 (3.18%).

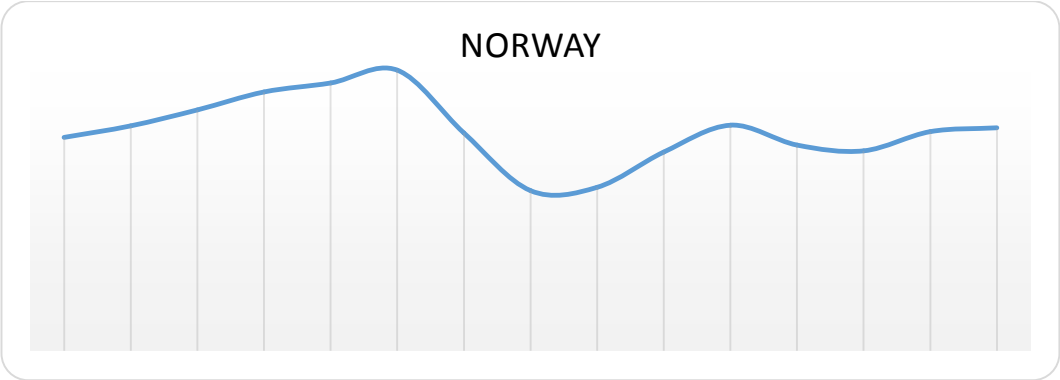

Figure 37. History of Norway's unemployment rate according to OECD data

Norway, with one of the lowest unemployment rate among OECD countries, was at its historical bottom with 2.5% in 2007 before the global crisis struck. However, it only increased by 0.98% by the end of 2014. Thus, we can say that Norway was almost not affected by the recession.

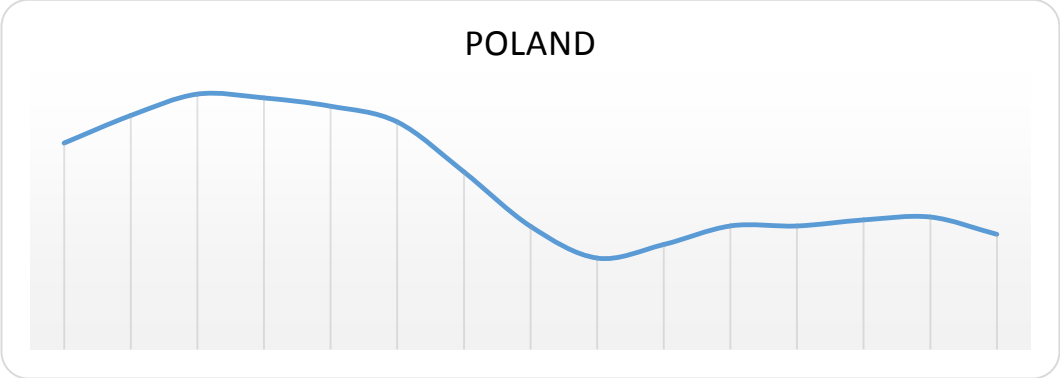

Figure 38. History of Poland's unemployment rate according to OECD data

Poland was not the best performing country in OECD before the global recession. Oddly enough, it had its historical bottom right after the crisis struck with a rate of 7.12%. However, it rose to 8.99 in the last quarter of 2014.

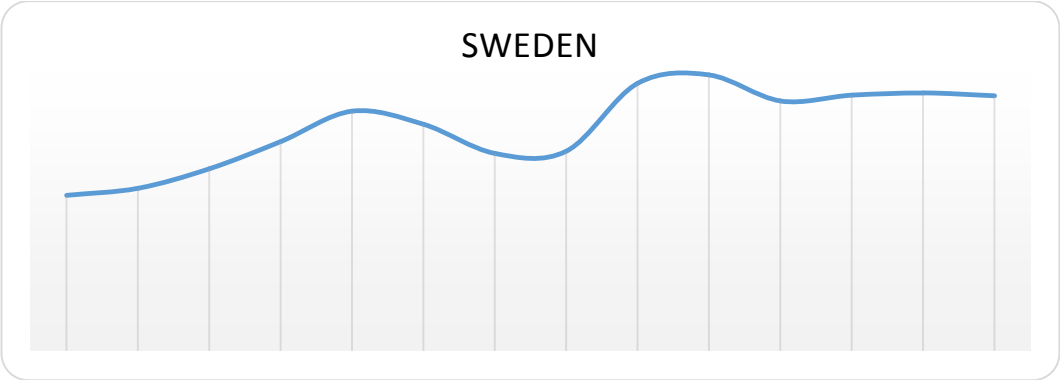

Figure 39. History of Sweden's unemployment rate according to OECD data

Sweden faced a historical peak 2 years after the beginning of the global recession with a level of 8.61%. With a slight recovery, it decreased to 7.96% at the end of 2014.

CHAPTER 3

3. THE EMPIRICAL LITERATURE ON HYSTERESIS IN UNEMPLOYMENT

In this chapter, the empirical literature about the hysteresis in unemployment was analyzed and classified. To test the hysteresis hypothesis researchers mostly used the OECD countries. While some researchers focused their studies on regions such as, Eurozone, Latin America, and East Asia Pacific Region; other researchers preferred to investigate economically grouped countries like G-7 and transition countries. Also some researchers studied only a single country like Turkey and Czech Republic. The results of the survey we did on the literature will be grouped according to the findings of the studies. In section 3.1 studies that found results in favor of the natural rate hypothesis will be reported, then section 3.2 will contain studies that resulted with hysteresis, and finally in section 3.3 studies with mixed results will be presented.

3.1 Studies with Natural Rate Results

Camarero et al. (2006) studied hysteresis in unemployment on 19 OECD countries for the years between 1956 and 2001. They preferred Panel data test as their testing method. The advantageous part of their tests were that they exploited the cross-sectional variations of the series. Moreover, their tests also allowed for various endogenous breakpoints in the series. The hysteresis in unemployment was rejected according to their tests.

Chang et al. (2007) analyzed hysteresis in unemployment for 21 regions of Taiwan for the period between June 1993 and September 2001. They applied Levin et al. (2002), Im et al. (2003) and Taylor and Sarno (1998) panel data tests. The results

of all three tests proved that the hysteresis hypothesis can be rejected for Taiwan's regions.

Camarero et al. (2008) conducted another research on this subject. This time, they did their research on transition countries for the period 1991 to 2003. They used Panel data method in this paper as well. Once again, their stationary tests were advantageous as they exploit the cross-sectional variations of the series and also they allow for numerous endogenous breakpoints. Their findings remained same with their previous work for transition countries.

Mohan et al. (2008) pointed out that similar studies on OECD and US data provided contrasting results because of specification problems. In order to get rid of these issues various panel unit root tests that can overcome them were utilized in their work. They studied three regions of Massachusetts and found enough evidence in support of natural rate hypothesis.

Lee et al. (2009) performed the Panel LM (Lagrange Multiplier) unit root test with heterogeneous structural breaks on 19 OECD countries. They found that the hysteresis in unemployment hypothesis strongly failed for these countries. As a result of their study, they suggested that the shocks in the unemployment rates are temporary rather than being permanent.

Akay et al. (2011) analyzed 23 OECD countries for the period between 1963 and 2007. They applied univariate time series test and Panel unit root test and failed to accept the hysteresis in unemployment hypothesis.

Çınar et al. (2014) made a study on Turkey for the period 1988 to 2008. The method they preferred was univariate time series unit root tests with and without structural break. The findings lead to the rejection of the hysteresis in unemployment hypothesis.

In Table 1 all of the studies with natural rate results are listed in the chronological order to make it easier to follow.

Table 1: Natural Rate of Unemployment

Researcher	Sample	Period	Method	Result
Camarero et al. (2006)	19 OECD countries	1956-2001	Panel data	Natural rate
Chang et al. (2007)	21 regions of Taiwan	1993:6-2001:8	Levin et al. (2002), Im et al. (2003) and Taylor and Sarno (1998) Panel datas	Natural rate
Camarero et al. (2008)	Transition countries	1991-2003	Panel data	Natural rate
Mohan et al. (2008)	3 regions of Massachusetts		Panel unit root tests	Natural rate
Lee et al. (2009)	19 OECD countries		Panel LM unit root test	Natural rate
Akay et al. (2011)	23 OECD countries	1963-2007	Univariate time series test, panel unit root test	Natural rate
Çınar et al. (2014)	Turkey	1988-2008	Univariate time series unit root tests with and without structural break	Natural rate

3.2 Studies with Hysteresis Results

In this section, studies that resulted with hysteresis are reported. It is extremely remarkable that only a handful of studies accepted the hypothesis of hysteresis in unemployment. It is also noteworthy that only the recent studies are involved in this group, this might be related with the new test methods some researchers came up with.

