HELLENIC REPUBLIC

UNIVERSITY OF MACEDONIA

University of Macedonia

School of economic and regional studies

Department of Economics

Interdepartmental program of postgraduate studies (I.P.P.S)

Master in Economics

Final Thesis

“ The validity of Okun’s law across countries, a panel data analysis”

Soupionis Georgios

Supervisor: Panagiotidis Theodore

March 2021

Thessaloniki

A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER IN ECONOMICS

Interdepartmental Program of Postgraduate Studies in Economics

with specialization in

Economic Theory and Policy

Table of Contents

ACKNOWLEDGMENTS

First off all, I would like to express my deep and sincere gratitude to my supervisor Prof. Theodore Panagiotidis for his support and encouragement throughout my studies in the field of economics. His passion for sharing economic knowledge is inspiring. I would like also to thank all my professors for their guidance and advises through the years.

I am extremely grateful to my parents for their love, caring, emotional support and sacrifices for educating and preparing me for my future. I would not be who I am today without them, so thank you.

I would also like to thanks my sister for being supportive and helpful in everything I want to do.

Last but not least, I would like to thank my girlfriend Laura for her unconditional love and support throughout my studies. Thank you!

ABSTRACT

This thesis investigates the validity of Okun's law over long and short term period across 35 countries. The panel data consisted of annual observation for GDP and Unemployment Rates, for the years 1995-2019. The dataset was split into 3 samples, the Full sample , the EU countries and the G7 countries. Firstly, panel unit roots were used in order to examine the stationarity of the variables. Secondly, the cointegration approach was used to examine the possibility of a long term relationship. Next, the Pooled Mean Group Estimation by Pesaran (1999) was performed to estimate the long and short term coefficients. Additionally, a panel quantile regression was used to examine the short term relationship across different quantiles. Lastly, an asymmetric model was introduced and supported the possibility of a non-linear relationship between output and unemployment. Finally, the analysis supported the validity of Okun's Law across countries.

1.INTRODUCTION

The negative relationship between output and unemployment is well known in macroeconomics as the Okun's law. It took that name due to Arthur M. Okun, who was the first to write about this relationship in his nominal paper of 1963. Okun used two different models on postwar data for the USA and found that a 1% increase in unemployment leads on average to a 3% decrease in real GNP.

Since then, this relationship became the standard rule for policy makers. After this finding, many researchers tried to investigate the relationship between output and unemployment for different countries. The rule evolved through the years for many countries, but the negative relationship still exists. Freeman (2000) showed that the Okun's law changed from 3% to 2% for the USA.

Attfield and Silverstone (1998), Lee (2000), Zagler (2003), Lang and de Peretti (2009), Kangasharju, Tavera and Nijkamp (2012), Palombi, Perman and Tavera (2015) and Rahman and Mustafa (2015) found that output and unemployment are cointegrated variables. Thus there is also a long term relationship between them.

For many years economists believed that the Okun's law was a symmetric relationship. Contrary to that hypothesis Lee (2000), Harris and Silverstone (2001), Silvapulle, Moosa and Silvapulle (2004), Holmes and Silverstone (2006), Kangasharju, Tavera and Nijkamp (2012), Hutengs and Stadtmann (2013) and Karfakis, Katrakilidis and Tsanana (2014) found proof that there is an asymmetric relationship between output and unemployment.

Nowadays, the environment of data is unlimited, thus Freeman (2001), Fouquau (2008), Kangasharju, Tavera and Nijkamp (2012), Huang and Yeh (2013) and Palombi , Perman and Tavera (2015) used panel data analysis in order to examine the validity of Okun's Law. This type of analysis has many advantages, since it solves problems which are emanated from the data.

The purpose of this thesis is to investigate the validity of Okun's law in both the long and short term periods for panel data. The dataset consists of annual observations for Gross Domestic Product and Unemployment rates from 35 countries. The period which is examined spans from 1995 to 2019. The dataset used is split into three different samples in order to compare the panel analysis.

From the Okun's models, the first difference approach was chosen, due to the difficulties to measure the potential values in the gap model. The basic methodology that was used was the Pooled Mean Group Estimation proposed by Pesaran (1999). Its main advantage is that the variables don’t need to be stationary in order to establish a long term relationship. For the short term analysis, quantile regression was used. Finally, a fixed effects model with two dummies for the first differences of unemployment, was used to investigate the presences of asymmetry.

The thesis is organized as follows. In section 2, the literature review tables are presented and summarize the previous analysis that have been made. Section 3 contains the data that was used. Section 4 is devoted to the methodology of the paper. In section 5 , the results from the empirical analysis are presented, and finally section 6, concludes and summarizes the main findings.

2. LITERATURE REVIEW

	Title	Author	Methodology	Data	Conclusion
(1)	Potential GNP: It's measurement and significance	Okun (1963)	OLS, first difference model, gap model and trend and elasticity method proposed by Okun	The data used, are quarterly observations for post war USA. The period examined were from 1947Q2 to 1960Q4 for first difference model, for the gap model from 1953 to 1960 and for the trend and elasticity method from 1947Q2 to 1960Q4.	In this paper Okun's states the negative relationship between output and unemployment. He used three models and found that a 1% increase in unemployment leads on average to a 3% decrease in real GNP. Later this relationship became the Okun's law.
(2)	Okun's Law, Cointegration and Gap Variables	Attfield and Silverstone (1998)	Beveridge and Nelson decomposition, ADF unit root test, Johansen's Cointegration, OLS, VECM	The data consisted of quarterly, seasonally adjusted GDP at factor cost in 1990 prices times 100 and the unemployment series from 100 minus the ratio of the workforce in employment to the total workforce times 100. The series were obtained from the CSO database at the University of Manchester Computer Centre.	The authors used the Beveridge and Nelson trend-component decomposition and found that the output gap and the unemployment gap were cointegrated. Moreover, Okun's coefficient for the UK was estimated and its value was -1.4535. Finally, they concluded that, the vector equilibrium correction model could be used for forecasts.

	Title	Author	Methodology	Data	Conclusion
(3)	Regional Tests of Okun's Law	Freeman (2000)	Quadratic Trend filter decomposition, Baxter- King filter decomposition and Pooled OLS	The dataset consist of two parts. The first part includes quarterly US data from 1958 to 1998 and the second part annually data from 1977 to 1997. The variables used, are unemployment rates, GDP and gross state product (GSP). The source of the data is the Bureau of Economic Analysis USA.	This paper investigates Okun's law for the USA and its regions. The authors found that the Okun's coefficient is stable and approximately around 2%. Also, that difference in the relationship of output and unemployment across regions of the USA can't be supported.
(4)	The Robustness of Okun's Law: Evidence from OECD Countries	Lee (2000)	Hodrick–Prescott filter decomposition, Beveridge-Nelson filter decomposition, Kalman filter decomposition, ADF and Zivot-Andrews unit root tests, Johansen cointegration, VAR, VECM and F-test	The data used, are annual observations for real GDP, CPI for inflation, unemployment rates and oil-prices. The dataset includes 16 OECD countries between the period 1955 and 1996.	The authors research supports the validity of the Okun's law but questions the robustness of its results. Their estimations differ across countries, as well as across methods of decomposition. Also, they find evidence of asymmetry in the Okun's relationship. Finally, structural breaks in the Okun's law were observed in the case of Europe.

	Title	Author	Methodology	Data	Conclusion
(5)	Panel tests of Okun's Law for ten industrial countries	Freeman (2001)	Baxter- King filter decomposition, Panel estimation, Pooled OLS, Time fixed effects, Weighted Symmetric unit root test, Seemingly Unrelated Regressions (SUR) and F-test for coefficient stability	The data used, are panel data for 6 European countries, USA, Canada, Australia and Japan for the period 1958–98, sub-periods of which were 1958–78 and 1979–98. The variables used, are annual real GDP growth, unemployment rates, capital stock and labor force growth. The sources of the data are U.S. Department of Labor and Quarterly Journal of Economics.	This paper proves that the cyclical component of macro-series is stationary with the use of Baxter-King filter. The main finding is a relationship two-one between output and unemployment. Also the Okun's law tends to be stable for the data used and the unemployment for Europe is more structural than cyclical.
(6)	Testing for Asymmetry in Okun's Law: A Cross-Country Comparison	Harris and Silverstone (2001)	Recursive, Rolling Sequential and normal ADF unit root tests, Asymmetric cointegration procedure by Enders and Silkos (2001), Engle-Granger and Johansen cointegration, Chow-test, Granger-Causality test and asymmetric Error Correction Model	The data used, are quarterly, seasonally adjusted series for real GDP and unemployment rates, from the OECD Quarterly National Accounts Database. The data spans from 1978 to 1999.	The main finding of this article is that the Okun's law should be estimated with an asymmetric approach. Also, by adopting this method the GDP and unemployment are cointegrated, thus there is a long-run relationship between the two time series.

	Title	Author	Methodology	Data	Conclusion
(7)	The Unemployment–Output Tradeoff in Transition Economies: Does Okun's Law Apply?	Izyumov and Vahaly (2002)	OLS	The dataset consists of 27 transition countries, members of the European Bank for Reconstruction and Development (EBRD). The data spans from 1991 to 2000. The source of the data is EBRD Transition report (2000).	This paper used data from 25 transition countries and divided them into two groups the reform leaders and the reform laggards, in order to investigate the Okun's law. Their results suggest that the Okun's Law mainly is useful for the leaders and most recently is applicable to the laggards.
(8)	An analysis on the structural stability of Okun's law--a cross-country study	Sögner and Stiassny (2002)	OLS, Kalman filter analysis, Bayesian analysis, Switching regression model: Markov-Chain Monte-Carlo, Chow break point test	The data used are, GDP growth, unemployment rates, labor force and employment for 15 OECD countries. The period examined spans from 1960 to 1999 and the data were taken from the OECD economic outlook database.	The main finding of this research is that there are structural breaks between the Okun's law coefficients across the countries which were examined. The main cause of this behavior is the employment reactions in GDP variations.
(9)	Okun's Law Revisited	Cuaresma (2003)	Structural times series methodology by Harvey(1989), Hodrick-Prescott filter decomposition and Hansen procedure (1996)	The author used quarterly data for unemployment rates and GDP of USA for the period 1965Q1 to 1999Q1.	The author research supports an asymmetric relationship between cyclical output and cyclical unemployment. His results were robust and the relationship was more significant for recessions than expansions.

	Title	Author	Methodology	Data	Conclusion
(10)	An examination of Okun's law: evidence from regional areas in Greece	Apergis and Rezitis (2003)	Hodrick–Prescott filter decomposition and the Baxter-King filter decomposition	The data used, are real GDP at 1990 prices and the unemployment rate for eight regional areas of Greece. The data covered the period 1960 to 1997. The frequency of the observations was annual and the source was the National Statistical Service.	This papers analysis suggested that the Okun's coefficient was stable in Greek regions, except for in the cases of Epirus and North Aegean Islands. Moreover, they find that Okun's law had a structural change in 1981. Finally, they support that their findings have serious policy implications that the policy makers should use in order to counter unemployment and increase labor productivity.
(11)	A vector error correction model of economic growth and unemployment in major European countries and an analysis of Okun's law	Zagler (2003)	Dickey-Fuller unit root tests, VAR, Vector Error Correction Model (VECM), and Johansen's Cointegration	This article uses data for GDP, unemployment rates and employment for France, Germany, Italy, and the UK. The data set consists of quarterly observations for UK from 1968Q1 to 2000Q1, for France from 1970Q1 to 2000Q2, for Italy from 1970Q1 to 2000Q2 and for Germany from 1968Q1 to 1997Q4.The data were taken from the OECD and for employment from OECD Quarterly Labor Force Survey.	The article supports that output and unemployment are cointegrated. Also, they find that in the long-run the relationship between economic growth and unemployment is positive which is different from Okun's Law. Finally in the short-run the Okun's law is valid.

	Title	Author	Methodology	Data	Conclusion
(12)	Asymmetry in Okun's law	Silvapulle, Moosa and Silvapulle (2004)	Harvey's structural time series model, OLS, M-estimation and confidence intervals	The data series used in this study is a sample of quarterly post-war U.S. data covering the period 1947Q1–1999Q4. The data set was obtained from Gordon (1993) and updated from the OECD database. The output variables real GDP (measured in 1987 prices).	In this paper the authors used an asymmetric approach to examine the Okun's law relationship. Their study presented evidence that Okun's coefficients for positive and negative cyclical outputs are not equal for the U.S. post-war economy. Thus they suggested that, the asymmetric approach is more efficient than the symmetric one.
(13)	Okun's law, asymmetries and jobless recoveries in the United States: A Markov-switching approach	Holmes and Silverstone (2006)	Markov regime-switching models approach	The data used are, real GDP and unemployment rates from the USA and spans the period between 1963Q1 to 2004Q3. The source of the data is the OECD database.	In this paper the authors used the Markov regime-switching model and they identified the presence of asymmetries within and across regimes of the USA. They also, observed a significant inverse relationship between cyclical output and unemployment for expansionary regimes.

	Title	Author	Methodology	Data	Conclusion
(14)	Testing for convergence of the Okun's Law coefficient in Europe	Perman and Tavera (2007)	Autoregressive Distributed Lag Model (ADL), Structural Vector Autoregressive Model (SVAR), Hodrick–Prescott filter decomposition, the Baxter- King filter decomposition, Seemingly Unrelated Regressions (SUR), OLS, Rolling regression and procedure suggested by Evans (1996)	This study uses semestrial (biannual) data for 17 European countries for unemployment and output. The period examined spans from the first semester of 1970 to the second semester of 2002 and the data are taken from the OECD.	In this research the authors find that the short-run Okun's law coefficient converge for several sub-groups of European countries, but this convergence can't be supported for the mid-run Okun's coefficient.

	Title	Author	Methodology	Data	Conclusion
(15)	Threshold effects in Okun's law: a panel data analysis	Fouquau (2008)	Non-dynamic panel transition regression model with fixed individual effects by Hansen (1999), Panel data unit root tests by Choi (2002) and Pesaran (2007), Beveridge and Nelson decomposition, Hodrick-Prescott filter decomposition and Baxter- King filter decomposition	The data consists of quarterly observations for GDP and unemployment for 20 OECD countries. The datasets spans from 1970 to 2004 and the series were obtained from the OECD database.	This article uses threshold effects and proves an asymmetric relationship between output gap and cyclical unemployment. Also the author solves the problem of heterogeneity by clustering countries with the same dynamic.
(16)	Smooth-time-varying Okun's coefficients	Huang and Lin (2008)	Smooth-time-varying parameter model adapted from Koop and Tobias (2006)	The data used are, quarterly observations for real GDP and unemployment rates for the USA. The data covers the period between 1948Q1 to 2006Q1.The data source was the Federal Reserve Bank of St. Louis.	They find that, the mean estimates of Okun's coefficients exhibit large variations and fluctuate around the fixed-Okun's coefficient obtained from the symmetric model, thus it can lead to incorrect results. The Okun's relationship tends to be negative for all the periods. Labor trend productivity growth can explain the time varying Okun's Law coefficient.

	Title	Author	Methodology	Data	Conclusion
(17)	Output, unemployment and Okun's law: Some evidence from the G7	Malley and Molana (2008)	Kalman filter analysis	The data consist of quarterly observations for GDP and unemployment rates for the G7 countries. The dataset spans from 1960Q1 to 2001Q4.	They find that threshold unemployment rate is significantly positive in all countries, except for Germany in the high-effort state. They use their finding to interpret the Okun’s law and finally they suggest that their empirical work could help in the determination of the natural rate of output.
(18)	The robustness of Okun’s law in Spain, 1980–2004 Regional evidence	Villaverde and Maza (2008)	Quadratic Trend filter decomposition, Hodrick–Prescott filter decomposition and the Baxter- King filter decomposition, ADF and KPSS unit root tests and OLS estimations	The data used, are GDP and unemployment rates for seventeen of the Spanish regions from 1980 to 2004. The source of the data was the Spanish National Statistics Institute.	Their main findings suggest an inverse relationship between unemployment and output holds for most of the regions and for the whole country. Moreover they find differences in the Okun’s coefficient across regions and they suggested that the central policy have to take into account the regional OLCs.

	Title	Author	Methodology	Data	Conclusion
(19)	A strong hysteretic model of Okun's Law: theory and a preliminary investigation	Lang and de Peretti (2009)	Strong hysteretic model, Cross et al. (2001) procedure, ADF unit root tests , Ljung-Box and Box-Pierce tests, VAR, and Johansen's Cointegration	The data used, are quarterly data for unemployment rates and GDP. For each country, the starting point for the data is determined by the earliest quarter for which data for both variables are available, that is: 1963:1 for France; 1991:1 for Germany; and 1960:1 for Finland, Italy, Sweden, the United Kingdom and the United States and is up to 2007:4. The data were taken from the 'main economic indicators' of the OECD Economic Outlook.	This article develops a strong hysteretic model of Okun's Law. The main findings of the paper suggest that this model works fine for France, but doesn't work for the USA and Sweden. The cases of the United Kingdom, Finland, Italy and Germany are more ambiguous. Finally, they support that if Okun's Law is hysteretic, economic policies should seek to erase the previous non-dominated growth shocks.

	Title	Author	Methodology	Data	Conclusion
(20)	Do professional economists' forecasts reflect Okun's law? Some evidence for the G7 countries	Pierdzioch, Rülke and Stadtmann (2011)	Pooled OLS and time fixed-effects model	The data used, are professional economist's forecasts of the growth rate of real output and the unemployment rate for the G7 countries. The dataset consists of annual observations from 1989 to 2007. The data sources were the Consensus Economic Inc and the Thompson Financial Datastream.	The research from the authors supports that, there is a significant negative relationship between the expected change in unemployment rate and the expected growth rate of real output. Also, they found that professional economists prefer the linear Okun's coefficient for their forecasts.
(21)	Regional Growth and Unemployment: The Validity of Okun's Law for the Finnish Regions	Kangasharju, Tavera and Nijkamp (2012)	Hidden cointegrations, , panel-ADF, group-ADF, fully modified OLS and dynamic OLS (DOLS), Error Correction Model	The dataset consists of annual observations of unemployment rates and GDP for 74 travel-to-work areas in Finland across the periods between 1976 and 2006.	The data for the Finnish region suggest that, there is a hidden cointegration between regional output expansions and regional unemployment decreases. Moreover they find that this relationship is asymmetric.

	Title	Author	Methodology	Data	Conclusion
(22)	Okun's Law: Fit at fifty?	Ball, Leigh and Loungani (2013)	Hodrick–Prescott filter decomposition, forecasting techniques and Wald test	The dataset consist of annual and quarterly observations for the USA (1948-2011) and 20 other advanced economies (1980-2011).	This articles main finding supports that, Okun's law exists and is stable. Thus, there is negative relationship between output and unemployment.
(23)	Why did unemployment respond so differently to the global financial crisis across countries? Insights from Okun's Law	Cazes, Verick and Al Hussami (2013)	Rolling regressions	The data used are quarterly observations for real GDP and unemployment rates for OECD countries. The dataset spans from 1990Q1 to 2010Q3.	This paper supports, that Okun's coefficient varies across countries and time. More specifically during the financial crisis there is a divergence between the different Okun's coefficients, in badly damaged economies the coefficient increases and in subdued economies the coefficient decreases.

	Title	Author	Methodology	Data	Conclusion
(24)	Okun's law in panels of countries and states	Huang and Yeh (2013)	Pooled Mean Group by Pesaran, Mean Group Estimator and fixed effects for panel data.	The data has two categories, across countries and across states of USA. The first panel consists of 53 countries with annual observations for unemployment rates and RGDP from 1980 to 2005. The source is the World Bank. For the second panel, they use 50 states from USA with annual observations from 1976 to 2006 for unemployment rates and GDP. The sources of the dataset are Econmagic and the Bureau of Economic Analysis.	In this paper, the authors research support that, output and unemployment are cointegrated. Also, they found strong validity for Okun's law both for short-term and for the long-term period for the panel data, that was used.
(25)	Age effects in Okun's law within the Eurozone	Hutengs and Stadtmann (2013)	OLS and age cohorts	The data used, are annual observations for real GDP and unemployment rates. The observation period is 1983 to 2011. The sources of the data were the Annual-Macro-Economic Database of the European Commission and the International Labor Organisation.	Their main finding is that Okun's law differs across countries, thus symmetric shocks have asymmetric effects on the GDP. From the cohorts perspective, the different Okun's coefficient can lead to conflicts within the countries.

	Title	Author	Methodology	Data	Conclusion
(26)	Does output predict unemployment? A look at Okun's law in Greece	Karfakis, Katrakilidis and Tsanana (2014)	ADF,ADF-GLS, Phillips-Perron, KPSS, LM test (Schmidt and Phillips, 1992) and LM test (Lee and Strazicich, 2004) unit root test, OLS, Granger-Causality, VAR and Cholesky-decomposition	The data used, are real GDP in constant prices and unemployment between the periods 2000Q1 and 2012Q4. The source of the data is the Hellenic Statistical Authority.	This paper supports the validity of Okun's Law in the case of Greece. A 1% increase in unemployment was associated with a 3% decrease in real output during the period 2000–12. Finally the relationship between output and unemployment tend to be asymmetric during the recessions period.
(27)	On Okun's law in OECD countries: An analysis by age cohorts	Zanin (2014)	OLS and age cohorts	The data used, are annual observations for real GDP and unemployment rates for the OECD countries. The dataset spans from 1998 to 2012. The source of the data was the OECD database.	The authors findings suggest that younger cohorts are more sensitive to economic fluctuations than the elderly cohorts, for all the countries that were examined.

	Title	Author	Methodology	Data	Conclusion
(28)	Regional growth and unemployment in the medium run: asymmetric cointegrated Okun's Law for UK regions	Palombi , Perman and Tavera (2015)	Granger-Yoon hidden cointegration, panel unit root tests: the Levin et al. (2002) test, the Im et al. (2003) test and the cross-sectional dependent panel unit root test (CIPS) of Pesaran (2007), fully modified OLS and dynamic OLS (DOLS)	The dataset consists of annual observations of unemployment rates and GDP for 128 UK regions across the period 1983 to 2009.	This papers main finding suggests that there is a hidden cointegration relationship between output and unemployment for the UK. This mid-run relationship seems to be asymmetric for the data examined.
(29)	Okun's law: evidence of 13 selected developed countries	Rahman and Mustafa (2015)	ADF, Phillips-Perron, modified Phillips-Perron and KPSS unit root tests, Johansen Cointegration, Stock-Watson dynamic OLS(DOLS) and Error Correction Model	The data used, are annual unemployment rates and real gross domestic product (RGDP) for 13 advanced countries. The dataset spans from 1970 to 2013. The data source is the IMF's International Financial Statistics.	Their research supports that the Okun's law is valid for the USA and South Korea. The law doesn't hold for Germany. Finally, there is some evidence for the validity of the law for the other countries which are examined.

	Title	Author	Methodology	Data	Conclusion
(30)	Does One Law Fit All? Cross-Country Evidence on Okun's Law	Ball, Furceri, Leigh and Loungani (2019)	Hodrick-Prescott filter decomposition and OLS	The data consists of annual observations for unemployment rate, employment, labor force and real GDP for 71 countries (29 advanced and 42 developed). The data comes from the IMF's World Economic Outlook database for the period 1980-2015.	The authors found that the cyclical relationship between jobs and growth is considerably weaker, on average, in developed than in advanced countries. On the other hand the validity of Okun's law for most developed countries suggests that cyclical considerations should not be ignored. Thus, policies should try to keep employment at its full potential.
(31)	Re-evaluating Okun's Law: Why all recessions and recoveries are ''different''	Gelfer (2020)	DSGE-DFM model and Impulse Response Functions	The dataset consists of 97 quarterly data series. The data period spans from 1984Q2 to 2019Q2.	Firstly, the author found that financial and investment driven recessions can create prolonged, sluggish recoveries and cause the unemployment rate to remain high for a significant period after the shock. Also, he found significant heterogeneity amongst the different structural shocks and the Okun's law coefficient each shock would generate.

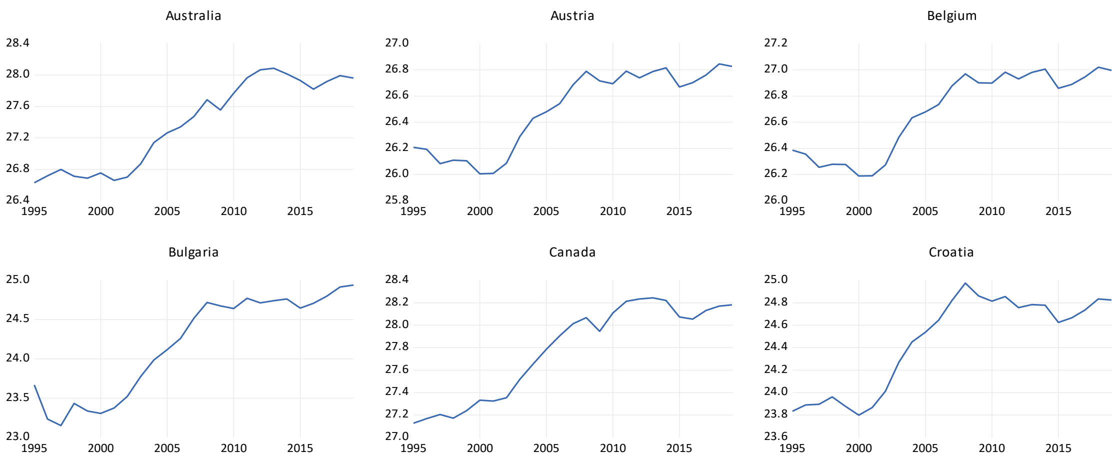
	Title	Author	Methodology	Data	Conclusion
(32)	Sectoral Okun's law and cross-country cyclical differences	Goto and Bürgi (2020)	Hodrick-Prescott filter decomposition and Quadratic Trend filter decomposition	This study used annual observations for GDP and unemployment rates for the USA, the UK, Switzerland and Japan. Each countries available dataset covered different periods. The overall dataset spans from 1995 to 2017, but there were missing values. The sources for the output were the Bureau of Economic Analysis for the USA, the Office for National Statistics for the UK, the Swiss National Statistics Office for Switzerland and the Cabinet Office, Government of Japan for Japan. The unemployment rates sources were the Bureau of Labor Statistics for the USA, the Office for National Statistics for the UK, the State Secretariat for Economic Affairs for Switzerland and the Ministry of the Internal Affairs and Communications for Japan.	The purpose of this article was to examine the Okun's law with sectoral data for the USA, the UK, Switzerland and Japan. They found that the sectoral coefficients follow similar patterns to the aggregate Okun's coefficients. Moreover, they suggested, that the deviation of unemployment was the driven force for cross-country differences in the Okun's coefficients.

3.DATA

This thesis investigates the short run and the long run relationship between output and unemployment in a panel data environment. More specifically, the validity of Okun's law was tested in 27 European Union countries, Australia, Canada, United States, United Kingdom, Japan, New Zeeland, Korea Republic and South Africa. Our panel data was consisted of annual observations for GDP and unemployment rates for 35 countries. The period which was examined spans from 1995 to 2019. The source of our data was the World Bank database. Firstly, we used the logarithmic form of GDP in our estimations, then we generated the first differences for log-GDP and unemployment series. We began by employing our methodology in the full sample of data and then we separated the data into sub-samples. The first one was the European Union countries without UK and the second one was the G7 countries. Finally, we compared the results from the different samples. This section, also contains the data summary. Moreover, we plotted the graphs from our variables and their descriptive statistics.

3.1. GRAPHS

LOG_GDP_SERIES

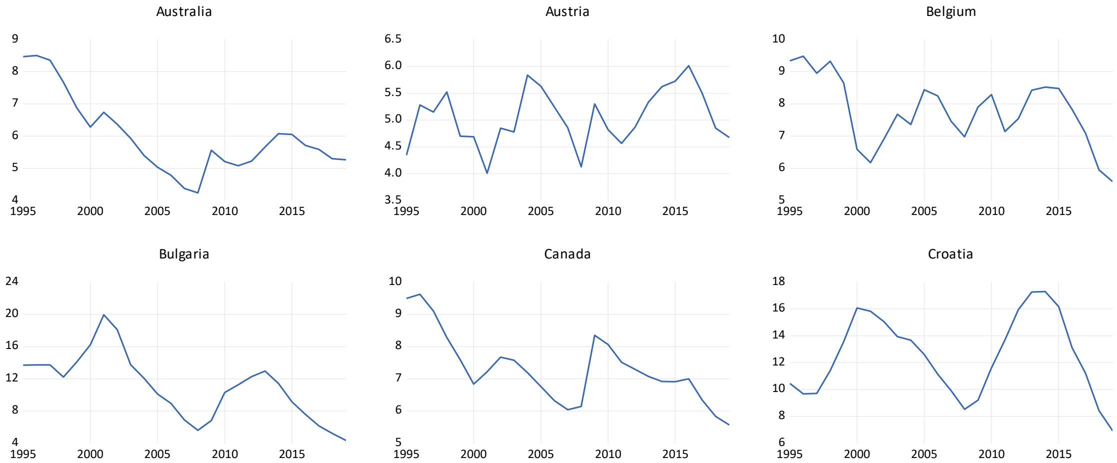


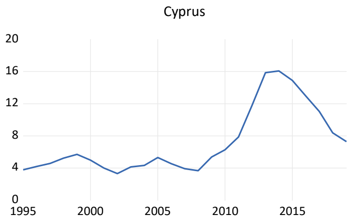

Cyprus
24.2
24.0
23.8
23.6
23.4
23.2
23.0
22.8
Czech Republic
26.4
26.0
25.6
25.2
24.8
Denmark
26.8
26.6
26.4
26.2
26.0
25.8
Estonia
24.5
24.0
23.5
23.0
22.5
22.0
Finland
26.4
26.2
26.0
25.8
25.6
25.4
France
28.8
28.6
28.4
28.2
28.0
27.8
Germany
29.2
29.0
28.8
28.6
28.4
28.2
Greece
26.8
26.6
26.4
26.2
26.0
25.8
25.6
25.4
Hungary
26.0
25.6
25.2
24.8
24.4
Ireland
26.8
26.4
26.0
25.6
25.2
24.8
Italy
28.6
28.4
28.2
28.0
27.8
27.6
Japan
29.5
29.4
29.3
29.2
29.1
29.0
Korea Republic
28.4
28.0
27.6
27.2
26.8
26.4
Latvia
24.4
24.0
23.6
23.2
22.8
22.4
Lithuania
25.0
24.5
24.0
23.5
23.0
22.5
Luxembourg
25.2
24.8
24.4
24.0
23.6
Malta
23.6
23.2
22.8
22.4
22.0
21.6
Netherlands
27.6
27.4
27.2
27.0
26.8
26.6
1995
2000
2005
2010
2015

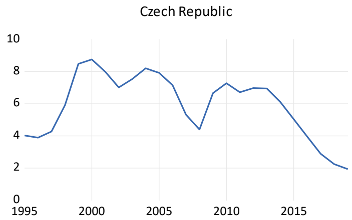
Block of figures 1

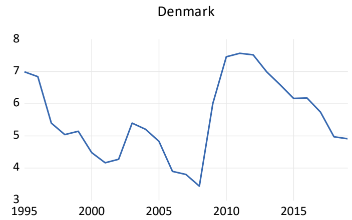
This block presents the log GDP series. We can observe, that all the countries have and upward trend. There is no evidence for stationarity in this variable.