Barışık and Çevik (2008) performed unit root test with structural break and semi-parametric long memory models on Turkey for the period 1923 to 2006. They noted that there was a structural break in the unemployment rate series of Turkey in 1968. They found sufficient proof to accept the null hypothesis of hysteresis in unemployment.

Romero-Ávila and Usabiaga (2008) made a study on Spain for the years between 1976 and 2004. They used Panel unit root test with structural breaks. The results of their study proved the hysteresis effect in unemployment.

Yılancı (2009) examined Turkey for the period 1923 to 2007. He applied using Perron, Zivot-Andrews (ZA), Lumsdaine – Papell (LP) and Lagrange Multiplier (LM) unit root tests allowing for structural breaks. He was able to accept the hysteresis hypothesis as well by pointing out that even temporary shocks effect the unemployment rates permanently.

Ener and Arıca (2011) conducted their test on Turkey and 15 European Union countries for the years between 1985 and 2005. Their preferred test was Panel unit root test. They accepted the hysteresis in unemployment hypothesis.

Gözgör (2012) performed both homogenous and heterogeneous Panel-based Unit Root (PUR) tests on Turkey between 2004 and 2011. His test results demonstrated that the regional unemployment rates do not revert back to their mean, hence, he found sufficient evidence to accept the hysteresis hypothesis.

Niclas (2012) studied 8 OECD countries; these are Australia, Belgium, Canada, France, Netherlands, Sweden, the United Kingdom, and the United States. He applied

univariate unit root tests (ADF and KSS), and ARFIMA approach. He also accepted the hysteresis in unemployment hypothesis.

Özcan (2012) conducted Lee and Strazicich (2003) and Im et al. (2005 and 2010) unit root tests which allow for structural breaks on 23 OECD countries. She evidently proved that hysteresis effect exists in most of the OECD countries.

Table 2: Hysteresis of Unemployment Rate

Researcher	Sample	Period	Method	Result
Barışık and Çevik (2008)	Turkey	1923-2006	Unit root test with structural break, semi-parametric long memory models	Hysteresis
Romero-Ávila and Usabiaga (2008)	Spain	1976-2004	Panel unit root test with structural breaks	Hysteresis
Yılancı (2009)	Turkey	1923-2007	Perron, ZA, LP, LM unit root tests with structural breaks	Hysteresis
Ener and Arıca (2011)	Turkey and 15 EU countries	1985-2005	Panel unit root test	Hysteresis
Gözgör (2012)	Turkey	2004-2011	Panel unit root test	Hysteresis
Niclas (2012)	8 OECD countries		Univariate unit root tests(ADF and	Hysteresis

			KSS),ARFIMA approach	
Özcan (2012)	23 OECD countries		Lee and Strazicich (2003) and Im et al. (2005 and 2010) unit root tests	Hysteresis

3.3 Studies with Mixed Results

In this section, studies that found both hysteresis and natural rate in different countries will be reported.

Smyth (2003) utilized panel data unit root tests on Australia over the period 1982 to 2002. Levin and Lin (1992) test which uses OLS and O'Connell (1998) test which uses FGLS proved natural rate hypothesis acceptable, while Im et al. (1997) test rejected it and accepted hysteresis hypothesis instead.

Camarero and Tamarit (2004) examined 19 OECD countries. They applied multivariate ADF test and Panel unit root test and accepted the null hypothesis of hysteresis in 7 countries, while rejecting it for the remaining 12 countries.

Chang et al. (2005) studied 10 European countries for the years between 1961 and 1999. They used Panel SURADF and found hysteresis in 8 countries, and natural rate in other 2 countries.

In another study, Yılancı (2008) conducted the new unit root test developed by KSS (2003) on 17 OECD countries. He found evidence to prove the existence of natural rate of unemployment for Belgium, Korea, Switzerland, USA, Netherlands and Poland and while he was unable to reject the null hypothesis of hysteresis for Australia,

Austria, Canada, Finland, Germany, Japan, Luxembourg, Norway, Slovak Republic and Turkey.

Mednik et al. (2008) utilized Time series tests (ADF, KPSS, LM) and Panel unit root tests (IPS 2003, Choi 2001 and 2002, Pesaran) on 13 Latin American countries for the period 1980 to 2005. Their findings lead to the acceptance of hysteresis in unemployment hypothesis for 7 countries and to the rejection of it for 6 countries.

Gustavsson and Österholm (2010) investigated 17 OECD countries by applying Mean-reverting Autoregressive model. They found evidence to prove unemployment hysteresis in Austria, Finland, Iceland, Israel, Italy, Japan and Sweden. However, they failed to find any evidence to prove it for the remaining 10 countries.

In another research, Lee, Cheng-Feng (2010) focused on 29 OECD countries. He used nonlinear panel unit root test and SPSM. He accepted the natural rate hypothesis for 23 countries and accepted the hysteresis hypothesis for 6 countries.

Chang and Lee (2011) studied G-7 countries (Canada, France, Germany, Italy, the United States, the United Kingdom, and Japan) for the period 1992 to 2008. They applied threshold unit root test and found hysteresis in 3 countries, and natural rate in 4 countries.

Chang (2011) conducted Stationary test with a Fourier function (Becker et al. 2006) on 17 OECD countries for the years between 1960 and 2009. He was able to confirm hysteresis in unemployment for most of these 17 OECD countries, with the exception of Australia, Canada, Finland, France, Sweden and the USA.

Furuoka (2012) chose 12 countries in the East Asia Pasific Region as his sample group. He applied Multivariate Augmented Dickey Fuller test (MADF) and Seeminly Unrelated Regression ADF test (SURADF). He was also able to confirm hysteresis in unemployment for most countries, except in South Korea and New Zealand.

Furuoka (2014) examined 14 regions of Czech Republic. He conducted SURADF, FADF tests and found evidence to accept hysteresis hypothesis for 9 regions, and to reject it for 5 regions.

Bolat et al. (2014) applied new nonlinear panel unit root tests on 17 Eurozone countries for the period between 2000 and 2013. They accepted the null hypothesis of hysteresis for all 17 countries according to the Panel unit root test and SPSM without fourier. However, when they applied Panel KSS with fourier they failed to accept the null hypothesis for 11 countries, while still accepting it for 6 countries.

In one of the most recent studies in the literature, Marjanovic and Mihajlovic (2014) examined the hysteresis effect in unemployment for the period of 2000:01 to 2013:01. They studied two different groups of countries, first group was 10 of the European OECD countries, and the second one was 10 central and eastern European countries in transition. They applied univariate and panel unit root tests as well as structural break analysis. According to univariate and panel unit root tests they failed to reject the hysteresis effect for most of the countries. However, structural break analysis provided enough evidence to reject the hysteresis effect in OECD countries. On the other hand, they also failed to reject the hysteresis hypothesis for the countries in transition.

Table 3: Mix of Hysteresis and Natural Rate of Unemployment

Researcher	Sample	Period	Method	Result
Smyth (2003)	Australia	1982 - 2002	Panel unit root tests	2 tests gave natural rate results, 1 test gave hysteresis result
Camarero and Tamarit (2004)	19 OECD countries		Multivariate ADF test,	Hysteresis in 7 countries, Natural rate

			panel unit root test	in 12 countries
Chang et al. (2005)	10 European countries	1961-1999	Panel SURADF	Hysteresis in all countries except Belgium and Netherlands
Yılancı (2008)	17 OECD countries		New unit root test developed by KSS(2003)	Hysteresis in 11 countries, Natural rate in 6 countries
Mednik et al. (2008)	13 Latin American countries	1980-2005	Time series tests (ADF, KPSS, LM) and Panel unit root tests (IPS 2003, Choi 2001 and 2002, Pesaran)	Hysteresis in 7 countries, Natural rate in 6 countries
Gustavsson and Österholm (2010)	17 OECD countries		Mean-reverting Autoregressive model	Hysteresis in 7 countries, Natural rate in 10 countries
Lee, Cheng-Feng (2010)	29 OECD countries		Nonlinear panel unit root test, SPSM	Hysteresis in 6 countries, Natural rate in 23 countries
Chang and Lee (2011)	G-7 countries	1992-2008	Threshold unit root test	Hysteresis in 3 countries, Natural rate in 4 countries

Chang (2011)	17 OECD countries	1960-2009	Stationary test with a Fourier function (Becker et al. 2006)	Hysteresis in 11 countries, Natural rate in 6 countries
Furuoka (2012)	12countries in the East Asia Pacific Region		Multivariate Augmented Dickey Fuller test(MADF), Seemingly Unrelated Regression ADF test (SURADF)	Hysteresis in all countries except South Korea and New Zealand
Furuoka (2014)	14 regions of Czech Republic		SURADF,FADF tests	Hysteresis in 9 regions, Natural rate in 5 regions
Bolat et al. (2014)	17 Eurozone countries	2000-2013	New nonlinear panel unit root tests	Panel unit root test and SPSM without fourier: All countries have hysteresis Panel KSS with fourier: 6 countries have hysteresis, 11 countries

				have natural rate
Marjanovic and Mihajlovic (2014)	10 OECD countries and 10 countries in transition	2000 – 2013	Univariate and Panel unit root tests, structural break analysis	Mixed results

CHAPTER 4

4. METHODOLOGY

In this thesis, our goal is to analyze the hysteresis in unemployment using unit root tests, both linear and nonlinear. For this purpose we used Augmented Dickey Fuller (ADF) test as the only linear unit root test. The nonlinear unit root test applied in this study was the Enders and Granger (EG) test. To allow for the possibility of structural breaks we have also considered the Leybourne, Newbold, Vougas (LNV) test. However, there is no need to think that structural breaks and nonlinearity should be present in the unemployment series in isolation. Therefore, to allow for both features we have also utilized the Sollis (2004) test. The LNV test allows for only structural breaks, and the EG test checks for only asymmetry. Sollis (2004) test combines these two tests to take into account both the structural breaks and asymmetry in the unemployment series. All the aforementioned tests are explained briefly in this section. For all the mentioned tests the null hypothesis is accepted if the presence of unit root is proved.

4.1 The Augmented- Dickey Fuller (ADF) Test

The model of Dickey Fuller test is as follows;

$$Y_t = Y_{t-1} + u_t \tag{4.1}$$

We get a random walk without drift with the model, while alternative hypothesis is stationary in AR (1) process. $u_t$is the error term,

$$Y_t = \rho Y_{t-1} + u_t \qquad 1 - \leq \rho \leq 1 \qquad (4.2)$$

In equation (4.2) if ρ = 1, which means if there is unit root, we can say that it is a random walk model without drift, which is a non-stationary stochastic process (Gujarati, 2004). In the equation (4.2) Y_{t-1} was subtracted from both sides. If we add them back we get:

$$Y_{t-1} - Y_t = \rho Y_{t-1} - Y_{t-1} + u_t \quad \Longrightarrow (\rho - 1) Y_{t-1} \qquad (4.3)$$

And if we rewrite equation 4.3;

$$\Delta Y_t = \delta Y_{t-1} + u_t \qquad (4.4)$$

$$\delta = (\rho - 1)$$

$H_0: \delta \geq 0$ (There is unit root / Non-stationary)
$H_1: \delta < 0$ (There isn't unit root / Stationary)

We can estimate the various possibilities of DF test in three different forms:

$\Delta Y_t = \rho Y_{t-1} + u_t$ (Pure random walk)

$\Delta Y_t = \beta_1 + \rho Y_{t-1} + u_t$ (Random walk with drift)

$\Delta Y_t = \beta_1 + \beta_{2t} + \delta Y_{t-1} + u_t$ (Random walk with drift around a stochastic trend)

It is crucial to note that the critical values to test the hypothesis δ = 0 for these three determinations are different (Gujarati 2004). These three different critical values are; 1%, 5% and 10%. In Dickey Fuller Test, standard distribution and t statistic weren't used, instead DF or MacKinnon (1991) critical value was used;

$$|\tau| > |McK - DF|$$

In this condition, we do not accept H_0, which means time series is stationary.

Augmented Dickey Fuller (ADF) test is advanced version of Dickey Fuller Test. ADF test was developed using the three different forms of the DF test. "This test is carried out by "augmenting" the three equations that was mentioned before by adding the lagged values of the dependent variableΔY_t" (Gujarati, 2004). The estimation of ADF test is as follows:

$$\Delta Y_t = \beta_1 + \beta_{2t} + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t \qquad (4.5)$$

Where ε_t is pure white noise error term,

$$\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$$

And,

$$\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$$

ADF test follows the exact same asymptotic distribution as the DF test. Therefore, same critical values are valid for the ADF test as well.

ADF test gives us the opportunity to test the null hypothesis $\delta = 0$ against the alternative hypothesis. If the t value is smaller than the critical value, then we fail to accept the null hypothesis while we can accept the alternative hypothesis. In other words, there is no unit root and the series are stationary.

4.2 Leybourne, Newbold, Vougas (LNV) Test

LNV test was developed by Leybourne, Newbold, Vougas (1998) (LNV). They proposed an alternative hypothesis suggesting stationarity around a smoothly changing trend, and they tested the null hypothesis against three possible alternatives. The derivation of the LNV model is as follows;

Model 1 $: y_t = \alpha + \alpha_2 S_t(\gamma.\tau) + \varepsilon_t$

Model 2 $: y_t = \alpha + \beta_1 t + \alpha_2 S_t(\gamma.\tau) + \varepsilon_t$

Model 3 $: y_t = \alpha + \beta_1 t + \alpha_2 S_t(\gamma.\tau) + \beta_2 t S_t(\gamma.\tau) + \varepsilon_t$

Where y_t be a changing trend function with smooth transition on the time domaint $= 1,2,\dots,T$. ε_t is a zero mean I (0) process and $S_t(\gamma.\tau)$ is logistic smooth transition function, based on a sample of size T and N.

$$S_t(\gamma.\tau) = [1 + \exp\{-\gamma(t - \tau T)\}]^{-1} \ , \ \gamma > 0 \qquad (4.6)$$

"In this modeling strategy, the structural change is modeled as smooth transition between different regimes rather than instantaneous structural break as in Leybourne et al (1998). The transition function$S_t(\gamma.\tau)$is continuous function bounded between 1 and 0. Thus the Smooth Transition Regression (STR) model can be interpreted as regime-switching model that allows for two regimes, associated with the extreme values of the transition function, $S_t(\gamma.\tau)$= 0 and $S_t(\gamma.\tau)$=1 , whereas the transition from one regime to the other is gradual. The parameter γ determines the smoothness of the transition, and thus, the smoothness of transition from one regime to the other. The two regimes are associated with small and large values of the transition variable$S_t = t$ relative to the threshold $c = \tau$.For the large values of γ , $S_t(\gamma.\tau)$ passes through the interval (0,1) very rapidly, and as γ approaches +∞ this function changes value from 0 to 1 instantaneously at time. Therefore, if we assume that ε_t is zero mean I (0) process and then model 1 $y_t$is stationary process around a mean which changes from initial value α_1 to final value$\alpha_1 + \alpha_2$." (Omay et al. 2014)

Omay et al. (2014) proposed the following hypothesizes for unit root testing based on the 3 equations:

H_0: Unit Root, (Linear Nonstationary)
H_1: Nonlinear Stationary (Nonlinear and Stationary around smoothly changing trend and intercept)

4.3 The Enders and Granger (EG) Test

The EG test is explained below in the sense of Sollis (2004).

Assume the model of TAR(1) for a time series y_t,

$$\Delta y_t - I_t \rho_1 (y_{t-1} - \alpha_0) + (1 - I_t) \rho_2 (y_{t-1} - \alpha_0) + \varepsilon_t , \quad (1)$$

> "where ε_t are zero-mean i.i.d. error terms and I_t is the Heaviside indicator function such that $I_t = 1$ if $y_{t-1} \geq \alpha_0$, $I_t = 0$ if $y_{t-1} < \alpha_0$. Petrucelli and Woolford (1984) proved that in order for y_t to be stationary it is required and sufficient that $\rho_1 < 0$, $\rho_2 < 0$ and $(1 + \rho_1)(1 + \rho_2) < 1$ for any value of α_0. If these conditions are provided, then $y_t = \alpha_0$ is the long-run equilibrium value of y_t, and if $\rho_1 \neq \rho_2$ we can say that the adjustment to this equilibrium is asymmetric. If $\rho_1 = \rho_2 = 0$ then y_t is nonstationary, in other words, a unit-root process. Enders and Granger (1998) developed critical values for an F-statistic (labelled Φ_μ) using Monte Carlo simulation to test the unit-root hypothesis. EG also suggested that the most significant of the t-statistics could be used to test $\rho_1 = 0$ or $\rho_2 = 0$ as a unit-root test (labelled T- $\max_\mu$). To make this testing they also simulated appropriate critical values. EG have developed even further tests to allow for higher-order stationary asymmetric processes and to include deterministic linear trends under the alternative hypothesis." (Sollis, 2004)

Sollis continues with pointing out the procedure proposed by EG in order to calculate their test statistics. This procedure contains three steps. The initial step is to determine whether the deterministic trend is needed to be included or not by using a visual analysis of the time series. The second step is an OLS regression of y_t on the

relevant deterministic components, saving the residuals from $\hat{u}_t$. To check if there is a unit root presence in y_t allowing for asymmetric adjustment under the alternative hypothesis, the presence of a unit root in $\hat{u}_t$ can be tested as well, using the *F*-statistic to test $\rho_1 = \rho_2 = 0$ and/or the most significant of the *t*-statistics to test $\rho_1 = 0$ or $\rho_2 = 0$ in the TAR(1) model (Sollis, 2004);

$$\Delta\hat{u}_t = I_t \rho_1 \hat{u}_{t-1} + (1 - I_t) \rho_2 \hat{u}_{t-i} + \eta_t, \quad (2)$$

where $I_t = 1$ if $\hat{u}_{t-1} \geq 0$, $I_t = 0$ if $\hat{u}_{t-1} < 0$ and OLS is used in order to estimate the parameters. If $\hat{u}_t$ has the presence of a unit-root, we can say that the process of y_t has nonlinearity. Finally, EG proposed the application of diagnostic tests to the residuals, $\hat{\eta}$. If the residuals are correlated then relevant test statistics should be re-calculated using the augmented TAR model

$$\Delta\hat{u}_t = I_t \rho_1 \hat{u}_{t-1} + (1 - I_t) \rho_2 \hat{u}_{t-1} + \sum_{i=1}^{k} \phi_i \Delta\hat{u}_{t-i} + \eta_t, \quad (3)$$

where *k* is required to have a value which would make the $\hat{\eta}_t$ a white noise.