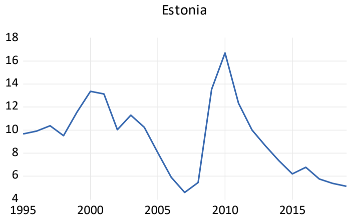
UNRATE_SERIES

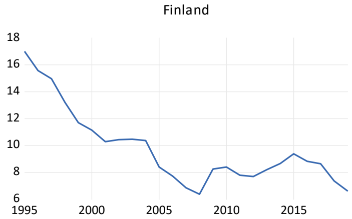


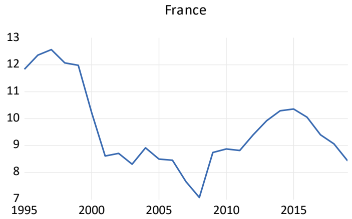

Cyprus
20
16
12
8
4
0
1995 2000 2005 2010 2015

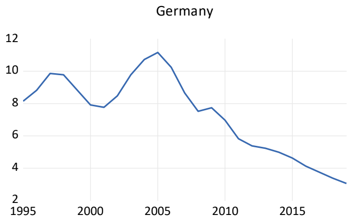

Czech Republic
10
8
6
4
2
0
1995 2000 2005 2010 2015

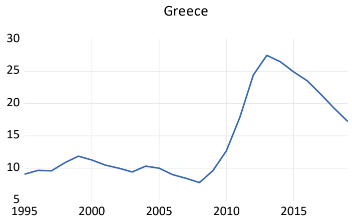

Denmark
8
7
6
5
4
3
1995 2000 2005 2010 2015

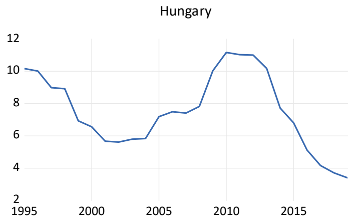

Estonia
18
16
14
12
10
8
6
4
1995 2000 2005 2010 2015

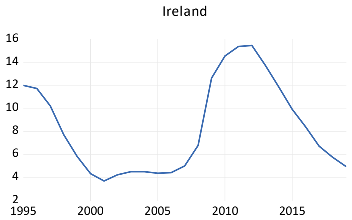

Finland
18
16
14
12
10
8
6
1995 2000 2005 2010 2015

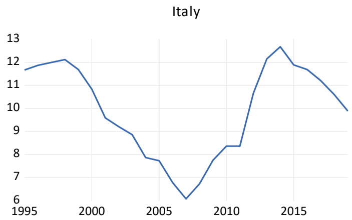

France
13
12
11
10
9
8
7
1995 2000 2005 2010 2015

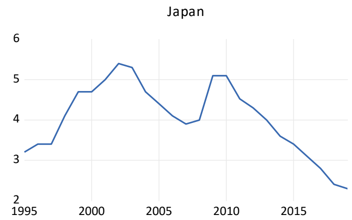

Germany
12
10
8
6
4
2
1995 2000 2005 2010 2015

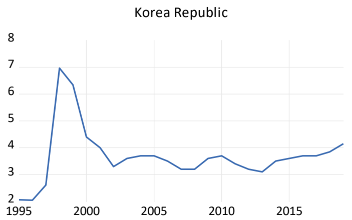

Greece
30
25
20
15
10
5
1995 2000 2005 2010 2015

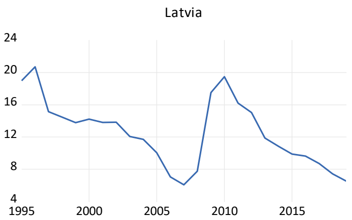

Hungary
12
10
8
6
4
2
1995 2000 2005 2010 2015

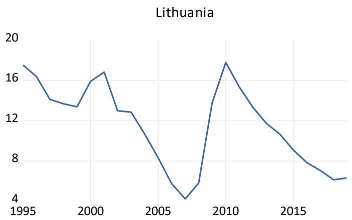

Ireland
16
14
12
10
8
6
4
2
1995 2000 2005 2010 2015

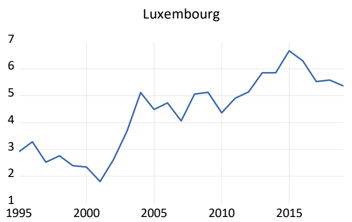

Italy
13
12
11
10
9
8
7
6
1995 2000 2005 2010 2015

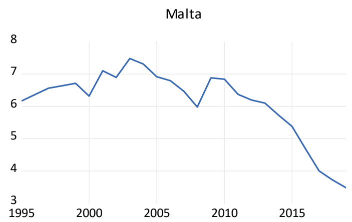

Japan
6
5
4
3
2
1995 2000 2005 2010 2015

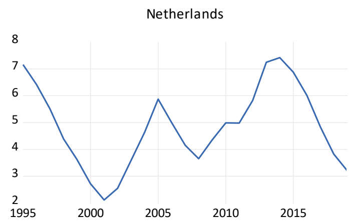

Korea Republic
8
7
6
5
4
3
2
1995 2000 2005 2010 2015

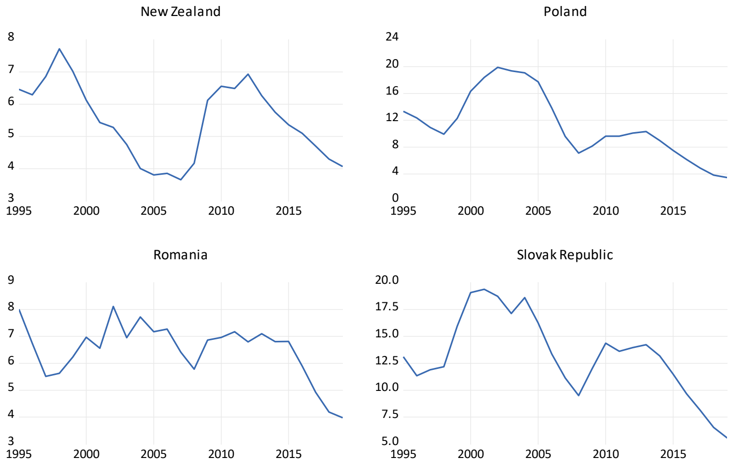

Latvia
24
20
16
12
8
4
1995 2000 2005 2010 2015

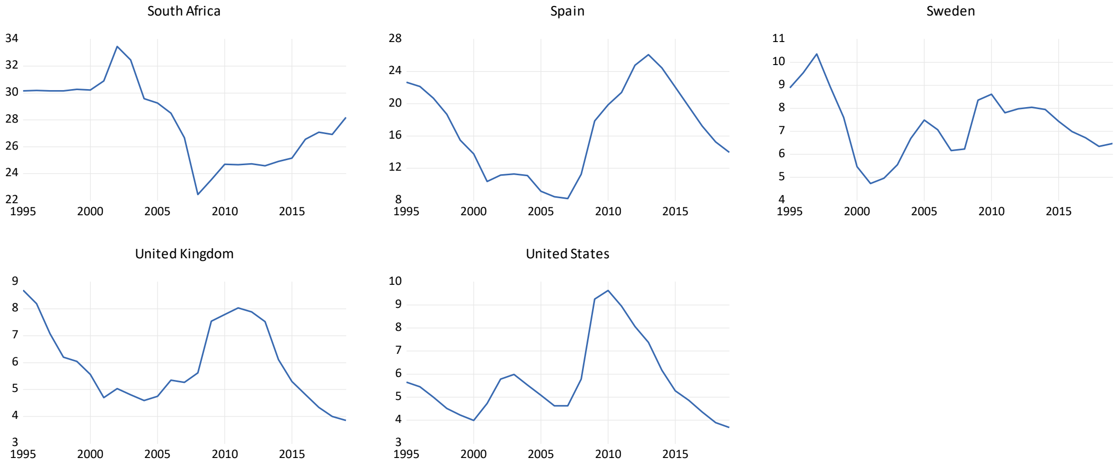

Lithuania
20
16
12
8
4
1995 2000 2005 2010 2015


Luxembourg
7
6
5
4
3
2
1
1995 2000 2005 2010 2015


Malta
8
7
6
5
4
3
1995 2000 2005 2010 2015


Netherlands
8
7
6
5
4
3
2
1995 2000 2005 2010 2015

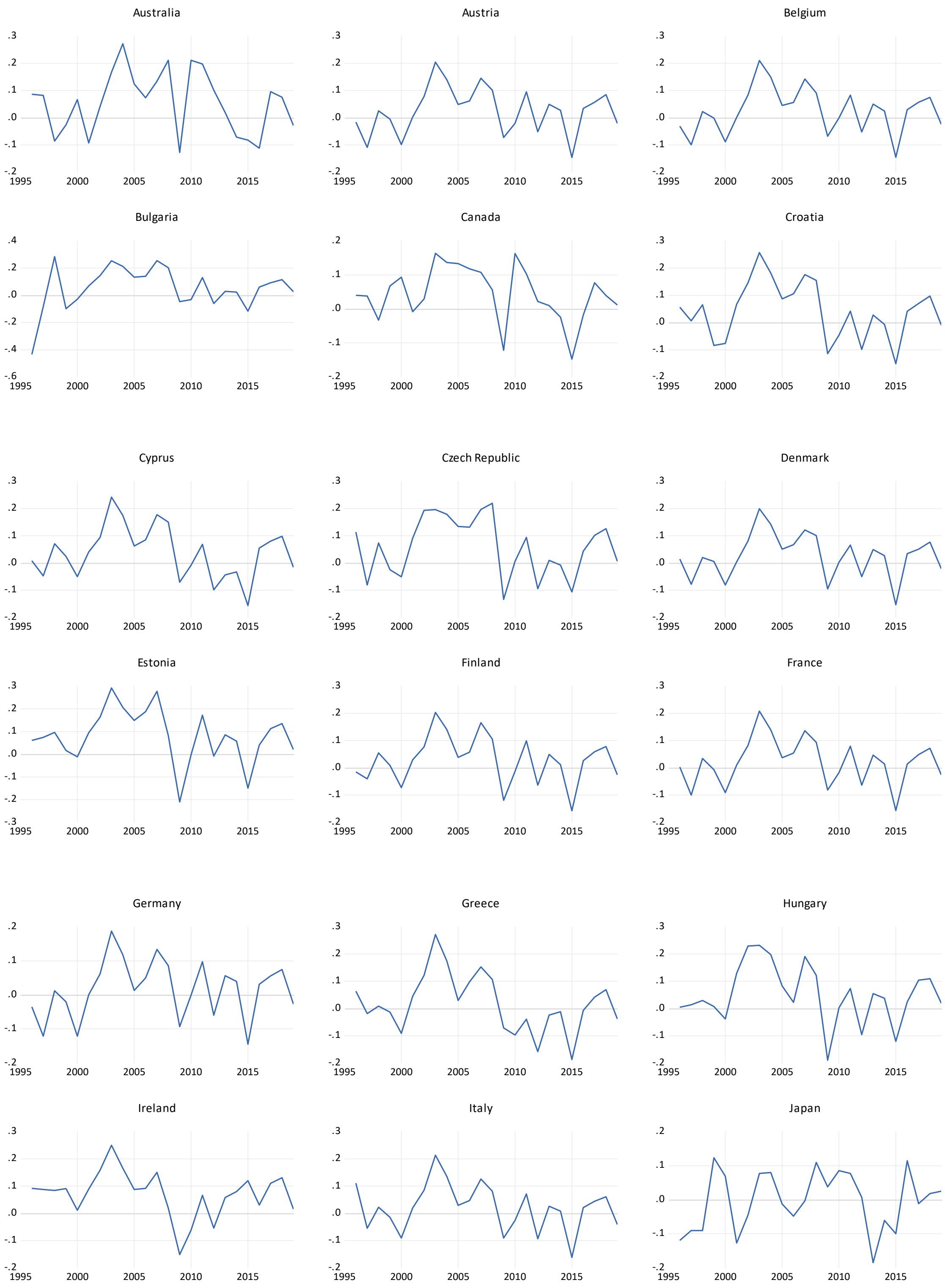


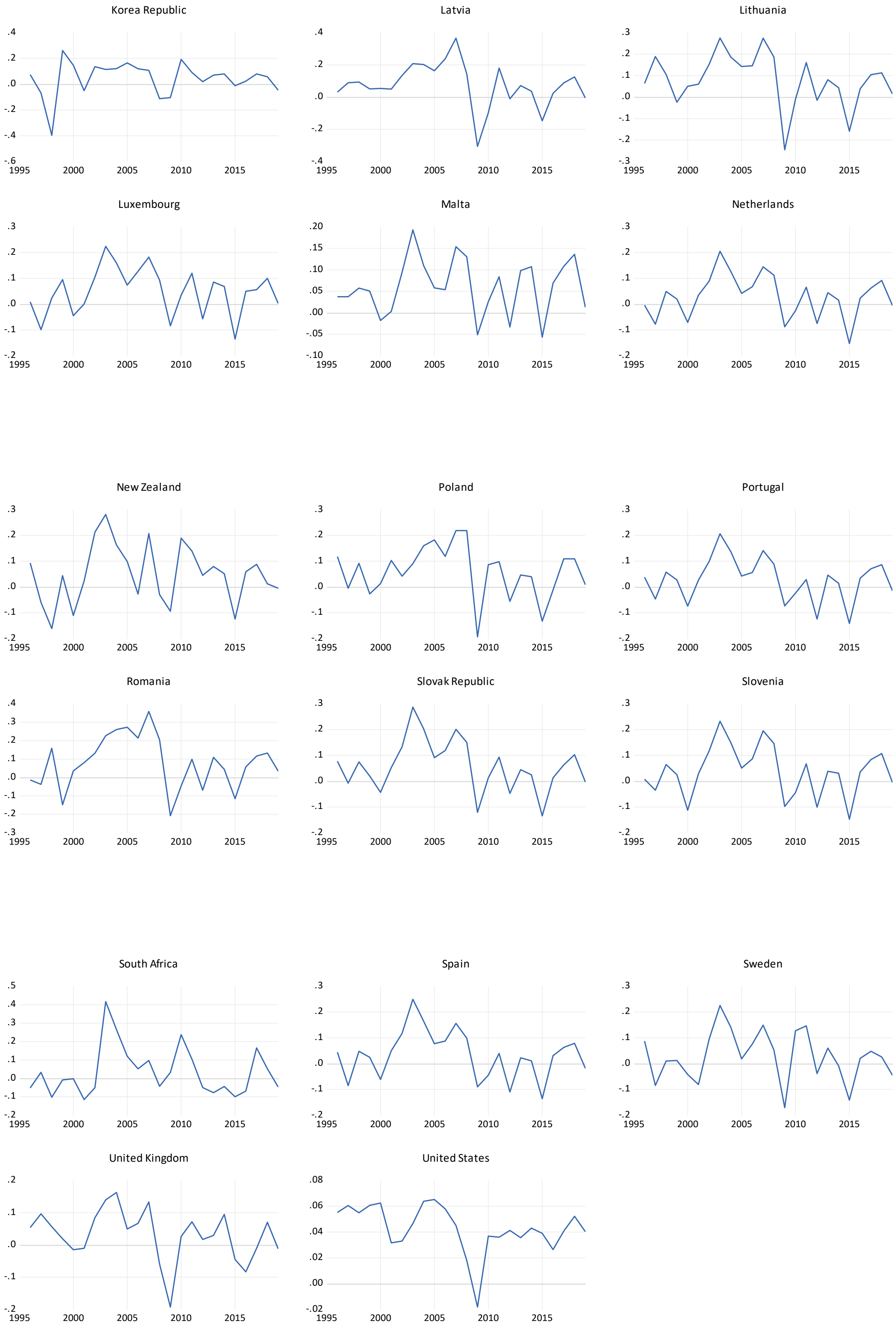


Block of figures 2

This block presents the unemployment rate series. The observation is that some of the countries have stationary unemployment and some do not. So, in conclusion to this figure, there is some evidence for stationarity in this variable.

DIF_GDP_SERIES

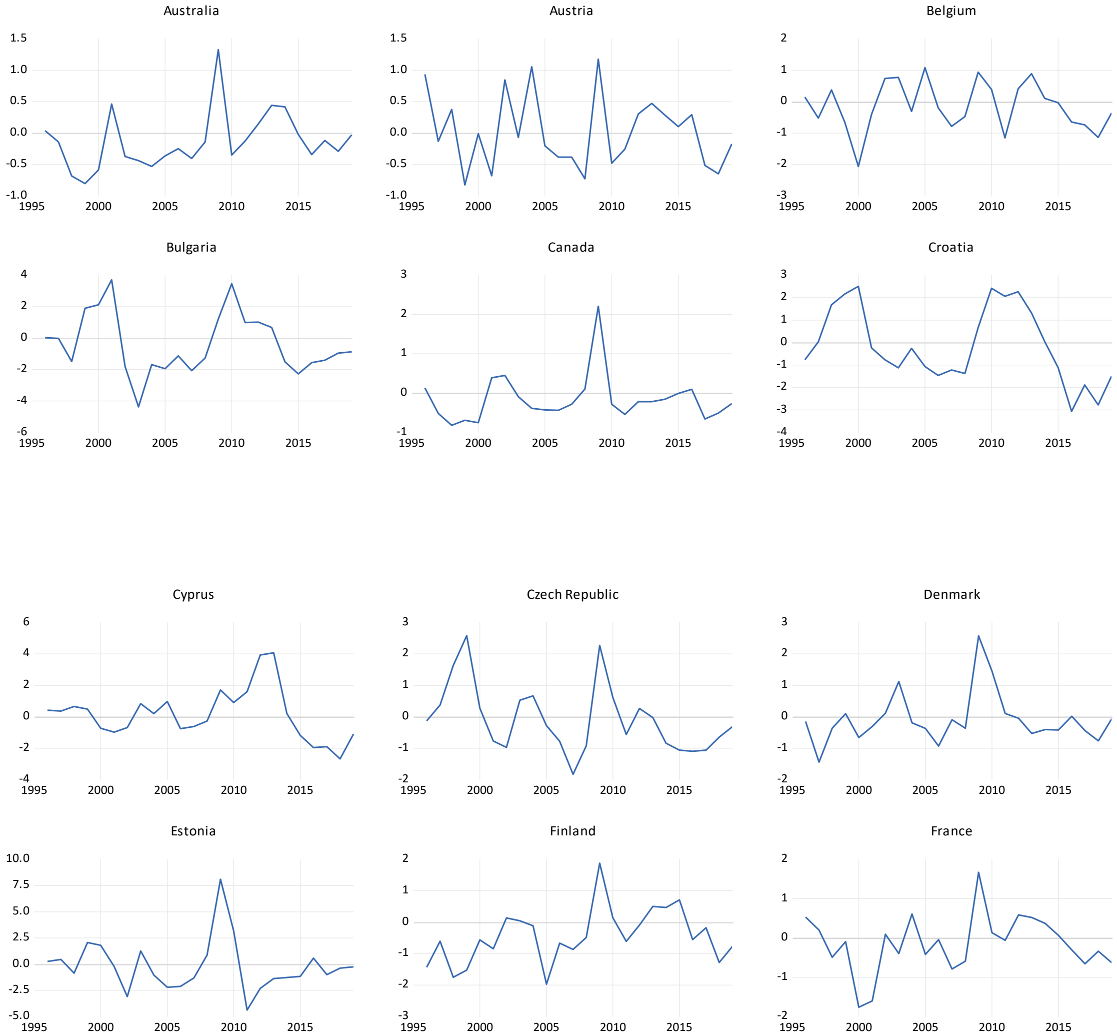




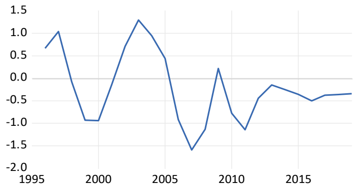
Block of figures 3

This block presents the first difference of log-GDP series. We observed that, there is evidence of stationarity in this variable.