4.4 Sollis (2004) Test

Sollis says that both LNV and EG tested the null hypothesis of a unit root and LNV suggested tests which allow for stationary autoregression with deterministic components that contains instantaneous or gradual breaks, modeled as smooth transitions, according to the alternative hypothesis. He also claims that these tests originate from smooth transition models and one can assume them as nonlinear alternatives to the structural break tests of Perron (1989) and Zivot and Andrews (1992). LNV proposed the following smooth transition models for y_t ;

$$y_t = \alpha_1 + \alpha_2 S_t(\gamma, \tau) + u_t \quad (1)$$

$$y_t = \alpha_1 + \beta_1 t + \alpha_2 S_t(\gamma, \tau) + u_t \quad (2)$$

$$y_t = \alpha_1 + \beta_1 t + \alpha_2 S_t(\gamma, \tau) + \beta_2 t S_t(\gamma, \tau) + u_t \quad (3)$$

where u_t is a zero-mean *I(0)* process and $S_t(\gamma, \tau)$ is the logistic function for a sample of size *T*, $S_t(\gamma, \tau) = (1 + \exp\{-\gamma[t - \tau T]\})^{-1}$ where $\gamma > 0$ and τ determines the mid-point of the transition.

As stated in Sollis (2004), one can use the models given in (1), (2) and (3) as shown below for testing the hypotheses that follows;

$H_0 : y_t = \mu_t \quad , \quad \mu_t = \mu_{t-1} + \varepsilon_t$

H_1 : (1), (2) or (3)

$H_0 : y_t = \mu_t \quad , \quad \mu_t = \kappa + \mu_{t-1} + \varepsilon_t$

H_1 : (2) or (3) ,

where ε_t is assumed as a stationary process with a mean of zero. LNV suggested a procedure involving two steps to calculate the statistics for testing these hypotheses. The first step is the estimation of the deterministic components of the relevant model by nonlinear least squares (NLS) and computing the NLS residuals

$$\hat{u}_t = y_t - \hat{\alpha}_1 - \hat{\alpha}_2 S_t(\hat{\gamma}, \hat{\tau}) \quad (4)$$

$$\hat{u}_t = y_t - \hat{\alpha}_1 - \hat{\beta}_1 t - \hat{\alpha}_2 S_t(\hat{\gamma}, \hat{\tau}) \quad (5)$$

$$\hat{u}_t = y_t - \hat{\alpha}_1 - \hat{\beta}_1 t - \hat{\alpha}_2 S_t(\hat{\gamma}, \hat{\tau}) - \hat{\beta}_2 t S_t(\hat{\gamma}, \hat{\tau}) \quad (6)$$

Next step is computing the t-statistic to test $\rho = 0$ in the autoregressive (AR) model

$$\Delta\hat{u}_t = \rho\hat{u}_{t-1} + \sum_{i=1}^{k} \delta_i \Delta\hat{u}_{t-i} + \eta_t , \quad (7)$$

where *k* needs to have a value which would make the $\hat{\eta}_t$ a white noise. LNV refers to the statistics of unit root tests associated with models (1), (2), and (3) as $S_{\alpha,}$ $S_{\alpha(\beta)}$, and $S_{\alpha\beta}$ respectively. Monte Carlo simulation method was used to develop suitable critical values for the statistics of the tests mentioned.

EG and LNV are very similar regarding their ways of checking for a unit root existence in the original series. They both remove the deterministic components of the data before they apply the test for unit root. One can say that the models used by them might be combined due to this reason. Consider y_t is generated by (1), (2) or (3) with u_t generated by the TAR model that follows;

$$\Delta u_t = I_t \rho_1 u_{t-1} + (1 - I_t) \rho_2 u_{t-1} + \sum_{i=1}^{k} \phi_i \Delta u_{t-i} + \eta_t, \qquad (8)$$

"where $I_t = 1$ if $u_{t-1} \geq 0$, $I_t = 0$ if $u_{t-1} < 0$, and η_t is a zero-mean stationary process. Thus yt is a smooth transition TAR (ST-TAR) process. Irrespective of which model from (1), (2), or (3) is used to describe the deterministic components of y_t, if $\rho_1 = \rho_2 = 0$ in (8) then u_t and therefore y_t contains a unit root, while if $\rho_1 = \rho_2 < 0$, y_t is a stationary ST-TAR process with *symmetric* adjustment, and if $\rho_1 < 0$, $\rho_2 < 0$ and $\rho_1 \neq \rho_2$, y_t is a stationary ST-TAR process displaying *asymmetric* adjustment. We propose testing for whether y_t contains a unit root using the F-statistic for testing $\rho_1 = \rho_2 = 0$ in (8), and/or the most significant of the *t*-statistics from those for testing $\rho_1 = 0$ and $\rho_2 = 0$. When the full model is (1) and (8), the relevant *F*- and *t*-statistic will be referred to as F_α and tS_α. When the full model is (2) and (8) the *F*- and *t*-statistic will be referred to as $F_{\alpha(\beta)}$ and $tS_{\alpha(\beta)}$, and when the full model is (3) and (8) the *F*- and *t*-statistic will be referred to as $F_{\alpha\beta}$ and $tS_{\alpha\beta}$." (Sollis 2004)

Sollis finally puts forward that to calculate the test statistics F_α, $tS_{\alpha,}$ $F_{\alpha(\beta)}$, $tS_{\alpha(\beta)}$, $F_{\alpha\beta}$, $tS_{\alpha\beta}$, we can use the two-step approach singled out by LNV, which estimates the deterministic components first and then testing for the presence of a unit root in the residuals from the first-step regression. This time, the TAR model provided by equation (3) in the EG test section is used to check for the presence of a unit root. Monte Carlo simulation was used in order to obtain the critical values for the tests F_α,$tS_{\alpha,}$ $F_{\alpha(\beta)}$, $tS_{\alpha(\beta)}$, $F_{\alpha\beta}$, $tS_{\alpha\beta}$. The simulations are done under the same null models as EG and following the two-step estimation procedure defined earlier.

CHAPTER 5

5. DATA AND EMPIRICAL RESULTS

5.1 Data

The hysteresis of unemployment is examined using the monthly data of 24 OECD member countries over the period 1998:04 and 2013:09. The countries involved are Australia, Austria, Belgium, Canada, Chile, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, Norway, Poland, Portugal, Spain, Sweden, and US. The monthly harmonized unemployment rate data were taken from the OECD database. The definition of unemployed according to harmonized unemployment rates is the people of working age who are without work, are available for work, and have taken specific steps to find work. Harmonized unemployment rate is seasonally adjusted, and it is measured in numbers of unemployed people as a percentage of the labour force.

5.2 Empirical Results

The results of the various unit root test that are applied are presented and discussed in this section of the study. We first present the results of the conventional ADF unit root test. Second, the results of the nonlinear unit root test, EG, is discussed. Third, the findings regarding the unit root test with smooth structural breaks (LNV test) are conveyed. Finally, we consider the Sollis (2004) test which allows for both structural breaks and nonlinearity.

The results of the ADF test which is the only linear unit root test applied in this study are reported in Table 4.