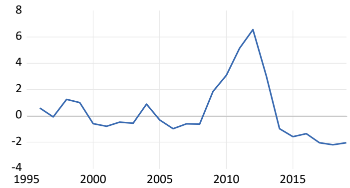
DIF_UNRATE_SERIES



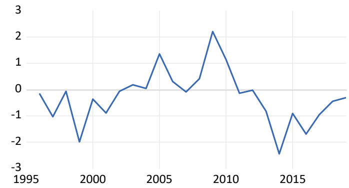
Germany



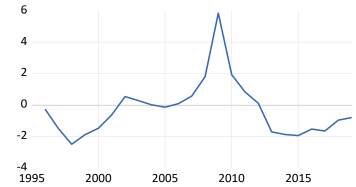
Greece



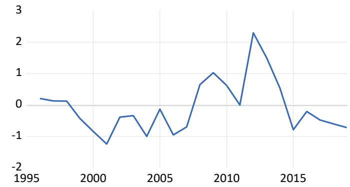
Hungary



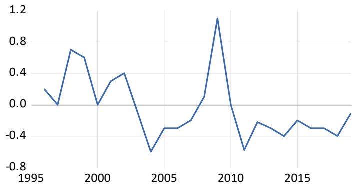
Ireland



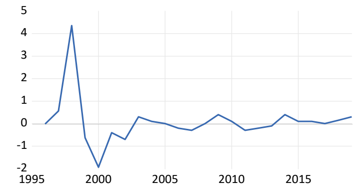
Italy



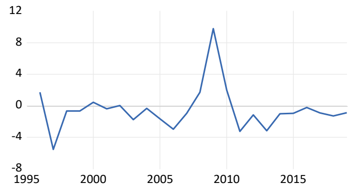
Japan



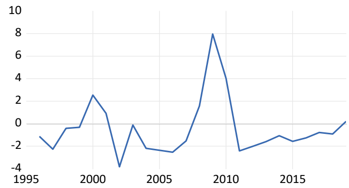
Korea Republic



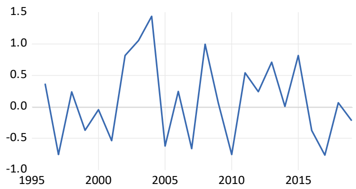
Latvia



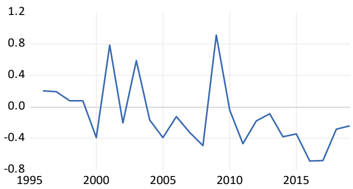
Lithuania



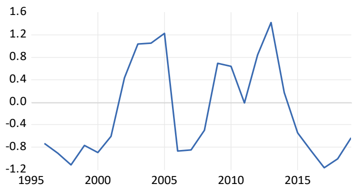
Luxembourg



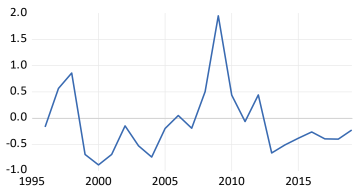
Malta



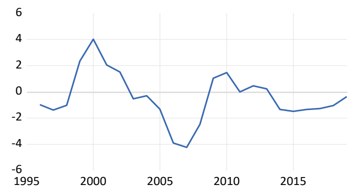
Netherlands



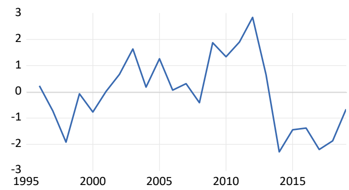
New Zealand



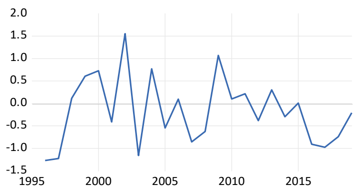
Poland



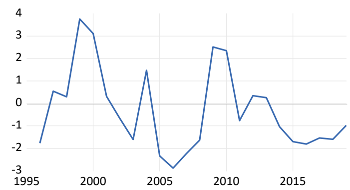
Portugal



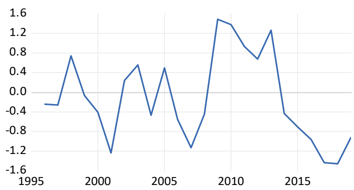
Romania

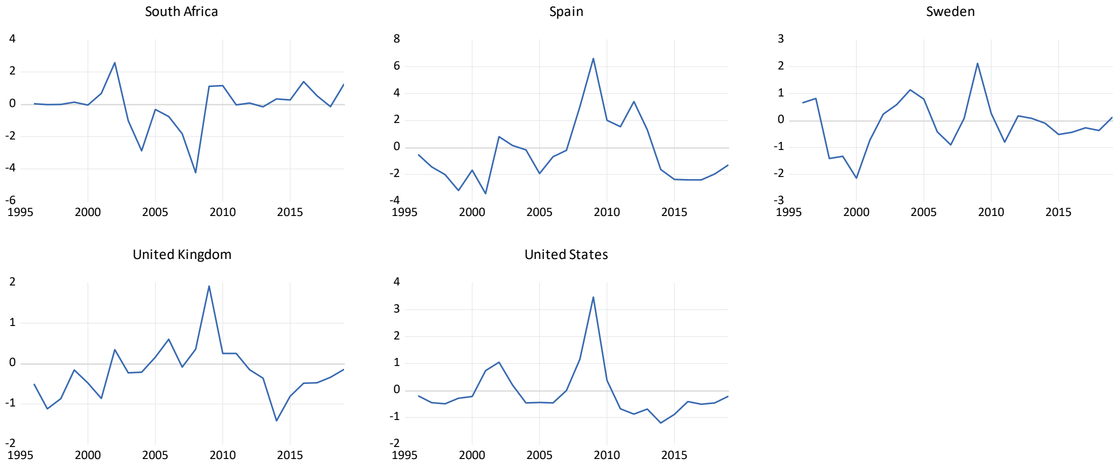


Slovak Republic



Slovenia





Block of figures 4

This block presents the first difference of unemployment rates series. We observe that there is evidence of stationarity in this variable.

3.2 DESCRIPTIVE STATISTICS

Table 1

DESCRIPTIVE STATISTICS FOR LOG_GDP_SERIES

SAMPLE: 1995 2019

COUNTRYNAME	Mean	Median	Max	Min.	Sum.	Std. Dev.	Skew.	Kurt.	Obs.
Australia	27.37999	27.47214	28.08603	26.62922	684.4997	0.558187	-0.139856	1.349893	25
Austria	26.49396	26.66821	26.84468	26.00545	662.3490	0.306497	-0.415921	1.510754	25
Belgium	26.67921	26.85915	27.01980	26.18796	666.9802	0.310687	-0.442138	1.507681	25
Bulgaria	24.18887	24.51662	24.94170	23.14948	604.7218	0.635974	-0.400771	1.498732	25
Canada	27.77798	27.94667	28.24470	27.12689	694.4496	0.416493	-0.402473	1.490343	25
Croatia	24.45484	24.64435	24.97588	23.79916	611.3711	0.420664	-0.499742	1.536163	25
Cyprus	23.58223	23.72263	24.04991	22.97958	589.5559	0.400555	-0.448481	1.508327	25
Czech Republic	25.62614	25.95346	26.23058	24.81387	640.6535	0.543195	-0.438799	1.470898	25
Denmark	26.28307	26.43592	26.59728	25.82410	657.0768	0.296031	-0.452232	1.480753	25
Estonia	23.34687	23.70356	24.16966	22.22686	583.6717	0.688610	-0.455997	1.554844	25
Finland	26.02441	26.18047	26.37419	25.55722	650.6103	0.314529	-0.450350	1.469919	25
France	28.39290	28.52228	28.70205	27.94016	709.8226	0.278616	-0.480710	1.549061	25
Germany	28.71576	28.84313	29.00462	28.29533	717.8939	0.239771	-0.461471	1.747787	25
Greece	26.05858	26.06967	26.59386	25.59183	651.4645	0.311292	-0.022272	1.797708	25
Hungary	25.28790	25.54781	25.80447	24.56112	632.1975	0.474221	-0.615502	1.658377	25
Ireland	25.94328	26.13936	26.68607	24.96059	648.5820	0.530200	-0.508690	1.936633	25
Italy	28.17571	28.26005	28.50601	27.76540	704.3928	0.253704	-0.492246	1.618016	25
Japan	29.21205	29.21009	29.45609	29.02541	730.3013	0.109280	0.571028	3.065048	25
Korea Republic	27.56199	27.67727	28.17368	26.67216	689.0496	0.444524	-0.296809	1.804395	25
Latvia	23.56099	23.89312	24.29724	22.47603	589.0248	0.660092	-0.466584	1.549618	25
Lithuania	23.96376	24.33511	24.71630	22.78642	599.0939	0.668297	-0.506158	1.644271	25
Luxembourg	24.40249	24.65290	24.98742	23.70550	610.0623	0.478056	-0.327629	1.427997	25
Malta	22.67010	22.78766	23.41696	21.95872	566.7526	0.476537	-0.094417	1.645962	25
Netherlands	27.22506	27.36349	27.57762	26.75501	680.6265	0.311340	-0.469084	1.498985	25
New Zealand	25.45517	25.52201	26.06042	24.68642	636.3792	0.495610	-0.265752	1.555788	25
Poland	26.50632	26.78487	27.10705	25.68006	662.6579	0.515664	-0.334432	1.411682	25
Portugal	25.93083	26.05253	26.29293	25.48558	648.2709	0.295097	-0.504545	1.561197	25
Romania	25.34411	25.83661	26.24504	24.29491	633.6028	0.752138	-0.354917	1.375616	25
Slovak Republic	24.82873	25.18288	25.38501	23.97520	620.7183	0.541885	-0.493496	1.492996	25
Slovenia	24.30149	24.48656	24.74059	23.73338	607.5374	0.381708	-0.437121	1.476301	25
South Africa	26.20201	26.38195	26.75496	25.47238	655.0503	0.432638	-0.405312	1.577341	25
Spain	27.66576	27.83972	28.11667	27.10352	691.6440	0.369756	-0.529235	1.552675	25
Sweden	26.72335	26.80214	27.09802	26.21384	668.0839	0.317957	-0.354279	1.472337	25
United Kingdom	28.44951	28.56267	28.76271	27.92487	711.2378	0.268849	-0.631452	1.866102	25
United States	30.22257	30.30164	30.69322	29.66439	755.5643	0.302483	-0.262993	1.969323	25
All	26.13251	26.18047	30.69322	21.95872	22865.95	1.848194	0.052923	2.456718	875

The above table contains the summary of the descriptive statistics for the first panel variable. The observation is that, the skewness for the most countries is approximately zero but the kurtosis is not around 3, so we can conclude that, there is no evidence for normal distribution.

Table 2

DESCRIPTIVE STATISTICS FOR UNRATE_SERIES

SAMPLE: 1995 2019

COUNTRYNAME	Mean	Median	Max	Min.	Sum.	Std. Dev.	Skew.	Kurt.	Obs.
Australia	5.990560	5.662000	8.506000	4.234000	149.7640	1.198920	0.873260	2.936651	25
Austria	5.050960	4.865000	6.014000	4.007000	126.2740	0.527171	-0.084074	2.272138	25
Belgium	7.774000	7.830000	9.483000	5.589000	194.3500	1.061365	-0.272605	2.315108	25
Bulgaria	11.05512	11.42400	19.92100	4.340000	276.3780	4.031088	0.201230	2.486544	25
Canada	7.305000	7.185000	9.620000	5.564000	182.6250	1.067576	0.586153	2.828765	25
Croatia	12.49264	12.59800	17.29000	6.935000	312.3160	2.983902	0.004959	1.909121	25
Cyprus	7.175360	5.304000	16.08800	3.298000	179.3840	4.106165	1.119731	2.827198	25
Czech Republic	5.905960	6.662000	8.762000	1.933000	147.6490	1.991472	-0.466000	2.100669	25
Denmark	5.561200	5.398000	7.573000	3.434000	139.0300	1.232050	0.120440	1.947218	25
Estonia	9.234160	9.659000	16.70700	4.592000	230.8540	3.174248	0.358733	2.443031	25
Finland	9.768400	8.663000	17.00500	6.369000	244.2100	2.832796	1.149971	3.492206	25
France	9.622600	9.059000	12.56600	7.063000	240.5650	1.518342	0.612926	2.396774	25
Germany	7.312320	7.773000	11.16700	3.043000	182.8080	2.439774	-0.253429	1.861989	25
Greece	14.50360	10.83900	27.46600	7.760000	362.5900	6.582275	0.816261	2.068085	25
Hungary	7.549200	7.406000	11.17200	3.399000	188.7300	2.345840	-0.015712	1.959785	25
Ireland	8.332000	6.774000	15.45100	3.683000	208.3000	4.010586	0.482264	1.752442	25
Italy	9.931320	10.61000	12.68300	6.075000	248.2830	2.015822	-0.391273	1.808579	25
Japan	4.036480	4.100000	5.400000	2.291000	100.9120	0.881969	-0.306667	2.199575	25
Korea Republic	3.684800	3.600000	6.963000	2.048000	92.12000	1.050704	1.611510	6.460545	25
Latvia	12.50816	12.06100	20.70000	6.052000	312.7040	4.172247	0.226115	2.157833	25
Lithuania	11.52252	12.87400	17.81400	4.250000	288.0630	4.155570	-0.179045	1.771256	25
Luxembourg	4.337640	4.731000	6.669000	1.805000	108.4410	1.402828	-0.261426	1.837656	25
Malta	6.126560	6.378000	7.488000	3.473000	153.1640	1.085802	-1.262882	3.640493	25
Netherlands	4.838400	4.839000	7.416000	2.119000	120.9600	1.507365	0.086623	2.110555	25
New Zealand	5.483720	5.433000	7.718000	3.661000	137.0930	1.191638	-0.021706	1.792708	25
Poland	11.31680	10.08800	19.89500	3.474000	282.9200	4.886539	0.325230	2.139652	25
Portugal	8.387120	7.552000	16.18300	3.809000	209.6780	3.537260	0.753922	2.632211	25
Romania	6.502680	6.802000	8.110000	3.976000	162.5670	1.044487	-0.881809	3.380166	25
Slovak Republic	13.21640	13.18400	19.38200	5.561000	330.4100	3.747149	-0.106574	2.473372	25
Slovenia	6.830960	6.647000	10.10200	4.195000	170.7740	1.530325	0.344003	2.658698	25
South Africa	27.81512	28.18100	33.47300	22.43300	695.3780	2.956036	-0.012965	1.980261	25
Spain	16.67840	17.22400	26.09400	8.232000	416.9600	5.581693	0.014051	1.700772	25
Sweden	7.296640	7.432000	10.35900	4.730000	182.4160	1.409251	0.117984	2.534534	25
United Kingdom	5.962120	5.562000	8.694000	3.851000	149.0530	1.458011	0.414269	1.846770	25
United States	5.699840	5.280000	9.633000	3.682000	142.4960	1.685039	1.129564	3.230182	25
All	8.765965	7.185000	33.47300	1.805000	7670.219	5.312921	1.922600	7.252414	875

The above table contains the summary of the descriptive statistics for the unemployment rate series. We can observe that, the skewness for most countries is approximately zero but the kurtosis is not in the region of 3, so we can conclude that, there is no evidence for normal distribution.

Table 3

DESCRIPTIVE STATISTICS FOR DIF_GDP_SERIES

SAMPLE: 1996 2019

COUNTRYNAME	Mean	Median	Max	Min.	Sum.	Std. Dev.	Skew.	Kurt.	Obs.
Australia	0.055543	0.074150	0.272301	-0.127522	1.333034	0.114057	0.008627	2.017728	24
Austria	0.025670	0.030938	0.204119	-0.146358	0.616069	0.084904	-0.075174	2.665932	24
Belgium	0.025379	0.027001	0.210415	-0.145776	0.609085	0.083429	0.048006	2.855041	24
Bulgaria	0.053120	0.064417	0.283878	-0.434430	1.274876	0.156537	-1.058849	4.994000	24
Canada	0.043998	0.039615	0.163276	-0.147546	1.055957	0.079790	-0.604525	3.125191	24
Croatia	0.041309	0.048881	0.257364	-0.151676	0.991409	0.103281	0.006881	2.433988	24
Cyprus	0.037726	0.047561	0.242021	-0.156421	0.905432	0.094872	0.118860	2.667350	24
Czech Republic	0.059030	0.082147	0.219691	-0.133889	1.416719	0.105927	-0.217282	1.913444	24
Denmark	0.026335	0.030469	0.199590	-0.153797	0.632034	0.080222	-0.182380	3.041973	24
Estonia	0.080950	0.084074	0.292522	-0.210551	1.942798	0.115511	-0.508811	3.641227	24
Finland	0.028940	0.033700	0.203494	-0.157741	0.694568	0.085514	-0.136307	2.908703	24
France	0.022012	0.024247	0.208378	-0.156815	0.528295	0.083943	-0.029545	2.936076	24
Germany	0.016538	0.022037	0.187857	-0.144740	0.396905	0.084381	-0.180989	2.541433	24
Greece	0.017805	0.000924	0.272038	-0.187058	0.427313	0.105742	0.272278	3.079282	24
Hungary	0.051806	0.033349	0.232458	-0.190092	1.243348	0.104969	-0.201247	2.937121	24
Ireland	0.071895	0.087660	0.249962	-0.151741	1.725477	0.083179	-0.628617	4.081021	24
Italy	0.022200	0.024044	0.214135	-0.162173	0.532789	0.085440	-0.037991	2.944312	24
Japan	-0.002908	0.002031	0.123389	-0.184961	-0.069794	0.086611	-0.297941	2.077127	24
Korea Republic	0.044345	0.076702	0.260722	-0.396307	1.064279	0.132505	-1.476683	6.224751	24
Latvia	0.074043	0.079671	0.365581	-0.306273	1.777040	0.135296	-0.647770	4.474155	24
Lithuania	0.080412	0.092481	0.275249	-0.245325	1.929880	0.120149	-0.813773	3.955307	24
Luxembourg	0.049667	0.062112	0.224393	-0.135200	1.192011	0.089542	-0.244819	2.585951	24
Malta	0.060760	0.057502	0.192618	-0.056413	1.458240	0.064565	-0.070229	2.433983	24
Netherlands	0.029086	0.038231	0.204783	-0.152101	0.698073	0.082697	-0.158476	2.839862	24
New Zealand	0.048948	0.048173	0.281063	-0.161393	1.174763	0.114635	0.066376	2.369581	24
Poland	0.059458	0.088313	0.218793	-0.193740	1.426991	0.100078	-0.646128	3.353976	24
Portugal	0.029135	0.035919	0.206106	-0.141441	0.699233	0.082227	-0.190110	2.969426	24
Romania	0.079132	0.089762	0.358203	-0.207789	1.899156	0.140776	-0.112484	2.487073	24
Slovak Republic	0.058585	0.057975	0.287172	-0.134296	1.406045	0.098242	0.159020	3.112583	24
Slovenia	0.038460	0.036976	0.232376	-0.147341	0.923042	0.096499	-0.066867	2.563366	24
South Africa	0.033984	-0.005156	0.417135	-0.115273	0.815621	0.132065	1.282485	4.212996	24
Spain	0.034126	0.042283	0.249722	-0.136126	0.819030	0.092274	0.124073	2.872830	24
Sweden	0.028586	0.023504	0.225467	-0.170535	0.686054	0.096102	-0.129798	2.659834	24
United Kingdom	0.031059	0.039350	0.163187	-0.192492	0.745405	0.078522	-0.788150	4.045522	24
United States	0.042868	0.042105	0.065203	-0.018100	1.028830	0.018169	-1.501141	6.332656	24
All	0.042857	0.045646	0.417135	-0.434430	36.00001	0.100471	-0.171435	4.069921	840

The above table contains the summary of the descriptive statistics for the GDP growth. We can observe that, the skewness for most countries is zero but, the kurtosis does not approach 3, so we can conclude that, there is no evidence for normal distribution.

Table 4

DESCRIPTIVE STATISTICS FOR DIF_UNRATE_SERIES

SAMPLE: 1996 2019

COUNTRYNAME	Mean	Median	Max	Min.	Sum.	Std. Dev.	Skew.	Kurt.	Obs.
Australia	-0.133375	-0.197000	1.327000	-0.804000	-3.201000	0.455445	1.397794	5.551647	24
Austria	0.013625	-0.101000	1.173000	-0.825000	0.327000	0.580373	0.495096	2.269099	24
Belgium	-0.156250	-0.255500	1.077000	-2.063000	-3.750000	0.771916	-0.327443	2.822934	24
Bulgaria	-0.389750	-1.042500	3.702999	-4.375999	-9.354000	1.936245	0.449693	2.829031	24
Canada	-0.163542	-0.275500	2.207000	-0.823000	-3.925000	0.607719	2.537003	10.75801	24
Croatia	-0.146542	-0.514500	2.504999	-3.072000	-3.517000	1.669903	0.216756	1.970678	24
Cyprus	0.145542	0.207500	4.076000	-2.682000	3.493000	1.626123	0.775055	3.681252	24
Czech Republic	-0.087125	-0.296500	2.585001	-1.828000	-2.091000	1.086635	0.956526	3.431701	24
Denmark	-0.086625	-0.253000	2.573000	-1.444000	-2.079000	0.814038	1.678919	6.426328	24
Estonia	-0.189333	-0.626500	8.093000	-4.379001	-4.544001	2.452351	1.504461	6.669640	24
Finland	-0.433750	-0.558500	1.880000	-1.974000	-10.41000	0.863726	0.481370	3.567910	24
France	-0.142042	-0.077000	1.673000	-1.764000	-3.409000	0.725194	-0.060252	3.912200	24
Germany	-0.213125	-0.349000	1.297000	-1.592000	-5.115000	0.756187	0.334965	2.357274	24
Greece	0.340667	-0.522000	6.573999	-2.196001	8.176001	2.235463	1.321585	4.183142	24
Hungary	-0.282042	-0.144500	2.213000	-2.451000	-6.769000	1.023418	0.169417	3.564622	24
Ireland	-0.293958	-0.450500	5.835000	-2.504000	-7.055000	1.770549	1.747437	6.997408	24
Italy	-0.074250	-0.274500	2.296000	-1.247000	-1.782000	0.846947	1.076740	3.882003	24
Japan	-0.037875	-0.154500	1.100000	-0.600000	-0.909000	0.413970	1.087424	3.766122	24
Korea Republic	0.086875	0.000000	4.355000	-1.942000	2.085000	1.037087	2.725771	13.71184	24
Latvia	-0.520000	-0.910000	9.776000	-5.560000	-12.48000	2.754088	2.002315	9.558113	24
Lithuania	-0.466167	-1.106001	7.959000	-3.832000	-11.18800	2.502327	1.831771	6.659499	24
Luxembourg	0.101875	0.062500	1.438000	-0.769000	2.445000	0.644937	0.285792	2.080944	24
Malta	-0.112292	-0.193500	0.912000	-0.692000	-2.695000	0.414076	1.018634	3.531100	24
Netherlands	-0.165042	-0.575000	1.422000	-1.167000	-3.961000	0.855262	0.546917	1.741440	24
New Zealand	-0.099667	-0.213500	1.954000	-0.893000	-2.392000	0.636714	1.508507	5.563365	24
Poland	-0.411000	-0.754500	4.023000	-4.238999	-9.864000	1.886784	0.184332	3.228277	24
Portugal	-0.030417	0.042000	2.850000	-2.289001	-0.730000	1.405074	0.114649	2.225902	24
Romania	-0.168083	-0.252500	1.552000	-1.270000	-4.034000	0.757547	0.420754	2.453996	24
Slovak Republic	-0.314500	-0.868500	3.759999	-2.883000	-7.548000	1.835447	0.764790	2.553544	24
Slovenia	-0.123125	-0.333500	1.486000	-1.456000	-2.955000	0.891506	0.288531	1.998102	24
South Africa	-0.082333	0.013500	2.577000	-4.233000	-1.976000	1.395560	-1.160840	5.156142	24
Spain	-0.363167	-0.995000	6.603001	-3.437000	-8.716000	2.388254	1.172868	4.148218	24
Sweden	-0.100875	-0.012500	2.116000	-2.141000	-2.421000	0.909300	0.071071	3.448295	24
United Kingdom	-0.201792	-0.221500	1.922000	-1.415000	-4.843000	0.667765	1.071461	5.584446	24
United States	-0.082000	-0.428500	3.470000	-1.207000	-1.968000	0.954827	2.321938	9.094134	24
All	-0.153756	-0.258000	9.776000	-5.560000	-129.1550	1.368899	1.463363	11.42624	840

The above table contains the summary of the descriptive statistics for the first differences of unemployment. We can observe that, the skewness for the most countries is not zero and also, the kurtosis is not close to 3, so we can conclude that, there is no evidence for normal distribution.

4.METHODOLOGY

We begin our analysis, by describing the two models, that Okun proposed for the relationship between output and unemployment. After, choosing the first difference model, the next stage of our methodology is the panel unit root tests. Two common panel unit root tests and tree individual panel unit root tests were used. More, specifically we executed Levin, Lin and Chu test, the Breitung test, the Im, Pesaran and Shin test, the Fisher Augmented Dickey Fuller test and Fisher Phillips Perron test. We found that the log-GDP-series and the Unrate-series were I(1), thus we tried to co-integrate them by applying cointegration methods for panel data. The cointegration approaches, that we used, were the Pedroni's cointegration test, the Kao's cointegration test and the Fisher's cointegration test. The first two are based on the Engle-Granger cointegration and the last one is based on the Johansen cointegration. The cointegration approach gave evidence for a long term relationship between output and unemployment, but we also wanted to investigate the short term relationship. To achieve this, we used the Pooled Mean Group Estimation by Pesaran (1999) to estimate the long term and the short term coefficients. Afterwards, we separated the full panel sample into two sub samples, the European Union countries and the G7 countries. This separation was made in order to compare our findings from the above methodologies. Next we, also used the quantile regression in order to examine the short run relationship for the different quantiles. Lastly, we used a pooled OLS estimation with time fixed effects and two dummy variables to test for asymmetry in the Okun's coefficients. The extended methodology that was used can be seen in the bellow sections. All estimations were computed with the use of Eviews and Stata econometric programs. We continue , by describing with more details the methodology , that we applied.

4.1 MODEL

Arthur M. Okun was the first to observe the negative relationship between GNP and unemployment rate, in his nominal paper in 1963. He introduced two models to measure this relationship. The first approach was the first difference model and the other approach was the gap model.

4.1.1.FIRST DIFFRENCE MODEL

Okun used quarterly post-war data and estimate the following equation:

$$\Delta U_t = b_0 + b_1 \Delta Y_t + e_t, \qquad b_1 < 0 \quad (1)$$

where, U_t = unemployment rate, Y_t = Gross Domestic Product, b_0 = constant term , b_1 = Okun's coefficient, which must be negative and finally e_t = error term.

4.1.2.GAP MODEL

This model uses the potential GDP and the non-accelerating inflation rate of unemployment to calculate the output and the unemployment gap.

$$U_t - U_t* = b_1(Y_t - Y_t*) + e_t, \qquad b_1 < 0 \quad (2)$$

where, U_t = unemployment rate, Y_t = Gross Domestic Product, U_t^* = NAIRU, Y_t^* = potential GDP, b_1 = Okun's coefficient, which has to be negative and finally e_t = error term.

Due to the difficulties in measuring the potential GDP and the NAIRU for all the countries of the data, we chose the first difference model in our analysis. We used panel data , thus the equation 1 could be written as :

$$\Delta U_{it} = b_0 + b_1 \Delta Y_{it} + e_{it}, \qquad b_1 < 0 \quad (3)$$

where, ΔY is the first log difference of GDP multiplied by 100 and ΔU is the first difference of unemployment rates. We have two dimensions the cross sectional (i) and the time (t).

4.2 PANEL UNIT ROOT TESTS

From the theory we know, that in order to run any estimation the variables, which we will use, have to be stationary. Based on the previous sentence, when we also analyze panel data we have to test for stationarity in the variables. In the panel environment, there are two types of unit roots, the common root and the individual root. We applied both in order to achieve better results for stationarity. Suppose that, we have an autoregressive AR(1) model:

$$y_{1t} = p_i y_{it-1} + \delta_i X_{it} + e_{it}, \qquad (4)$$

where, i= 1,2,…N cross-section of series, that is observable for periods t = 1,2,…T_i. The X_{it} is the representation of the exogenous variables and e_{it} is the error term.

If $|p_i| < 1$, then y_i is weakly trend stationary.

If $|p_i| = 1$, then y_i has a unit root.

Assumption 1

If $p_i = p, for\ every\ i$, then we have common unit root. The unit root tests, that we executed for this hypothesis were, the Levin, Lin & Chu and the Breitung tests.

Assumption 2

If $p_i \neq p, for\ every\ i$, then we have individual unit roots. The unit root tests, that we applied were, the Im, Pesaran & Shin, Fisher Augmented Dickey Fuller and Fisher Phillips Perron tests.

For the common unit root test there is a specification in the model. Moreover, the equation that is used, was:

$$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + X'_{it}\delta + e_{it},\ (5)\ \text{, where } \alpha = p - 1.$$

The null hypothesis is, that we have a unit root, thus $H0: a = 0$.

The alternative hypothesis is stationarity, thus $H1: a < 0$.

4.2.1. Levin, Lin and Chu common unit root test

Levin, Lin and Chu (2002) developed a method to estimate α for Δy_{it} and y_{it} from proxies. They hypothesized, that Δy_{it} and y_{it} were standardized and free of autocorrelations and deterministic components. The process begins by regressing Δy_{it} and y_{it} on the Δy_{it-j} and X_{it}. From the two estimations they, take the two coefficients $(\widehat{\beta},\ \hat{\delta})$ and $(\dot{\beta}, \dot{\delta})$. With the use of the first set of estimates they remove the autocorrelations and deterministic components from Δy_{it} and define $\Delta \overline{y}_{it}$. With the same way they define $\overline{y}_{it-1}$. From the above procedure they obtain two equations:

$$\Delta \overline{y}_{it} = \Delta y_{it} - \sum_{j=1}^{p_i} \widehat{\beta}_{ij} \Delta y_{it-j} - X'_{it}\widehat{\delta}, (6)$$

$$\overline{y}_{it-1} = y_{it-1} - \sum_{j=1}^{p_i} \dot{\beta}_{ij} \Delta y_{it-j} - X'_{it}\dot{\delta}, (7).$$

In the next stage they create the two proxies by dividing $\Delta \overline{y}_{it}$ and $\overline{y}_{it-1}$ with the standard errors Si, which were obtained from equation (5). $\Delta \widetilde{y}_{it} = \frac{\Delta \overline{y}it}{Si}, (8)$ and $\widetilde{y}_{it-1} = \frac{\overline{y}it-1}{Si}, (9)$. Finally, they ran the equation:

$\Delta\tilde{y}_{it} = \alpha\tilde{y}_{it-1} + \eta_{it}, (10)$ and estimate the coefficient α. They show that t-statistic for $\hat{\alpha}$ follows asymptotically the normal distribution, with type:

$t_a * = \frac{t_a - (NT)S_N \hat{\sigma}^{-2} se(\hat{\alpha})\mu_{m\tilde{T}*}}{\sigma_{m\tilde{T}*}} \rightarrow \mathrm{N}(0,1), (11)$, where t_a is standard t-statistic for $\hat{\alpha} = 0$, $\hat{\sigma}^2$ is the estimated variance of the error term η, $se(\hat{\alpha})$ is the standard error of $\hat{\alpha}$ and $\tilde{T} = T - (\sum_i pi/N) - 1$ (12), S_N is the average standard deviation ratio, $\mu_{m\tilde{T}*}$ and $\sigma_{m\tilde{T}*}$ are adjustment terms for the mean and the standard deviation. The null hypothesis of the test is $H0{:}\,Unit\ Root$ and the alternative is $H1{:}\,No\ Unit\ Root$.

4.2.2. Breitung common unit root test

Breitung (2000) developed a similar test, with the LLC, but with two major differences. First, he removes only the autoregressive component when he standardized proxies:

$$\Delta\tilde{y}_{it} = \left(\Delta y_{it} - \sum_{j=1}^{p_i} \hat{\beta}_{ij}\Delta y_{it-j}\right) \Big/ S_i, (13)$$

$$\tilde{y}_{it-1} = \left(y_{it-1} - \sum_{j=1}^{p_i} \dot{\beta}_{ij}\Delta y_{it-j}\right) \Big/ S_i, (14)$$

where, $\hat{\beta}, \dot{\beta}$ and Si are as defined for LLC. Second the proxies are transformed and detrended according to equations:

$$\Delta y_{it} * = \sqrt{(T-t)/(T-t-1)}\,(\Delta\tilde{y}_{it} - \Delta\tilde{y}_{it+1} + \cdots + \Delta\tilde{y}_{iT}/\mathrm{T} - t, (15)$$

$$y_{it} * = \tilde{y}_{it} - \tilde{y}_{i1} - \frac{t-1}{T-1}(\tilde{y}_{iT} - \tilde{y}_{i1}), (16).$$

Finally, he ran the equation:

$\Delta y_{it} * = \alpha y *_{it-1} + v_{it}, (17)$ and estimate the coefficient α. He, also show that the $\alpha *$ follows asymptomatically the normal distribution. The null hypothesis of the test is $H0{:}\,Unit\ Root$ and the alternative is $H1{:}\,No\ Unit\ Root$.

4.2.3. Im, Pesaran and Shin individual unit root test

Im, Pesaran and Shin (2003) developed an individual unit root test for each cross section. They estimate separated ADFs regressions based on equation:

$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + X'_{it}\delta + e_{it}$, (18). After estimating αi for every cross section, the average of the t-statistics is as follows,

$t_{iTi}(p_i)$: $\overline{t_{NT}} = (\sum_{i=1}^{N} t_{iTi}(p_i))/N$, (19). If the lag order is zero ($p_i = 0 \; \forall \; i$) the authors provide critical values in IPS paper. In the general case for lag order different that zero, they show that $\overline{t_{NT}}$ has an asymptotic standard normal distribution, according to the type:

$$W_{\overline{t_{NT}}} = \sqrt{N}(\overline{t_{NT}} - N^{-1} \textstyle\sum_{i=1}^{N} E(\overline{t_{iTi}}(p_i)))/\sqrt{N^{-1} \textstyle\sum_{i=1}^{N} Var(\overline{t_{iTi}}(p_i))} \quad ,$$

(20) The values for the expected mean and variance of $\overline{t_{iTi}}(p_i)$, for different values of T and p can be provided by IPS paper. The null hypothesis is $H0: a_i = 0, \forall i$, thus we have unit root and the alternative is $H1: a_i = 0, for\ i = 1,2, \ldots N_1$ or $H1: a_i < 0, for\ i = N+1, N+2, \ldots N$.

4.2.4. Fisher ADF and Fisher PP individual unit root test

Based on the panel unit root test proposed by Fisher (1932), Maddala and Wu (1999) and Choi (2001) used tests that combined the *p-values* from individual unit root tests. They define π_i as the *p-value* from any individual unit root test for cross-section i. The null hypothesis is unit root for all N cross-sections and the alternative is stationarity. Maddala and Wu construct a statistic based on π_i which asymptotically follows X^2 . This statistic has the type:

$$-2 \sum_{i=1}^{N} \log(\pi_i) \to x_{2N}^2 , (21)$$

Choi, also show that:

$Z = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} \Phi^{-1}(\pi_i) \to N(0,1), (22)$, where Φ^{-1} is the inverse of the standard normal cumulative distribution function. Finally the null and the alternative hypothesis are the same with IPS test.