Table 4: ADF Test Results

	Intercept only	Intercept and Trend
Australia	-1.794	-0.820
Austria	-1.506	-1.710
Belgium	-4.316***	-4.184***
Canada	-2.429	-2.666
Chile	-1.047	-2.187
Denmark	-1.516	-2.172
Finland	-2.024	-1.846
France	-3.503***	-3.840**
Germany	-0.685	-1.694
Greece	-2.003	-2.832
Hungary	-1.084	-1.792
Ireland	-1.534	-2.337
Italy	-0.897	-0.530
Japan	-1.499	-1.746
Korea	-3.711***	-3.232*
Luxembourg	-0.965	-2.206
Mexico	-0.899	-2.814
Netherlands	-1.983	-2.788
Norway	-2.176	-2.276
Poland	-2.103	-2.787
Portugal	-0.430	-2.862
Spain	-0.424	-1.272
Sweden	-2.491	-3.340*
US	-1.938	-3.136*

Notes: The superscripts *, **, *** represent significance at the 10%, 5% and 1% levels respectively using the ADF critical values for T=250 (the sample size is 186). We use Akaike

Information Criteria (AIC) with a maximum lag length of 12. The ADF t-statistic critical values for the intercept only case are -2.57, -2.88 and -3.46 at 10%, 5% and 1% significance levels, respectively. The ADF t-statistic critical values for the intercept and trend case are -3.13, -3,69 and -3.99 at 10%, 5% and 1% significance levels, respectively.

As Table 4 demonstrates; for Belgium, France, and Korea the standard ADF test rejects the null hypothesis when only intercept is included, which means there is no unit root in the unemployment rates of these countries. In other words, only 3 countries out of all 24 OECD countries have natural rate where for other 21 countries the null hypothesis is accepted and they have hysteresis. So the ADF test with only intercept included gives us a remarkable low percentage of countries that have natural rate, which is 12.5% while the remaining 87.5% have hysteresis.

When we include both an intercept and a trend together the results for the 3 countries with natural rate doesn't change, however, 2 more countries turns into natural rate from hysteresis. These countries are Sweden and the US. The results for the other 19 countries remain unchanged. After these changes, the percentage of countries with natural rate increases to approximately 20.8%, and the percentage of countries with hysteresis drops to 79.2%. Still, however, for a majority of the countries in our sample the natural rate hypothesis is rejected in favor of the hysteresis hypothesis. Thus, using the conventional ADF unit root test we can conclude that hysteresis holds for most of the OECD countries. However, the results of the conventional ADF tests will be biased if the unemployment rates display nonlinear behavior and/or are subject to breaks. Thus, in the rest of the thesis we present the results of the nonlinear unit root tests and unit root tests that allow for structural breaks.

The nonlinear unit root test used in this study was the EG test. The EG test allows for asymmetry. The results of this test is tabulated in Tables 5, respectively.

Table 5: EG Test Results

	Intercept only	Intercept and Trend
Australia	3.194	2.181
Austria	2.575	3.249
Belgium	4.709*	4.356
Canada	2.559	2.405
Chile	2.793	9.034*
Denmark	0.781	1.608
Finland	3.018	2.350
France	3.476	4.053
Germany	0.814	1.119
Greece	0.692	0.432
Hungary	0.146	5.788*
Ireland	1.232	3.296
Italy	0.861	0.750
Japan	1.210	2.247
Korea	3.377	2.915
Luxembourg	0.771	3.427
Mexico	0.531	3.646
Netherlands	0.710	1.680
Norway	2.252	2.387
Poland	1.569	4.379
Portugal	0.797	2.703
Spain	0.712	1.621
Sweden	1.363	4.786

US	1.595	4.268

Notes: The superscripts *, ** and *** represent significance at the 10%, 5% and 1% levels respectively using the EG critical values for T=250 (the sample size is 186). We used Akaike Information Criteria (AIC), and a lag selection criterion is 12 lag with an upper bound. The EG critical values for the nonzero mean case and T=250 are 3.74, 4.56 and 6.47 for 10%, 5% and 1% significance levels, respectively. The EG critical values for the nonzero mean and trend case are 5.18, 6.12 and 8.23 for 10%, 5% and 1% significance levels, respectively (Enders and Granger,1998).

To see whether allowing for asymmetry adjustment changes the results of our tests, we also considered the EG test. As shown in the Table 5, for only one country the null hypothesis of a unit root is rejected when only an intercept term is included. This country is Belgium and it is the only country for which the natural rate hypothesis holds. For all of the other countries the null hypothesis is accepted meaning they have hysteresis according to this test. The rate of the countries with hysteresis has now increased to 95.8%, while only 4.2% of the countries support the natural rate hypothesis.

With the addition of a trend term to the EG test regression, Belgium joins to the countries with hysteresis as well. However, Chile and Hungary do not contain a unit root this time. Therefore, they have natural rate. After the inclusion of the trend term, the rate of the countries with natural rate increases to 8.3%, and the rate of the countries with hysteresis decreases to 91.7%.

The implementation of the EG test has considerably decreased the number of countries for which the natural rate hypothesis holds. Thus, the OECD unemployment rate series seems to display rather less asymmetry then it was suspected at the beginning of the study.

Up to now our results verify the hysteresis hypothesis for a majority of the OECD countries, whether linear or nonlinear unit root tests are applied. However, the EG test implemented above considers only the possibility of nonlinear adjustment in the unemployment series. But, it is equally likely that the series under question will be

subject to structural breaks during the time period analyzed. Thus, to see whether accounting for the potential structural breaks in the unemployment series changes our results, now we present the results of the LNV unit root test with structural breaks. The results of this LNV unit root test are reported in Table 6.

Table 6: LNV Test Results

Australia	-2.037
Austria	-2.608
Belgium	-3.706
Canada	-2.836
Chile	-2.835
Denmark	-1.781
Finland	-3.198
France	-3.512
Germany	-2.571
Greece	-1.586
Hungary	-3.140
Ireland	-3.288
Italy	-0.227
Japan	-2.485
Korea	-3.178
Luxembourg	-1.797
Mexico	-3.042
Netherlands	-1.207
Norway	-2.677
Poland	-3.262
Portugal	-2.877
Spain	-3.283
Sweden	-3.616
US	-1.293

Notes: The superscripts *, ** and *** represent significance at the 10%, 5% and 1% levels, respectively using the LNV critical values for T=200 (the sample size is 186) and Model 1. The LNV critical values for T=200 are -3,851, -4.161 and -4.761 for 10%, 5% and 1% significance levels, respectively.

As it can be seen from Table 6, when smooth structural breaks are allowed the entire sample now contains a unit root. Thus, all of the OECD countries have hysteresis according to the LNV test. Accounting for structural breaks has caused us to conclusively reject the natural rate hypothesis for all the OECD countries included in our sample.

To provide clearer interpretation of the time path implied by the estimated deterministic component, it is plotted, together with the actual values of the individual unemployment series, in Figure 40 at Appendix A. For all countries the transition between regimes seems to be not rapid in general but rather smooth.

Finally, we consider the possibility that the unemployment series under question may display both asymmetry and structural breaks by applying the Sollis (2004) test. The results of the Sollis (2004) test are reported in Table 7.

Table 7: Sollis (2004) Test Results

	T test	**F Test**
Australia	-1.198	5.723
Austria	-1.492	5.425
Belgium	-0.404	2.537
Canada	0.405	1.855
Chile	1.050	5.807
Denmark	-0.142	2.163
Finland	-1.588	4.987
France	0.634	3.458
Germany	0.485	2.692
Greece	-0.632	1.581
Hungary	1.428	4.306
Ireland	0.765	4.538
Italy	1.495	1.268
Japan	1.585	4.055
Korea	2.261	13.517***
Luxembourg	1.703	2.195
Mexico	1.311	3.327
Netherlands	0.848	0.821

Norway	0.173	3.581
Poland	-1.804	4.712
Portugal	-0.708	5.934
Spain	0.833	3.682
Sweden	-0.612	3.506
US	-1.530	1.538

Notes: The superscripts *, ** and *** represent significance at the 10% 5% and 1% levels respectively using the Sollis (2004) critical values for T=200 (the sample size is T=186).. The Sollis (2004) t-statistic critical values for Model 1 are are -3.140, -3.385 and -3.890 for 10%, 5% and 1% significance levels, respectively. The Sollis (2004) F-statistic critical values for Model 1 are 7.759, 9.029 and 11.789 for 10%, 5% and 1% significance levels, respectively

Sollis (2004) test has two different indicators to look at T-test and F-test. According to the results of the test with T-test, none of the countries have natural rate as they all contain a unit root. So we can say that the null hypothesis is accepted for 100% of the countries. As for the F-test results, only Korea has natural rate but the remaining 23 countries still have hysteresis. The rate of the countries with hysteresis is 95.8%.

Overall, our results have verified the hysteresis hypothesis for a majority of the OECD countries included in our study. The natural rate hypothesis is accepted at most in 5 countries (corresponding to only 20.8% of our sample) with the application of the ADF unit root test when both intercept and trend were included.