4.3 PANEL COINTEGRATION

In the time series analysis, when two variables are I(1), we can use cointegration in order to examine their long run relationship. I(1) are variables, that become stationary when we use first differences. The same approach can be also used for panel data. Okun examined the short run relationship between output and unemployment , but in our analysis , we also want to investigate the long run relationship between the two variables. In order to achieve this, we use three panel cointegration tests. The Pedroni's , the Kao's and the Fisher's cointegration test. The first two are based on Engle Granger cointegration and the last one is based on Johansen cointegration.

4.3.1 Pedroni's Panel Cointegration

Engle Granger (1987) show, that when the residuals from a spurious regression performed using I(1) variables are I(0) the two variables are cointegrated. Pedroni (1999, 2004) tried to extend this method for panel data. He proposed the following equation:

$y_{it} = a_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \cdots + \beta_{Mi} x_{Mi,t} + e_{i,t} \quad (23),$ where y and x are I(1). The parameters a_i and δ_i represent the constant term and the trend respectively. If we want we can assume that both are zero. The methodology continues as follows, we run the equation (23) and retrieve the residuals $e_{i,t}$. Finally we perform a unit root test and if $e_{i,t}$ is I(0), y and x are cointegrated. In this sense Pedroni used these equations:

$e_{it} = p_i e_{it-1} + u_{it} \quad (24)$ and

$e_{it} = p_i e_{it-1} + \sum_{j=1}^{p_i} \psi_{ij} \Delta e_{it-j} + v_{it} \; (25)$ for the unit root. The null hypothesis has no cointegration, thus $p_i = 1$. There are two alternative hypothesis, the homogenous and the heterogeneous. In the first we assume that, $p_i = p < 1$ for all i (within dimension test) and in the second we assume that, $p_i < 1$ for all i (between-dimension test). Pedroni constructed a panel cointegration statistic $\boldsymbol{N}_{N,T}$ based on equations (24) and (25). He generates eleven different statistics with varying degree of properties. He shows that this statistic is asymptotically normally distributed:

$\boldsymbol{N}_{N,T} - \mu\sqrt{N} \big/ \sqrt{v} \Rightarrow \; N(0,1), \; (26),$ where μ and v are Monte Carlo generated adjustment terms.

4.3.2 Kao's Panel Cointegration

The Kao test is similar to Pedroni's tests, but specifies cross-section specific intercepts and homogeneous coefficients on the first-stage regressors. Kao (1999) proposed:

$y_{it} = a_i + \beta x_{it} + e_{it}, (27)$, for $y_{it} = y_{it-1} + u_{i,t}, (28)$ and

$x_{it} = x_{it-1} + e_{i,t},\ (29)$ for t=1,… T, i=1,…N. Generally, we can estimate equation (23) with a_i heterogeneous, β homogenous across cross-sections and setting $\delta_i = 0$. Kao then used two methods:

Method 1: Pooled auxiliary regression:

$e_{it} = pe_{it-1} + v_{it}, (29)$

Method 2: augmented version of the pooled specification:

$e_{it} = \bar{p}e_{it-1} + \sum_{j=1}^{p_i} \psi_{ij}\, \Delta e_{it-j} + v_{it}, (30)$. The null hypothesis is no cointegration. He constructed statistics:

$$DF_p = {T\sqrt{N}(\hat{p}-1) + 3\sqrt{N}} \Big/ {\sqrt{10.2}}, (31)$$

$$DF_t = \sqrt{1.25}t_p + \sqrt{1.875N}, (32)$$

$$DF_p^* = \sqrt{N}T(\hat{p}-1) + 3\sqrt{N}\hat{\sigma}_u^2/\hat{\sigma}_{0u}^2 \Big/ \sqrt{3 + 36\hat{\sigma}_u^4/(5\hat{\sigma}_{0u}^4)}, (33)$$

$$DF_t^* = t_p + \sqrt{6N}\hat{\sigma}_u/(2\hat{\sigma}_{0u}) \Big/ \sqrt{\hat{\sigma}_{0u}^2/2\hat{\sigma}_u^2 + 3\hat{\sigma}_u^2/10\hat{\sigma}_{0u}^2}, (34)$$

and for the case of $p > 0$:

$ADF = t_{\bar{p}} + \sqrt{6N}\hat{\sigma}_u/(2\hat{\sigma}_{0u}) / \sqrt{\hat{\sigma}_{0u}^2/2\hat{\sigma}_u^2 + 3\hat{\sigma}_u^2/10\hat{\sigma}_{0u}^2},$ (35), all statistics converge asymptotically to normal distribution N(0,1), where the estimated variance is $\hat{\sigma}_u^2 = \hat{\sigma}_u^2 - \hat{\sigma}_{ue}^2 \sigma_e^{-2}$ and the long run estimated variance is $\hat{\sigma}_{0u}^2 = \hat{\sigma}_{0u}^2 - \hat{\sigma}_{0ue}^2 \sigma_{0e}^{-2}$.

4.3.3 Fisher's Panel Cointegration

Fisher (1932) derives a combined test that uses the results of the individual independent tests. Maddala and Wu (1999) use Fisher's result to propose an alternative approach to testing for cointegration in panel data by combining tests from individual cross-sections to obtain at test statistic for the full panel. Maddala and Wu construct a statistic based on π_i which asymptotically follows X^2 . This statistic has the type:

$$-2\sum_{i=1}^{N}\log(\pi_i) \rightarrow x_{2N}^2\,, (36).$$

The null hypothesis is no cointegration and the alternative is cointegration.

4.4 POOLED MEAN GROUP ESTIMATION

Pesaran, Shin and Smith (1999) developed a model, that takes the cointegration form of the simple ARDL model and adapts it for a panel setting by allowing the intercepts, short-run coefficients and cointegrating terms to differ across cross-sections. Autoregressive Distributed Lag (ARDL) models are standard least squares regressions which include lags of both the dependent variable and independent variables as regressors. The PMG model is described as follows :

$$\Delta y_{i,t} = \Phi_i EC_{i,t} + \sum_{j=0}^{q-1} \Delta X_{i,t-j}{}' \beta_{i,j} + \sum_{j=1}^{p-1} \lambda_{i,j}{}^* \Delta y_{i,t-j} + e_{i,t} \ (37)$$

where, $EC_{i,t} = y_{i,t-1} - X_{i,t}{}'\theta$ (38). The first assumption is that, both the dependent variable and the regressors have the same number of lags in each cross-section. Second, they assumed that the regressors X, have the same number of lags q in each cross-section, but this assumption is not strictly required for estimation. The θ coefficient is the long run coefficient and Φ_i is the adjustment coefficients. The log-likelihood function can be written as follows:

$l_t(\varphi) = -(T_i/2)\sum_{i=1}^{N}\log(2\pi\sigma_i^2) - (1/2)\sum_{i=1}^{N}(1/\sigma_i^2)(\Delta Y_i - \Phi_i EC_i)' H_i (\Delta Y_i - \Phi_i EC_i), (39)$, where

$$\Delta Y_i = \left(\Delta y_{i,1}, \Delta y_{i,2}, \dots \Delta y_{i,T_i}\right)', (40)$$

$$EC_i = \left(EC_{i,1}, EC_{i,2}, \dots EC_{i,T_i}\right)', (41)$$

$$H_i = (I_{T_i} - W_i(W_i^{'}W_i)^{-1}W_i^{'})^{-1}, (42)$$

$$W_i = \Delta Y_{i,-1}, \dots, \Delta Y_{i,-p+1}, \Delta X_{i,}\Delta X_{i,-1}, \dots \Delta X_{i,-q+1}, (43)$$

$$\Delta X_i = \left(\Delta X_{i,1}, \Delta X_{i,2}, \dots \Delta X_{i,T_i}\right)^{'}, (44)$$

and they defined the j-th lags of ΔY_i, ΔX_i, $\Delta Y_{i,-j}$ and $\Delta X_{i,-j}$. The log-likelihood can be maximized directly, however the authors suggested an iterative procedure based upon the first derivatives of (38). Initial least squares estimates of θ based on the regression $Y_t = \theta X_t$, are used to compute estimates, using the first-derivative relationships, of Φ_i and σ_i^2. Y_t and X_t are the stacked forms of $y_{i,t}$ and $x_{i,t}$. These estimates are then used to compute new estimates of θ, and the process continues until convergence. Given the final estimates of θ, Φ_i and σ_i^2 they estimate $\beta_{i,j}$ and λ_{i,j^*}. Although this iterative procedure's estimates converge to the full likelihood estimates, their covariance matrix does not. Fortunately, PSS provide the analytical form of the estimate of the covariance matrix based upon the coefficient estimates in their paper. We chose the PMG approach because the methodology is equally applicable irrespective of stationary or nonstationary variables being used.

4.5 PANEL QUANTILE REGRESSION

Quantile regression (Koenker and Bassett, 1978) is new econometric approach that is increasingly used by the analysts. For $0 < \tau < 1$ the τ -th quantile of y given x is defined by $Q_y(\tau|x) = \min\{\eta|P(y \le \eta|x) \ge \tau\}, (45)$. We assume linearity, thus $Q_y(\tau|x) = x^{'}\beta(\tau), (46)$. With linear quantiles, we can write

$y = x^{'}\beta(\tau) + u(\tau), (47)$ and $Q_{u(\tau)}(\tau|x) = 0, (48)$. The errors and the parameters depend on τ and also we need to restrict the support of x to ensure that quantiles do not cross. The estimator $\beta(\tau)$ is defined by

$$\hat{\beta}(\tau) = argmin_b 1/n\{\sum_{y_i \ge x_i^{'}b} \tau\left|y_i - x_i^{'}b\right| + \sum_{y_i < x_i^{'}b} (1-\tau)\left|y_i - x_i^{'}b\right|$$

(49) and it can be estimated by linear programming. Asymptotic theory is non-standard because the objective function is not differentiable. However, under certain regularity conditions, $\hat{\beta}(\tau)$ has standard properties:

$\sqrt{n}\left(\hat{\beta}(\tau) - \beta(\tau)\right) \xrightarrow{d} N(0, D^{-1}AD^{-1}), (50)$ where

$D = E[f_{u(\tau)}\left(0|x_i\right)x_i x_i^{'}], (51)$ and $A = E[\left(\tau - 1(u(\tau)_i \le 0)\right)^2 x_i x_i^{'}]$, (52). The reason why the quantile regression is important, is the information gains that, it provides. Quantiles are robust measures of location and are estimated using a robust estimator. Their properties are, first that there are not additive, the quantile of the sum is not the sum of the quantiles and second quantiles

are equivariant to non-decreasing transformations. For the panel data estimation we used the XTQREG command in Stata which was developed by Machado and Silva (2019) and conducts the quantile regression via moments. We want to estimate the model $y_i = x_i^{'}\beta + (x_i^{'}\gamma)u_i, (53)$,where x_i and u_i are independent and $\Pr(x_i^{'}\gamma > 0) = 1, (54)$. In this case all the quantiles are linear:
$Q_y(\tau|x) = x_i^{'}\beta + (x_i^{'}\gamma)Q_u(\tau|x_i) = x_i^{'}\beta(\tau), (55)$ and $\beta(\tau) = \beta + \gamma Q_u(\tau), (56)$. The parameters β,γ and $Q_u(\tau)$ provide the same information with the quantile regression. Machado and Santos Silva (2019) assume that, $E(U) = 0$ and by normalizing $E(|U|) = 1$, β and γ are identified by conditional expectations:$E[y_i|x_i] = \beta_0 + \beta_1 x_i, (57)$, $E[|y_i - \beta_0 - \beta_1 x_i||x_i] = \gamma_0 + \gamma_1 x_i, (58)$. $Q_u(\tau|x_i)$ can be estimated from the scaled errors: $\frac{y_i - \beta_0 - \beta_1 x_i}{\gamma_0 + \gamma_1 x_i}$. This provides a way to estimate quantile regression using two OLS regressions and the computation of a univariate quantile. Suppose now that we are interested in estimating
$Q_{y_{it}}(\tau|x_{it}, \eta_i) = x_{it}^{'}\beta(\tau) + \eta(\tau)_i, (59)$ with i=1,…n and t=1,…T. Fixed effects can be very important in this estimation. Estimation of quantile regression with fixed effects is difficult because there is no transformation that can be used to eliminate the incidental parameters. Therefore, due to the incidental parameter problem consistency requires that $n \to \infty$ and $T \to \infty$. They consider a location-scale model for panel data with the form:

$$y_{it} = \alpha_i + x_{it}^{'}\beta + (\delta_i + x_{it}^{'}\gamma)u_{it}, (60)$$
$$\eta(\tau)_i = a_i + \delta_i Q_u(\tau), (61)$$
$$\beta(\tau) = \beta + \gamma Q_u(\tau), (62)$$

where x_i and u_i are independent and $\Pr\left((\delta_i + x_{it}^{'}\gamma) > 0\right) = 1, (63)$. Estimation is performed using two fixed effects regressions(xtreg) and computing a univariate quantile. Consistency requires $(n, T) \to \infty$ with $n = o(T)$. For fixed T the estimator will have a bias. But simulations suggest that the bias is negligible for $n/T \leq 10$ and also the bias can be removed using jackknife. Thus we run the quantile regression with fixed effects for time.

4.6 POOLED OLS WITH TIME FIXED EFFECTS AND DUMMIES FOR ASYMMETRY

Many researchers addressed the possibility of asymmetries in Okun's law coefficients. Moreover, Lee (2000), Harris and Silverstone (2001), Silvapulle, Moosa and Silvapulle (2004), Holmes and Silverstone (2006) and others highlight the asymmetries in Okun's Law. In the present analysis we used a time fixed effect model along with two dummies for the sign of the first difference of unemployment. We ran the pooled estimation:

$$D\_GDP_{it} = C_{it} + \beta_1^{+} D1 * D\_UNRATE_{it} + \beta_1^{-} D2 * D\_UNRATE_{it} + \mu_i + \lambda_t + e_{it,} (63),$$

where C_{it} is the constant term, β_1^{+} is the Okun's coefficient for positive differences in unemployment, β_1^{-} is the Okun's coefficient for negative differences in unemployment, μ_i is the cross- section heterogeneity, λ_t is the time heterogeneity, D1 and D2 are the two dummies and e_{it} is the error term. $D1 = 1\ if\ D\_Unrate\ \geq 0$ or $D1 = 0\ if\ D\_Unrate\ < 0$ and

$D2 = 1\ if\ D\_Unrate\ < 0$ or $D2 = 0\ if\ D\_Unrate\ \geq 0.$ If β_1^+ and β_1^- are different, then we have the presence of asymmetries in Okun's law.

5. EMPIRICAL RESULTS

In this section we are going to interpret the results of our analysis. First of all, we present the unit root tests for the 3 panel samples. After that, we try to establish a long run relationship between output and unemployment, in order to do so, we used the approach of cointegration for panel data. Next we used the pooled mean group estimation by Pesaran, Shin and Smith (1999) to investigate the long run and the short run coefficient for every country in each sample. Next we used the quantile regression for the quantile short run coefficients. Finally , we test for asymmetry with a time fixed effect model with dummies depending on the sign of the first differences of unemployment.

5.1. PANEL UNIT ROOT TESTS

Table 5

Panel Unit Root Tests Log_GDP									
Common Unit Root									
	Full Sample			European Union			G7		
	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis
Levin, Lin & Chu	1.17361	0.8797	H0: I(1)	1.53657	0.9378	H0: I(1)	0.03893	0.5155	H0: I(1)
Breitung	-1.09758	0.1362	H0: I(1)	-1.06404	0.1437	H0: I(1)	-0.44969	0.3265	H0: I(1)
Individual Unit Root									
	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis
Im,Pesaran & Sin	2.66598	0.9962	H0: I(1)	3.26224	0.9994	H0: I(1)	0.4623	0.6781	H0: I(1)
ADF- Fisher	34.5867	0.9999	H0: I(1)	17.3424	1	H0: I(1)	10.5541	0.7207	H0: I(1)
PP-Fisher	21.9867	1	H0: I(1)	12.6184	1	H0: I(1)	6.56806	0.9501	H0: I(1)

From the above table we can observe that the *p-value* in every test is bigger than 5%, thus the H0 is valid, so the Log_GDP is not stationary in each sample.

Table 6

Panel Unit Root Tests Unrate									
Common Unit Root									
	Full Sample			European Union			G7		
	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis
Levin, Lin & Chu	-2.91968	0.0018	H1: I(0)	-2.81946	0.0024	H1: I(0)	-0.97062	0.1659	H0: I(1)
Breitung	-4.20527	0	H1: I(0)	-3.89038	0.0001	H1: I(0)	-2.04428	0.0205	H1: I(0)
Individual Unit Root									
	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis
Im,Pesaran & Sin	-3.64306	0.0001	H1: I(0)	-3.55987	0.0002	H1: I(0)	-0.70384	0.2408	H0: I(1)
ADF- Fisher	116.587	0.0004	H1: I(0)	94.5464	0.0005	H1: I(0)	15.0203	0.3768	H0: I(1)
PP-Fisher	35.9049	0.9998	H0: I(1)	28.1192	0.9986	H0: I(1)	5.42757	0.9789	H0: I(1)

In this table for the full sample and the European countries the Unrate seems to be stationary (4 out of 5 tests suggest that), but in the G7 countries, we show that the Unrate is non-stationary. All in all, we assume, that Unrate is stationary in the first two samples, thus it is a I(0), but it is non-stationary in G7 sample.