CHAPTER 6

6. CONCLUSION

The main aim of this thesis was to re-investigate the hysteresis hypothesis in unemployment. The reason why we chose this subject is to provide reliable information to understand how persistent the effect of the shocks in an economy on unemployment rates is. For this purpose, we studied 24 OECD countries. We analyzed the monthly unemployment rate data of these countries for the period 1998:04 to 2013:09. We applied various unit root tests. We implemented both linear and nonlinear unit root tests. Besides the conventional Augmented Dickey Fuller (ADF) test, we applied the univariate nonlinear unit root test, to allow for business cycle asymmetries we implemented the Enders and Granger (EG) unit root test. It is well known that the non-rejection of the unit root hypothesis may be caused by the misspecification of the deterministic components (Perron, 1989). Therefore, to consider the existence of structural breaks in the individual unemployment series of the OECD countries we applied the Leybourne, Newbold, Vougas (LNV) unit root test. The LNV test allows one to test whether a series is I(1) against the alternative of I(0) around a deterministic component which changes gradually and smoothly between regimes. Finally, to allow for structural breaks and asymmetry to occur simultaneously in the unemployment series we used the Sollis (2004) unit root test.

First the ADF test was applied to the OECD unemployment rates. We applied the ADF test twice, first taking only the intercepts into consideration, and then by adding also trend terms to the test regressions. This was the procedure we followed for most of the tests in our study. ADF test, considering intercept only, was able to reject the null hypothesis of hysteresis in favor of the natural rate hypothesis, for only 3 countries, which include Belgium, France and Korea. For the remaining 21 countries however, there were enough evidence to accept the null hypothesis of hysteresis. This gives us an 87.5% rate of acceptance of the null hypothesis of unit root or hysteresis.

When we add trend terms to the test equations 2 additional countries, namely Sweden and US, started to show natural rate characteristics, with the other 3 countries with natural rate remain unchanged. As a result of these changes, we get a rate of 79.2% proved hysteresis effect. When we look into both of these methods, we see that when we include trends the rate of countries with hysteresis effect drops slightly.

To see whether the strong hysteresis result obtained above using the conventional ADF test was because of preserving the linearity assumption, second, nonlinear unit root tests were utilized. It is well known that linear models have important drawbacks in terms of matching the properties of most economic variables including the unemployment rates. Unemployment rates tend to display asymmetric behavior during business cycles; they fall more sharply in recessions then they rise during expansions. If nonlinearity is present in the individual unemployment series, then the standard linear unit root tests will suffer from low power and may often falsely accept the null hypothesis of a unit root (i.e., verifying the hysteresis hypothesis).

When applying our nonlinear unit root test, the EG test, the same procedure with ADF test was followed. This test had high percentage of hysteresis results. With the intercept only method EG test found only for a single country (Belgium). Hence, we get a 95.8% acceptance rate of hysteresis effect with the EG test. These rates drop for EG tests when we include trends. For EG test, 2 countries (Chile and Hungary) turn into natural rate, while 1 country (Belgium) switches to hysteresis. These changes cause a decrease in the rate of hysteresis for EG to 91.7%.

In the unit root test implemented so far, no structural break was assumed. However, as mentioned before, the violation of the assumption of parameter constancy may lead to improper inference and thereby to incorrect policy implications from the miss-specified models. Hence, in performing unit root tests, special care must be taken if it is suspected that structural change has occurred. Thus, to allow for structural breaks, we used the LNV test. The LNV test was used because it assumes that the change in parameters over time is smooth rather than instantaneous or abrupt. This is important because structural changes in economic variables which are affected by the changes in the behavior of many economic agents are more likely to follow a smooth rather than an instantaneous time path. According to LNV test, there was no evidence

to reject the null hypothesis of hysteresis for any of the countries. In other words, LNV test results gave us a 100% acceptance rate of hysteresis in unemployment.

The last test used in this study was Sollis (2004) which is a unit root test that accounts for both smooth breaks and asymmetry. Sollis (2004) test was applied twice as well. However, dissimilar to the tests with intercept and trend procedures, Sollis (2004) test was conducted considering T-test and F-test. According to T-test results, no countries showed natural rate characteristics; therefore we accept the hysteresis effect for 100% of the countries. On the other hand, F-test was able to reject the null hypothesis for a single country (Korea). Consequently, the rate of hysteresis according to F-test results was 95.8%.

Overall, LNV and Sollis (2004) were the tests with the highest hysteresis results, as they led us to conclusively reject the natural rate hypothesis for all the OECD countries included in the study. Including the trends dropped the rate of acceptance of hysteresis for all tests. According to these empirical results, we found hysteresis effect in unemployment for the vast majority of the countries at all tests.

From the policy perspective, since the majority of the OECD unemployment rates are found nonstationary, the shocks affecting the labor markets of these countries, like the recent 2008-2009 global financial crisis, certainly will have permanent effects. The equilibrium unemployment rate may have no tendency to revert back to its equilibrium level and can stay at its currently high level for a long period of time. If this is the case, then urgent stability policy measures are required to return the unemployment to its original level.

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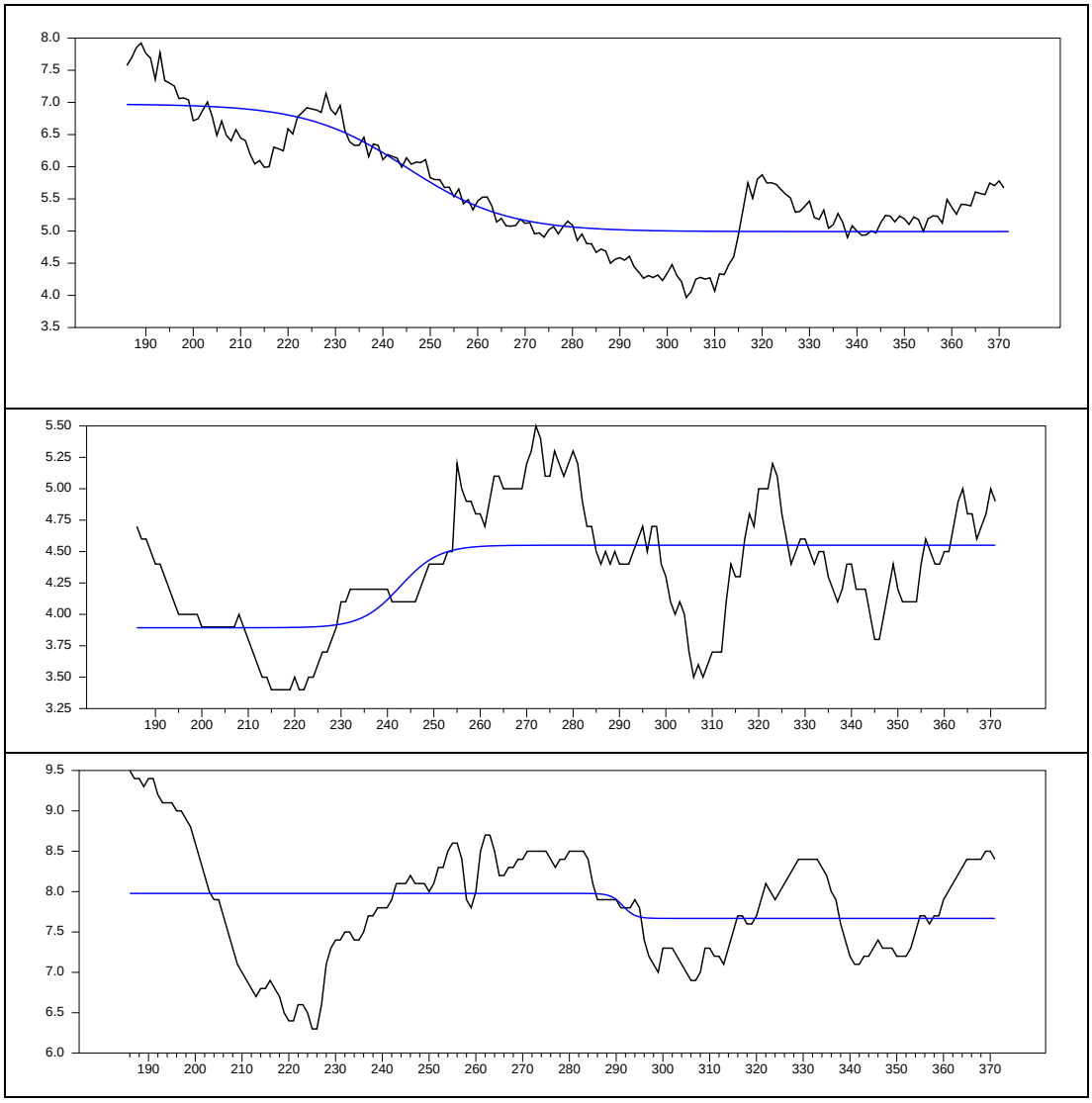
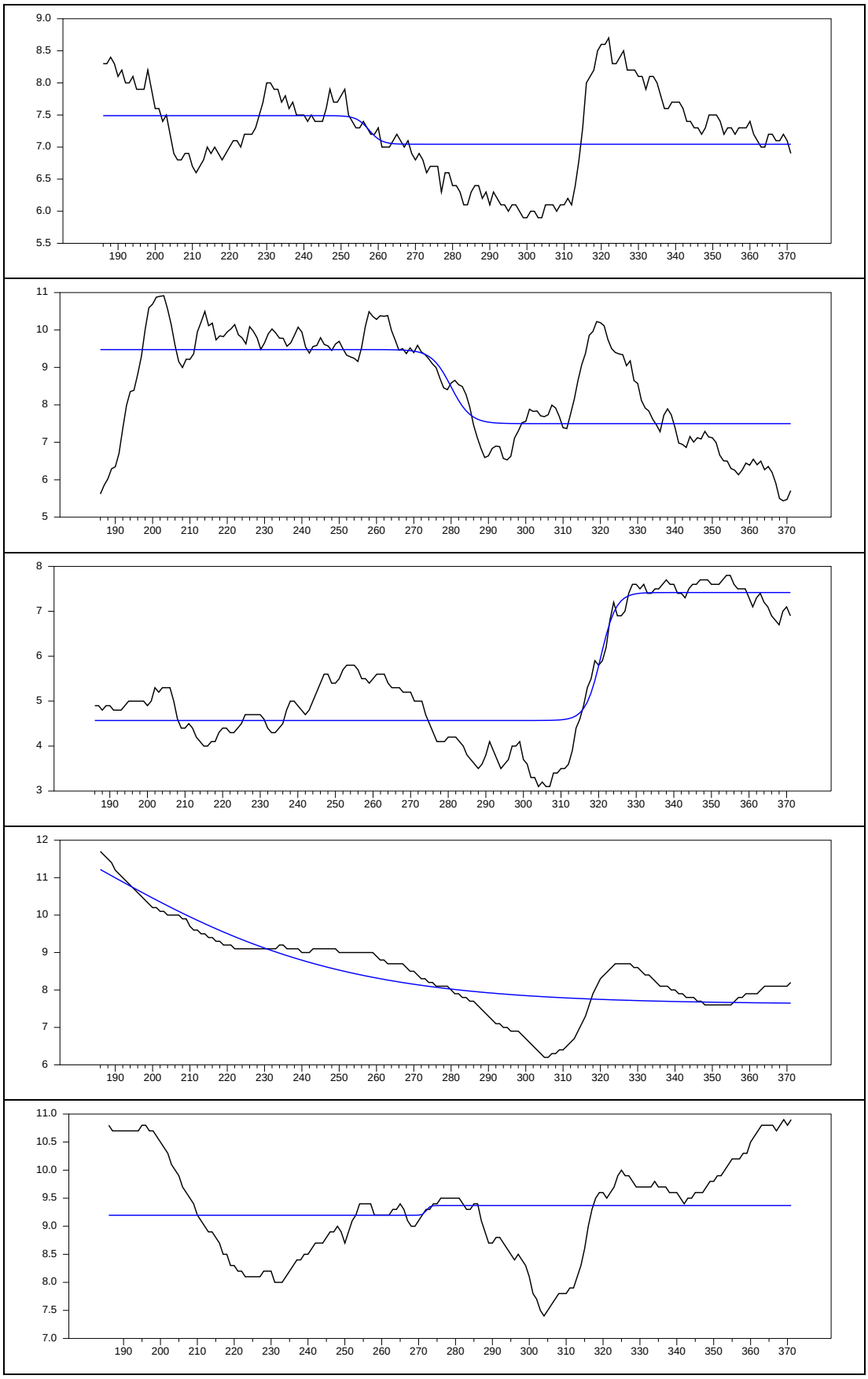
APPENDICES

APPENDIX A: Graphs

Figure 40. Unemployment series and the estimated transitions

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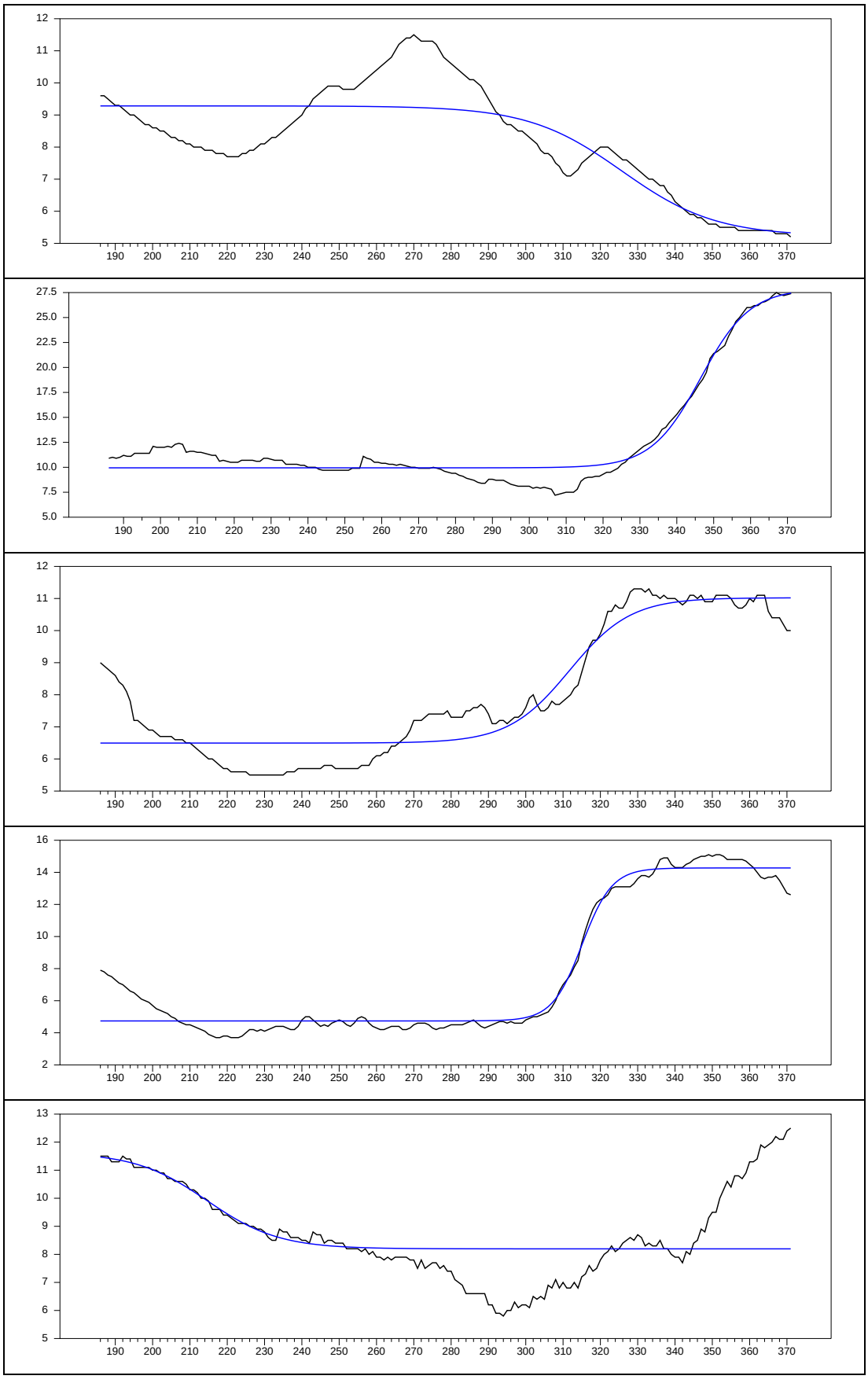
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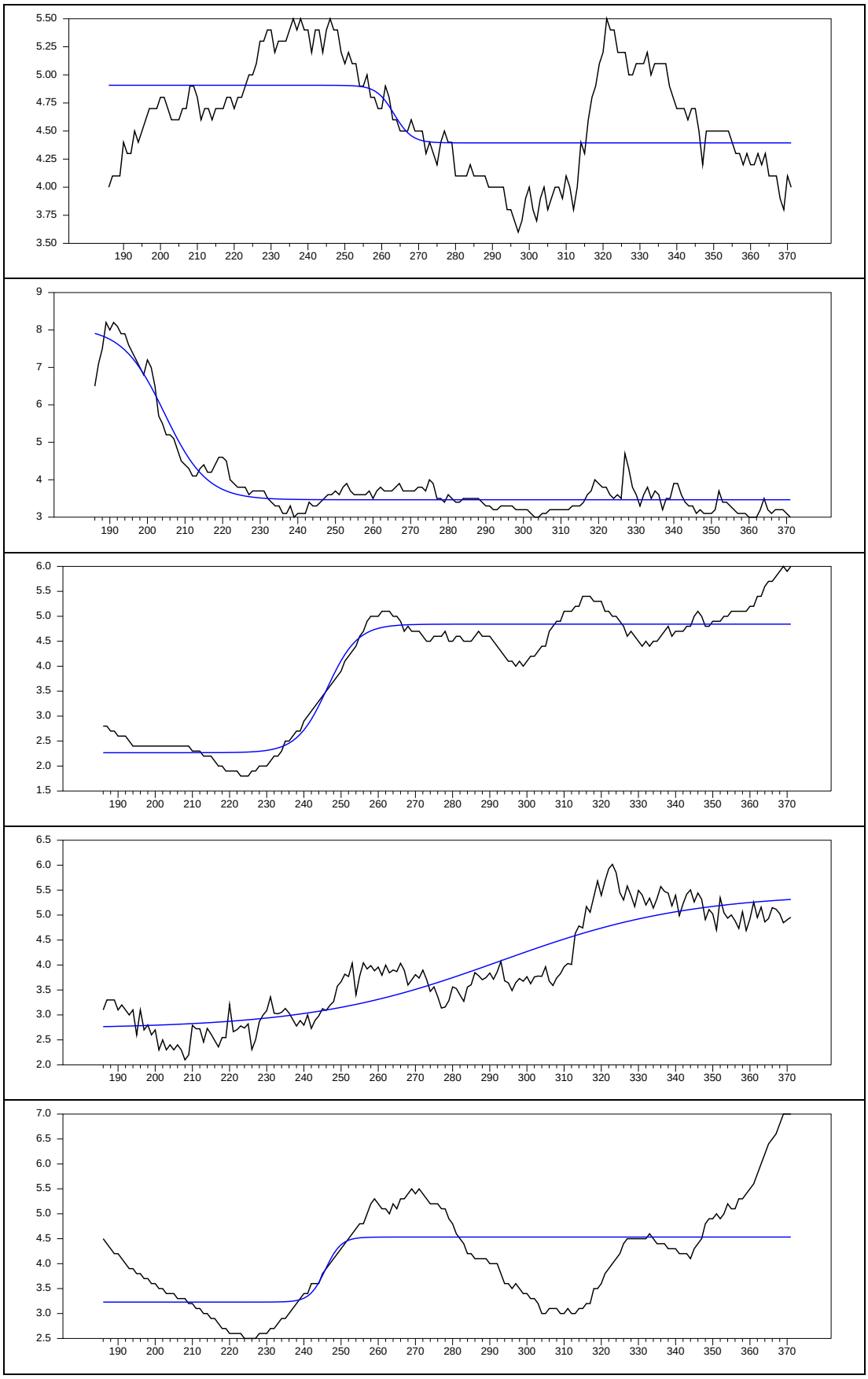
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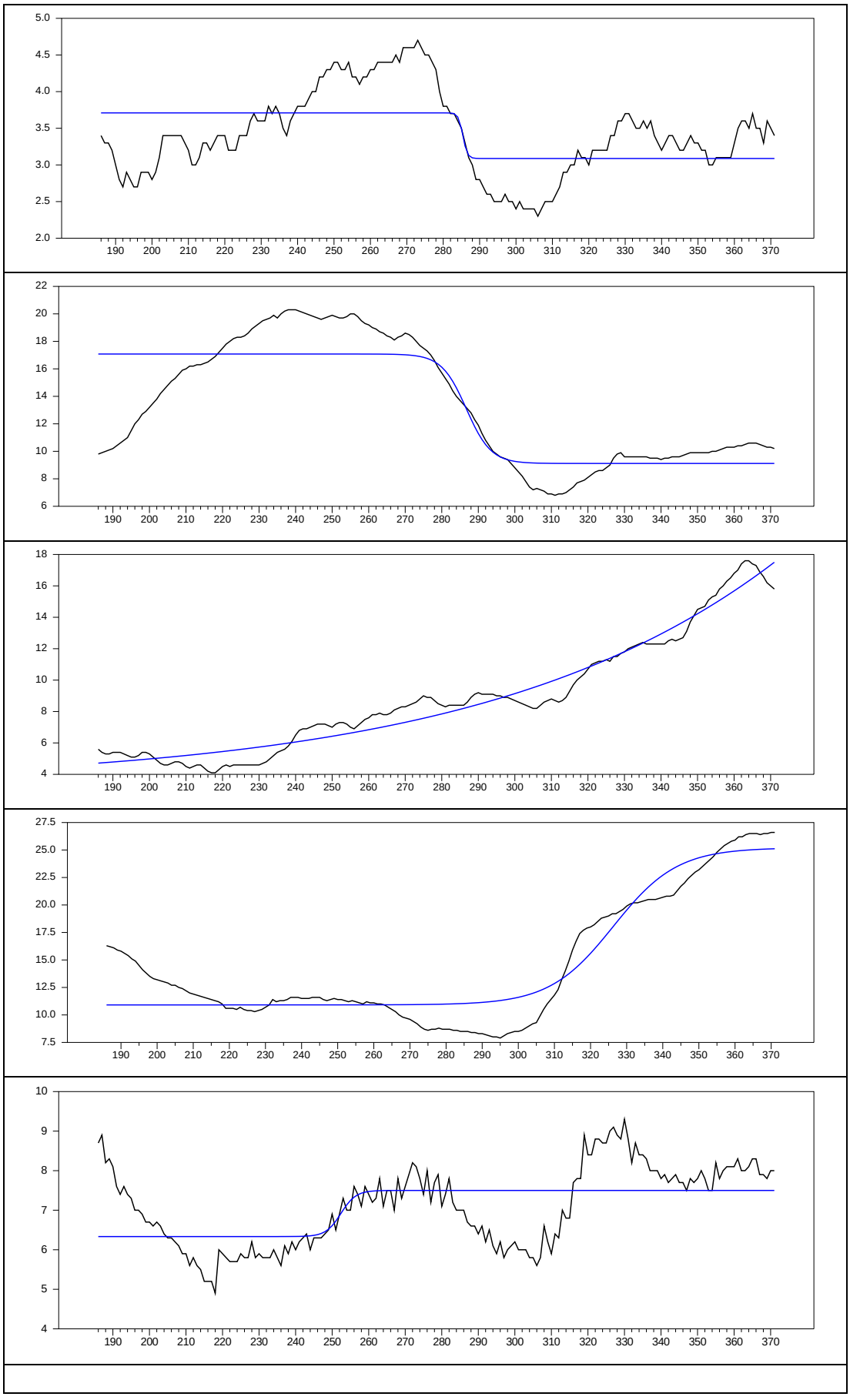
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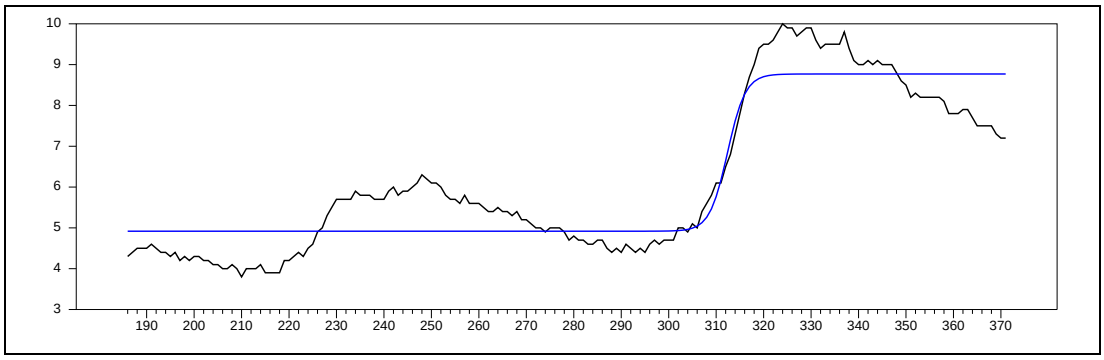

Note: The graphs correspond to Australia, Austria, Belgium, Canada, Chile, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, Norway, Poland, Portugal, Spain, Sweden, US, and the UK.

APPENDIX B: CURRICULUM VITAE

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4. **Thesis Administrated:** 'Hysteresis Hypothesis in Unemployment: New Evidence from 24 OECD Countries.' **Supervisor:** Assist. Prof. Dr. Ayşegül Eruygur.

5. **Awards:**
   1. High Honor Student Award at Department of Economics, Faculty of Economics and Administrative Science, Çankaya University (2010, 2011, 2012 and 2013 Fall and Spring Semesters)

   2. High Honor Student Award and Graduation Degree in the First Rank Award at the Department of Economics, Second Rank Award Faculty of Economics and Administrative Sciences, Çankaya University (2014).

   3. High Honor Scholarship at Financial Economics Graduate Program, Graduate School of Social Sciences, Çankaya University (2014).