Table 7

Panel Unit Root Tests Dif_GDP									
Common Unit Root									
	Full Sample			European Union			G7		
	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis
Levin, Lin & Chu	-12.8284	0	H1: I(0)	-11.0956	0	H1: I(0)	-6.04812	0	H1: I(0)
Breitung	-12.6955	0	H1: I(0)	-10.6563	0	H1: I(0)	-6.49954	0	H1: I(0)
Individual Unit Root									
	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis
Im,Pesaran & Sin	-8.06947	0	H1: I(0)	-6.93838	0	H1: I(0)	-3.96627	0	H1: I(0)
ADF- Fisher	182.947	0	H1: I(0)	138.497	0	H1: I(0)	39.4456	0.0003	H1: I(0)
PP-Fisher	191.701	0	H1: I(0)	145.404	0	H1: I(0)	38.778	0.0004	H1: I(0)

From the above table, we can observe that all *p-values* are smaller than 5%, thus the alternative hypothesis of stationarity is valid. The Dif-GDP is stationary for all samples. The results are the same for the 100*Dif_GDP_series.

Table 8

Panel Unit Root Tests Dif_Unrate									
Common Unit Root									
	Full Sample			European Union			G7		
	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis
Levin, Lin & Chu	-6.04931	0	H1: I(0)	-4.06317	0	H1: I(0)	-4.54	0	H1: I(0)
Breitung	-10.1789	0	H1: I(0)	-8.37317	0	H1: I(0)	-4.81482	0	H1: I(0)
Individual Unit Root									
	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis	Statistic	P-Value	Hypothesis
Im,Pesaran & Sin	-6.12912	0	H1: I(0)	-4.95818	0	H1: I(0)	-2.9676	0.0015	H1: I(0)
ADF- Fisher	153.468	0	H1: I(0)	112.602	0	H1: I(0)	32.4521	0.0035	H1: I(0)
PP-Fisher	171.142	0	H1: I(0)	128.692	0	H1: I(0)	27.3232	0.0175	H1: I(0)

From the above table, we can observe that all *p-values* are smaller than 5%, thus the alternative hypothesis of stationarity is valid. The Dif-Unrate is stationary for all samples. To sum up, the GDP variable is non stationary at levels and stationary at first differences, the Unrate variables seems stationary both at levels and at first differences for the first two samples and it is non-stationary at levels and stationary at first differences for the last sample.

5.2. COINTEGRATION

5.2.1 Pedroni's Panel Cointegration

Table 9

Panel Cointegration Unrate-Log_GDP									
Common AR coefficients (within-dimension)									
	Full Sample			European Union			G7		
	Stat	P-Value	Hypothesis	Stat	P-Value	Hypothesis	Stat	P-Value	Hypothesis
Panel v-Stat	2.638336	0.0042	H1: Coint.	-0.811177	0.7914	H0: No coint.	-1.031583	0.8489	H0: No coint.
Panel rho-Stat	-0.333314	0.3694	H0: No coint.	4.66978	1	H0: No coint.	1.569981	0.9418	H0: No coint.
Panel PP-Stat	-0.367621	0.3566	H0: No coint	5.035027	1	H0: No coint.	1.205066	0.8859	H0: No coint.
Panel ADF-Stat	-6.306627	0	H1: Coint.	3.610061	0.9998	H0: No coint.	-1.061055	0.1443	H0: No coint.
	Full Sample			European Union			G7		
	Weig.-St.	P-Value	Hypothesis	Weig.-St.	P-Value	Hypothesis	Weig.-St.	P-Value	Hypothesis
Panel v-Stat	3.548637	0.0002	H1: Coint.	-1.265176	0.8971	H0: No coint.	-1.089616	0.8621	H0: No coint.
Panel rho-Stat	-0.779488	0.2178	H0: No coint.	4.407862	1	H0: No coint	1.564894	0.9412	H0: No coint
Panel PP-Stat	-0.867187	0.1929	H0: No coint	4.548401	1	H0: No coint.	1.057431	0.8548	H0: No coint.
Panel ADF-Stat	-5.387218	0	H1: Coint.	3.033366	0.9988	H0: No coint	-1.060983	0.1443	H0: No coint
Individual AR coefficients (between-dimension)									
	Full Sample			European Union			G7		
	Stat	P-Value	Hypothesis	Stat	P-Value	Hypothesis	Stat	P-Value	Hypothesis
Group rho-Stat	1.593284	0.9445	H0: No coint.	5.939328	1	H0: No coint.	2.491997	0.9936	H0: No coint.
Group PP-Stat	0.458793	0.6768	H0: No coint.	6.429617	1	H0: No coint.	1.89091	0.9707	H0: No coint.
Group ADF-Stat	-6.275448	0	H1: Coint.	4.748401	1	H0: No coint.	-0.464499	0.3211	H0: No coint.

The above table summarizes the Pedroni's 11 tests for cointegration between Unrate and Log-GDP. As we can see, there is no evidence for cointegration between the two variables, because the H0 is valid for most of the cases and samples.

Table 10

Panel Cointegration Log_GDP-Unrate									
Common AR coefficients (within-dimension)									
	Full Sample			European Union			G7		
	Stat	P-Value	Hypothesis	Stat	P-Value	Hypothesis	Stat	P-Value	Hypothesis
Panel v-Stat	-0.465578	0.6792	H0: No coint.	-0.811177	0.7914	H0: No coint.	-0.069811	0.5278	H0: No coint.
Panel rho-Stat	5.005806	1	H0: No coint.	4.66978	1	H0: No coint.	1.911345	0.972	H0: No coint.
Panel PP-Stat	5.191375	1	H0: No coint.	5.035027	1	H0: No coint.	1.561202	0.9408	H0: No coint.
Panel ADF-Stat	3.025042	0.9988	H0: No coint.	3.610061	0.9998	H0: No coint.	0.029414	0.5117	H0: No coint.
	Full Sample			European Union			G7		
	Weig.-St.	P-Value	Hypothesis	Weig.-St.	P-Value	Hypothesis	Weig.-St.	P-Value	Hypothesis
Panel v-Stat	-0.706139	0.7599	H0: No coint.	-1.265176	0.8971	H0: No coint.	0.001214	0.4995	H0: No coint.
Panel rho-Stat	4.719518	1	H0: No coint.	4.407862	1	H0: No coint.	1.758114	0.9606	H0: No coint.
Panel PP-Stat	4.638315	1	H0: No coint.	4.548401	1	H0: No coint.	1.270454	0.898	H0: No coint.
Panel ADF-Stat	2.351078	0.9906	H0: No coint.	3.033366	0.9988	H0: No coint.	-0.277293	0.3908	H0: No coint.
Individual AR coefficients (between-dimension)									
	Full Sample			European Union			G7		
	Stat	P-Value	Hypothesis	Stat	P-Value	Hypothesis	Stat	P-Value	Hypothesis
Group rho-Stat	6.363674	1	H0: No coint.	5.939328	1	H0: No coint.	2.690736	0.9964	H0: No coint.
Group PP-Stat	6.469906	1	H0: No coint.	6.429617	1	H0: No coint.	2.144401	0.984	H0: No coint.
Group ADF-Stat	3.752988	0.9999	H0: No coint.	4.748401	1	H0: No coint.	0.514855	0.6967	H0: No coint.

The above table summarizes the Pedroni's 11 tests for cointegration between Log-GDP and Unrate. As we can see, there is no evidence for cointegration between the two variables, because the H0 is valid for all cases and samples.

5.2.2 Kao's Panel Cointegration

Table 11

Panel Cointegration Kao Unrate-Log_GDP								
Full Sample			European Union			G7		
t-stat	P-Value	Hypothesis	t-stat	P-Value	Hypothesis	t-stat	P-Value	Hypothesis
-7.88324	0	H1: Cointegration	-2.071821	0.0191	H1: Cointegration	-3.112736	0.0009	H1: Cointegration
Panel Cointegration Kao Log_GDP-Unrate								
t-stat	P-Value	Hypothesis	t-stat	P-Value	Hypothesis	t-stat	P-Value	Hypothesis
-2.058306	0.0198	H1: Cointegration	-2.071821	0.0191	H1: Cointegration	-1.048504	0.1472	H0: No cointegration

In contrast to Pedroni's cointegration test, the Kao test support that there is a cointegration relationship between Unrate and Log-GDP for all samples. Also, there is an evidence for cointegration between Log-GDP and Unrate for the first two samples. All in all, Kao's cointegration test reveals a cointegration relationship between the output and unemployment.

5.2.3 Fisher's Panel Cointegration

Table 12

Panel Cointegration Johansen-Fisher Unrate-Log_GDP					
			Full Sample		
Hypothesizes No of CE(s)	Trace Test	P-Value	Max-Eigen test	P-Value	Result
None	111.3	0.0012	111.2	0.0013	Cointegration
At most one	48.62	0.9759	48.62	0.9759	1
			European Union		
	Trace Test	P-Value	Max-Eigen test	P-Value	Result
None	73.49	0.04	77.93	0.0182	Cointegration
At most one	31.36	0.9942	31.36	0.9942	1
			G7		
	Trace Test	P-Value	Max-Eigen test	P-Value	Result
None	36.5	0.0009	34.2	0.0019	Cointegration
At most one	14.02	0.4482	14.02	0.4482	1

We can observe that the none cointegration hypothesis is rejected because *p-value* is smaller than 5% and at most one cointegration hypothesis is valid because *p-value* is bigger than 5% for all cases. To sum up the trace test and the max-eigen test support that there is a cointegration relationship between unemployment and output for all samples.

Table 13

Panel Cointegration Johansen-Fisher Log_GDP-Unrate					
			Full Sample		
Hypothesizes No of CE(s)	Trace Test	P-Value	Max-Eigen test	P-Value	Result
None	111.3	0.0012	111.2	0.0013	Cointegration
At most one	48.62	0.9759	48.62	0.9759	1
			European Union		
	Trace Test	P-Value	Max-Eigen test	P-Value	Result
None	73.49	0.04	77.93	0.0182	Cointegration
At most one	31.36	0.9942	31.36	0.9942	1
			G7		
	Trace Test	P-Value	Max-Eigen test	P-Value	Result
None	36.5	0.0009	34.2	0.0019	Cointegration
At most one	14.02	0.4482	14.02	0.4482	1

We can observe that the none cointegration hypothesis is rejected because *p-value* is smaller than 5% and at most one cointegration hypothesis is valid because *p-value* is bigger than 5% for all cases. To sum up the trace test and the max-eigen test support that there is a cointegration relationship between output and unemployment for all samples. From the above cointegration approaches the Pedroni's test does not support a cointegration relationship between the two variables, on the other hand the Kao's test and the Johansen-Fisher test reveals evidence of cointegration relationship.

5.3 POOLED MEAN GROUP ESTIMATION

Table 14

Pooled Mean Group Unrate-Log_GDP			
	Full Sample	European Union	G7
ARDL MODEL	ARDL(2, 1)	ARDL(2, 1)	ARDL(4, 1)
Long Run Coefficient	-0.007467	0.002704	-0.0204267
P-Value	0.0002	0.3554	0
Speed of adjustment	-0.251631	-0.229205	-0.334854
P-Value	0	0	0
Autocorrelation term 1	0.490303	0.478761	0.589986
P-value	0	0	0
Short Run Coefficient	-0.045628	-0.039619	-0.077017
P-Value	0	0	0.1918
Constant Term	7.181155	0.480351	22.28986
P-Value	0	0.006	0
Autocorrelation term 2	x	x	0.007894
P-value	x	x	0.9529
Autocorrelation term 3	x	x	0.267212
P-value	x	x	0

From the first PMG estimation we observe, that for the full sample the ARDL(2,1) model was chosen. The long run coefficient is -0.007467 and is statistical significant because *p-value* is smaller than 5%. The speed of adjustment or the error correction factor is -0.251631 and it is significant. The average short run coefficient is -0.045628 and it's also significant. Finally the autocorrelation term is positive and significant. For the European countries sample the ARDL(2,1) model was chosen. The long run coefficient is not significant because *p-value* is bigger than 5%. The speed of adjustment is -0.229205 and statistical significant. The average short run coefficient is -0.039619 and significant and lastly the autocorrelation term is positive and significant. For the last sample the ARDL(4,1) was chosen. The long run coefficient is -0.0204267 and is statistical significant because *p-value* is smaller than 5%. The speed of adjustment or the error correction factor is -0.334854 and it is significant. The average short run coefficient is -0.077017 and it's also significant. Finally the autocorrelation terms are positive and significant. The results from the PMG for unemployment and GDP validates the Okun's law. We can observe a negative relationship between unemployment and output. This relationship is also valid for the long run. The long run coefficient is bigger in the G7 countries than the full sample. The average short run coefficient spans from -0.039619 to -0.077017. The error correction term is negative as it should be and it differs across samples. To sum up , our data support the Okun's law for all countries and samples. The next table contains the PME results for cross section short run coefficients. In all the cases the short run coefficients are statistical significant. All the coefficients are negative and thus support the validity of Okun's Law, except for Luxembourg, which has positive coefficients.

Table 15

Pooled Mean Group Unrate-Log GDP Cross Section						
	Full Sample		European Union		G7	
Country	Short Run Coefficient	P-Value	Short Run Coefficient	P-Value	Short Run Coefficient	P-Value
Australia	-0.022485	0.0000	X	x	x	X
Austria	-0.004100	0.0010	-0.006360	0.0000	X	X
Belgium	-0.022491	0.0000	-0.020535	0.0000	X	X
Bulgaria	-0.064815	0.0000	-0.067903	0.0000	X	X
Canada	-0.039781	0.0000	X	x	-0.053759	0.0000
Croatia	-0.022031	0.0000	-0.020733	0.0000	X	X
Cyprus	-0.035330	0.0000	-0.038493	0.0000	X	X
Czech Republic	-0.019106	0.0000	-0.022028	0.0000	X	X
Denmark	-0.018312	0.0000	-0.023092	0.0000	X	X
Estonia	-0.082538	0.0000	-0.086474	0.0000	X	X
Finland	-0.034113	0.0000	-0.034417	0.0000	X	X
France	-0.026097	0.0000	-0.025315	0.0000	-0.018744	0.0000
Germany	-0.004349	0.0002	-0.005181	0.0001	0.004983	0.0001
Greece	-0.050163	0.0000	-0.051465	0.0000	X	X
Hungary	-0.035796	0.0000	-0.034559	0.0000	X	X
Ireland	-0.087084	0.0000	-0.087356	0.0000	X	X
Italy	-0.022930	0.0000	-0.023390	0.0000	-0.009269	0.0002
Japan	-0.008509	0.0000	X	x	-0.001447	0.0006
Korea, Rep.	-0.045107	0.0000	X	x	X	X
Latvia	-0.111247	0.0000	-0.110985	0.0000	X	X
Lithuania	-0.078519	0.0000	-0.079676	0.0000	X	X
Luxembourg	0.018498	0.0000	0.017188	0.0000	X	X
Malta	-0.015328	0.0000	-0.015564	0.0000	X	X
Netherlands	-0.013126	0.0000	-0.017015	0.0000	X	X
New Zealand	-0.025359	0.0000	X	x	X	X
Poland	-0.050990	0.0000	-0.054743	0.0000	X	X
Portugal	-0.043419	0.0000	-0.046342	0.0000	X	X
Romania	-0.010553	0.0000	-0.014963	0.0000	X	X
Slovak Republic	-0.037202	0.0001	-0.045697	0.0001	X	X
Slovenia	-0.022948	0.0000	-0.024230	0.0000	X	X
South Africa	-0.029104	0.0000	X	x	X	X
Spain	-0.085797	0.0000	-0.088621	0.0000	X	X
Sweden	-0.039880	0.0000	-0.041776	0.0000	X	X
United Kingdom	-0.036414	0.0000	X	x	-0.034586	0.0000
United States	-0.370453	0.0000	X	x	-0.426295	0.0000

Table 16

	CURRENT FS	SÖGNER(2002)	ZAGLER(2003)	PERMAN(2007)	PERMAN(2007)	LANG(2009)	LANG(2009)	BALL(2013)	ZANIN MAL(2014)	ZANIN FEM(2014)	BALL GAP(2019)	BALL FD(2019)
Country		VARIABLE	UNEMPLOYMENT									
Australia	-0.022485							-0.536	-0.57	-0.31	-0.57	-0.508
Austria	-0.0041	-0.15		-0.1	-0.07			-0.136	-0.24	-0.07	-0.166	-0.136
Belgium	-0.022491	-0.57		-0.277	-0.137			-0.511	-0.36	-0.22	-0.516	-0.337
Bulgaria	-0.064815										-0.291	-0.248
Canada	-0.039781	-0.6						-0.432	-0.46	-0.23	-0.44	-0.418
Croatia	-0.022031										-0.333	-0.166
Czech Republic	-0.019106								-0.24	-0.24	-0.244	-0.243
Denmark	-0.018312	-0.47		-0.655	-0.207			-0.434	-0.38	-0.23	-0.448	-0.343
Estonia	-0.082538								-0.5	-0.28		
Finland	-0.034113	-0.61		-0.659	-0.212	-6.0384		-0.504	-0.26	-0.09	-0.482	-0.345
France	-0.026097	-0.43	-0.068	-0.346	-0.173		-0.3403	-0.367	-0.39	-0.29	-0.315	-0.237
Germany	-0.004349	-0.38	-0.034	-0.16	-0.085	-11.0103	0.2275	-0.367	-0.27	-0.13	-0.37	-0.23
Greece	-0.050163			-0.07	-0.024				-0.45	-0.48	-0.508	-0.361
Hungary	-0.035796								-0.21	-0.09	-0.338	-0.322
Ireland	-0.087084			-0.161	-0.378			-0.406	-0.47	-0.24	-0.406	-0.341
Italy	-0.02293	-0.21	-0.046	-0.575	-0.112			-0.254	-0.3	-0.34	-0.334	-0.183
Japan	-0.008509	-0.12						-0.152	-0.13	-0.13	-0.171	-0.07
Korea, Rep.	-0.045107								-0.16	-0.13	-0.317	-0.159
Luxembourg	0.018498			-0.045	-0.036				-0.04	-0.08		
Netherlands	-0.013126	-0.82		-0.552	-0.113			-0.511	-0.25	-0.21	-0.449	-0.312
New Zealand	-0.025359							-0.341	-0.34	-0.26	-0.473	-0.314
Poland	-0.05099								-0.94	-0.84	-0.667	-0.527
Portugal	-0.043419			-0.335	-0.102			-0.268	-0.49	-0.31	-0.427	-0.33
Romania	-0.010553										-0.049	-0.058
Slovak Republic	-0.037202								-0.48	-0.37	-0.51	-0.349
South Africa	-0.029104										-0.33	-0.249
Spain	-0.085797			-0.708	-0.293			-0.852	-0.99	-0.99	-0.934	-0.809
Sweden	-0.03988	-0.35		-0.416	-0.142	-3.4886		-0.524	-0.26	-0.12	-0.493	-0.364
United Kingdom	-0.036414	-0.58	-0.043	-0.639	-0.238			-0.343	-0.31	-0.17	-0.417	-0.367
United States	-0.370453	-0.52				-0.1375		-0.454	-0.61	-0.39	-0.518	-0.426

Table 17

	DEPENDENT	VARIABLE	UNEMPLOYMENT								
	CURRENT FS	OKUN(1963)	SÖGNER(2002)	CUARESMA(2003)	SILVAPULLE(2004)	LIN(2008)	LANG(2009)	BALL(2013)	ZANIN(2014)	BALL(2019)	GOTTO(2020)
USA	PMGE	FD	FD	HPF	GAP	SMOOTH GAP	FD	HPF 1	FD M	GAP	FD
	-0.370453	-0.3	-0.52	-0.166	-0.35	-0.2198	-0.1375	-0.411	-0.61	-0.518	-0.45
		GAP		BIV	MOLS			HPF 2	FD W	FD	HPF
		-0.36		-0.237	-0.25			-0.383	-0.39	-0.426	-0.6
				TRES HPF U-G				FD			QTF
				-0.389				-0.405			-0.611
				TRES BIV U-G				-0.405			
				-0.143				-0.405			

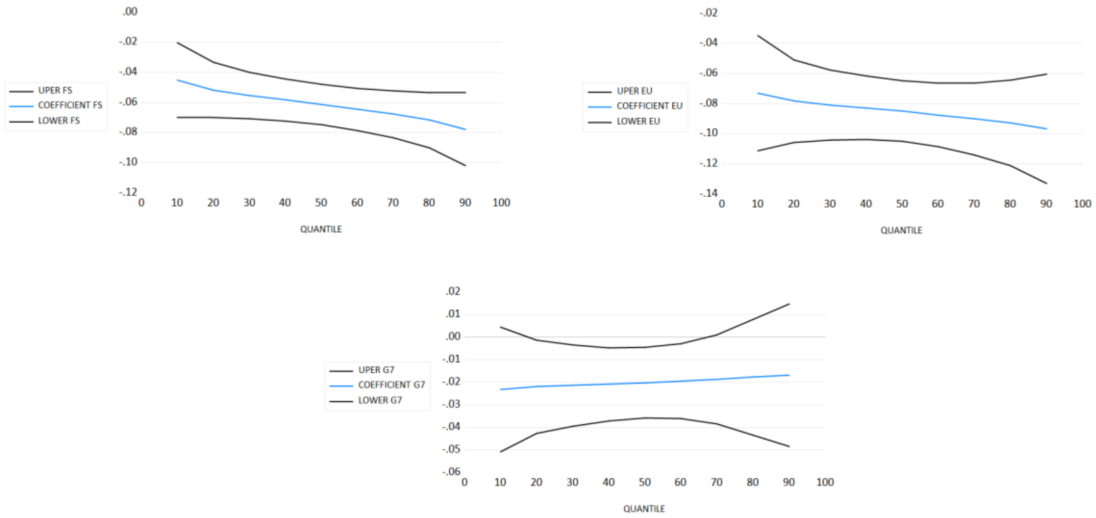
Tables 16 and 17 present the comparison between the coefficients from Pooled Mean Group estimation and the recent bibliography. The second table contains information, only for the USA. Our results for USA are very similar to the bibliography.

5.4 PANEL QUANTILE REGRESSION

Table 18

Panel Quantile Regression for Dif_Unrate_Series - Did_GDP_Series						
	Full Sample		European Union		G7	
Quantile	Short RunCoef.	P-value	Short RunCoef.	P-value	Short RunCoef.	P-value
10	-0.04517946	0	-0.07302651	0	-0.02323493	0.099
20	-0.0517432	0	-0.07830246	0	-0.02207467	0.036
30	-0.05543626	0	-0.08087055	0	-0.02153602	0.02
40	-0.05830797	0	-0.08290303	0	-0.02093783	0.011
50	-0.06129573	0	-0.08497772	0	-0.02031194	0.011
60	-0.06468241	0	-0.08763453	0	-0.01970236	0.02
70	-0.06788121	0	-0.09010936	0	-0.01888903	0.061
80	-0.07180987	0	-0.09283544	0	-0.01786332	0.172
90	-0.0779066	0	-0.09662885	0	-0.01698624	0.291

The above table summarizes the results for the quantile regression between the first differences of the two variables which were examined. As we can see the coefficient is negative and increases as the quantile increases for the first two samples. All the coefficients in the two first samples were significant, with the EU countries having higher coefficients. The G7 sample has most of its coefficients significant for the 5% or the 10%, but the last two were not significant. Lastly, the G7 sample has the lower coefficients, but there were also negative. To conclude, for each quantile it seems that the Okun's Law is valid.



Block of figures 5

The above graphs conclude the results from our quantile regression analysis. With the black lines we have the upper and the lower bound for the 95% confidence interval. With the blue line is the coefficient of every quantile. As we can see all the coefficients seems to be significant for all the samples.

5.5 POOLED OLS TIME FIXED EFFECTS

Table 19

Pooled OLS Time Fixed Effects Model for Dif-GDP			
	Full Sample	European Union	G7
Constant Term	0.04688	0.046048	0.021105
P-Value	0	0	0.007
Dummy_plus * Dif_Unrate	-0.022623	-0.015031	-0.01578
P-Value	0	0	0.2451
Dummy_minus*Dif_Unrate	-0.008787	-0.008296	-0.021529
P-Value	0.0075	0.0019	0.1327

In this table we can observe the results from the asymmetric model that we used. Our main results are, that there is asymmetry in Okun's Law. The coefficient of positive differences in unemployment lead to higher results than the negative ones. This is valid for the cases of the full sample and the EU countries. In the case of the G7 the opposite is true, the negative shock has a bigger impact, but both coefficients are not significant, due to *p-value* being bigger than 5%.

6.CONCLUSION

The purpose of this thesis was to examine the Okun's law in the long and short term period for 35 countries in a panel data environment. In order to exploit this relationship between output and unemployment, annual data was used for the period which spans from 1995 to 2019. The dataset consisted of 3 samples, the Full sample, the EU countries (excluding the UK) and the G7 countries.

As a starting point the variables were tested for panel unit roots. The results suggested that, the output variable is non-stationary in the levels and it becomes stationary in the first differences. For the unemployment rates, the variable seems to be stationary in the levels for the first two samples, but is not stationary in the G7 sample. Finally the unemployment rates variable becomes stationary in all samples when the first differences were used. The above results support that the two variables could be I(1), thus they could be cointegrated.

Three cointegration approaches were used and the main findings revealed that, the Pedroni's test does not support a cointegration relationship between the two variables, on the other hand the Kao's test and the Johansen-Fisher test reveals evidence of cointegration relationship between output and unemployment both ways, so there is a long run relationship between the two variables.

The next step in the analysis was the Pooled Mean Group Estimation proposed by Pesaran (1999). This methodology main advantage is that, it establishes a long and short term relationship between the variables without the need for them to be stationary. The results revealed that, for the unemployment rates-output relationship, in the Full sample the long term and the average short term coefficients were negative and significant. In the EU sample the long term coefficient was not significant and the average short term coefficient was negative and significant. Finally in the G7 sample the long term and the average short term coefficients were negative and significant. The long term coefficient is larger in the G7 countries than the full sample. The average short term coefficient spans from -0.039619 to -0.077017. The error correction term is negative, as it should be, and it differs across samples. The data supported the Okun's law for all countries and samples, except the case of Luxemburg. In most cases the cross-country short term coefficients were statistical significant for all samples. Next, the quantile regression approach was used, to examine the validity of the law across the different quantiles. For the first estimation the coefficients in the Full sample and the EU sample were negative and significant. It was observed that, the negative coefficient increases as the quantiles increase. The G7 sample had most of its coefficients significant for the 5% or the 10%, but the last two were not statistically significant. Lastly, the G7 sample had the lower coefficients, but there were also negative. To conclude, for each quantile it seems that the Okun's Law is valid.

Finally, as many researchers address there might be an asymmetric relationship between output and unemployment. The pooled OLS fixed effects model with two dummies for the differences in unemployment rates supported this idea. The main findings suggested that, positive differences in unemployment lead to higher results than the negative ones. This is valid for the cases of the Full sample and the EU countries. In the case of the G7 the opposite is true, the negative shock seems to has a larger impact, but the coefficients are not significant. For that reason, Okun's law may be an asymmetric relationship.

To sum up , in this thesis the validity of the Okun's law was examined under different panel samples and methodologies. The rule of thumb that, a 1% increase in unemployment rate leads to 3% decrease in output seems to have changed over the years. This thesis uses new panel data techniques, such as the quantile regression for panel data, in order to investigate the relationship between output and unemployment. Our main findings revealed that, there is a long and short term relationship between the two variables. Thus, Okun's law is valid for the long and short term period. The asymmetric model that was used, supported that Okun's law might be not a linear relationship. All in all, the standard rule seems to be valid and can continue to be used by policy makers. However it differs between countries and might not be linear, so more research is needed in order to understand the nature of this relationship across countries.

REFERENCES

Apergis, N. and Rezitis, A., 2003. An examination of Okun's law: evidence from regional areas in Greece. *Applied Economics*, *35*(10), pp.1147-1151.

Attfield, C.L. and Silverstone, B., 1998. Okun's law, cointegration and gap variables. *Journal of Macroeconomics*, *3*(20), pp.625-637.

Ball, L.M., Leigh, D. and Loungani, P., 2013. *Okun's Law: fit at fifty?* (No. w18668). National Bureau of Economic Research.

Ball, L., Furceri, D., Leigh, D. and Loungani, P., 2019. Does one law fit all? Cross-country evidence on Okun's Law. *Open Economies Review*, *30*(5), pp.841-874.

Breitung, J., 2001. The local power of some unit root tests for panel data. Emerald Group Publishing Limited.

Cazes, S., Verick, S. and Al Hussami, F., 2013. Why did unemployment respond so differently to the global financial crisis across countries? Insights from Okun's Law. *IZA Journal of Labor Policy*, *2*(1), pp.1-18.

Choi, I., 2001. Unit root tests for panel data. *Journal of international money and Finance*, *20*(2), pp.249-272.

Cuaresma, J.C., 2003. Okun's law revisited. *Oxford Bulletin of Economics and Statistics*, *65*(4), pp.439-451.

Engle, R.F. and Granger, C.W., 1987. Co-integration and error correction: representation, estimation, and testing. *Econometrica: journal of the Econometric Society*, pp.251-276.

Fisher, R.A., 1992. Statistical methods for research workers. In *Breakthroughs in statistics* (pp. 66-70). Springer, New York, NY.

Fouquau, J., 2008. Threshold effects in Okun's law: a panel data analysis.

Freeman, D.G., 2000. Regional tests of Okun's law. *International Advances in Economic Research*, *6*(3), pp.557-570.

Freeman, D.G., 2001. Panel tests of Okun's law for ten industrial countries. *Economic Inquiry*, *39*(4), pp.511-523.

Gelfer, S., 2020. Re-evaluating Okun's Law: Why all recessions and recoveries are "different". *Economics Letters*, *196*, p.109497.

Goto, E. and Bürgi, C., 2020. Sectoral Okun's Law and Cross-Country Cyclical Differences.

Harris, R. and Silverstone, B., 2001. Testing for asymmetry in Okun’s law: A cross-country comparison. *Economics bulletin*, *5*(2), pp.1-13.

Holmes, M.J. and Silverstone, B., 2006. Okun's law, asymmetries and jobless recoveries in the United States: A Markov-switching approach. *Economics Letters*, *92*(2), pp.293-299.

Huang, H.C. and Yeh, C.C., 2013. Okun's law in panels of countries and states. *Applied Economics*, *45*(2), pp.191-199.

Hutengs, O. and Stadtmann, G., 2013. Age effects in Okun's law within the Eurozone. *Applied Economics Letters*, *20*(9), pp.821-825.

Im, K.S., Pesaran, M.H. and Shin, Y., 2003. Testing for unit roots in heterogeneous panels. *Journal of econometrics*, *115*(1), pp.53-74.

Izyumov, A. and Vahaly, J., 2002. The unemployment–output tradeoff in transition economies: does Okun's law apply?. *Economics of Planning*, *35*(4), pp.317-331.

Johansen, S., 1991. Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica: journal of the Econometric Society*, pp.1551-1580.

Kangasharju, A., Tavera, C. and Nijkamp, P., 2012. Regional growth and unemployment: the validity of Okun's Law for the Finnish regions. *Spatial Economic Analysis*, *7*(3), pp.381-395.

Kao, C., 1999. Spurious regression and residual-based tests for cointegration in panel data. *Journal of econometrics*, *90*(1), pp.1-44.

Karfakis, C., Katrakilidis, C. and Tsanana, E., 2014. Does output predict unemployment? A look at Okun's law in Greece. *International Labour Review*, *153*(3), pp.421-433.

Lang, D. and De Peretti, C., 2009. A strong hysteretic model of Okun’s Law: theory and a preliminary investigation. *International Review of Applied Economics*, *23*(4), pp.445-462.

Lee, J., 2000. The robustness of Okun's law: Evidence from OECD countries. *Journal of macroeconomics*, *22*(2), pp.331-356.

Levin, A., Lin, C.F. and Chu, C.S.J., 2002. Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of econometrics*, *108*(1), pp.1-24.

Lin, S.C., 2008. Smooth-time-varying Okun's coefficients. *Economic Modelling*, *25*(2), pp.363-375.

Machado, J.A. and Santos Silva, J., 2019. XTQREG: Stata module to compute quantile regression with fixed effects.

Maddala, G.S. and Wu, S., 1999. A comparative study of unit root tests with panel data and a new simple test. *Oxford Bulletin of Economics and statistics*, *61*(S1), pp.631-652.

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

Okun, A.M., 1963. *Potential GNP: its measurement and significance* (pp. 98-103). New Haven: Yale University, Cowles Foundation for Research in Economics.

Palombi, S., Perman, R. and Tavéra, C., 2015. Regional growth and unemployment in the medium run: asymmetric cointegrated Okun's Law for UK regions. *Applied Economics*, *47*(57), pp.6228-6238.

Pedroni, P., 1999. Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and statistics*, *61*(S1), pp.653-670.

Pedroni, P., 2004. Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econometric theory*, pp.597-625.

Perman, R. and Tavera, C., 2007. Testing for convergence of the Okun's law coefficient in Europe. *Empirica*, *34*(1), pp.45-61.

Pesaran, M.H., Shin, Y. and Smith, R.P., 1999. Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American statistical Association*, *94*(446), pp.621-634.

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

Rahman, M. and Mustafa, M., 2017. Okun's law: evidence of 13 selected developed countries. *Journal of Economics and Finance*, *41*(2), pp.297-310.

Silva, J.S., 2019, September. Quantile regression: Basics and recent advances. In *London Stata Conference 2019* (No. 27). Stata Users Group.

Silvapulle, P., Moosa, I.A. and Silvapulle, M.J., 2004. Asymmetry in Okun's law. *Canadian Journal of Economics/Revue canadienned'économique*, *37*(2), pp.353-374.

Sögner, L. and Stiassny, A., 2002. An analysis on the structural stability of Okun's law--a cross-country study. *Applied Economics*, *34*(14), pp.1775-1787.

Villaverde, J. and Maza, A., 2009. The robustness of Okun's law in Spain, 1980–2004: Regional evidence. *Journal of Policy Modeling*, *31*(2), pp.289-297.

Zagler, M., 2003. A Vector Correction Model of Economic Growth and Unemployment in Major European Countries and an Analysis of Okun's Law. *Applied Econometrics and International Development*, *3*(3).

Zanin, L., 2014. On Okun’s law in OECD countries: An analysis by age cohorts. *Economics Letters*, *125*(2), pp.243-248.