ORIGINAL PAPER

FRACTIONAL REGRESSION MODEL FOR INVESTIGATING THE DETERMINANTS OF THE UNEMPLOYMENT RATES IN OECD COUNTRIES

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Abstract. *Unemployment is a serious problem for all over the world. It is a crucial task to endeavor with the unemployment for the welfare of the world. Once, the potential factors should be known to accomplish this task. The aim of this study is to investigate the determinants of the unemployment rates using fractional regression models for the 35 OECD (Organization for Economic Co-operation and Development) countries over the periods 2000-2017. We determined the factor affecting the unemployment rate by the fractional regression model using GMMbgw and GMMpre estimators for panel data. The empirical results revealed the significant determinants of unemployment as the result of the fractional regression models. Finally, we observe that saving rates, the growth rate of import and export are expressive on the unemployment rates.*

Keywords: *fractional regression model; OECD; panel data; unemployment; unemployment rate.*

1. INTRODUCTION

Regardless of their level of development, unemployment is the biggest problem of all countries. It is accepted that the social aspects of the unemployment is as important as its financial aspects. Unemployment rate is one of the most critical financial indicators. This rate is calculated by dividing the number of the unemployed with the labor force. Increase in unemployment rates indicates deteriorating economic condition while a drop shows ameliorating economic conditions. There are many factors influencing unemployment rates.

Many researchers have used many different methods to look into the macroeconomic factors having an impact on the unemployment rates. Soylu [1] examined the relationship between economic growth and unemployment in Eastern European countries in the period of 1992-2014 within the scope of panel data. Güriş and Yaman [2] analyzed the factors affecting unemployment in the OECD countries with panel data models.

In the analysis, many models have been created and it is found that the most appropriate model is the model that included the economic crisis dummy variable. According to the results of the model, it was determined that the most effective variable that reducing unemployment was investment rate. In addition, economic growth, inflation, budget deficit and current account balance have also had a decreasing effect on unemployment. Ukpere and

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Slabbert [3] show in their Meta analytic study that there is a positive relation between globalization, unemployment, inequality and poverty. Dursun et al. [4] examined the relationship between various types of crime and economic variables, unemployment and gross national product per capita by the panel data approach. Conducting a research on the factors leading to unemployment in Australian economy, Karanassou and Sala [5] reached the conclusion that there are different factors causing unemployment: In 1970s, petrol shocks resulted in unemployment while an increase in exchange rates was an important cause of unemployment between 1990 and 2000. In addition, they also suggested that shrinking foreign demand due to a global financial crisis in 2008 led to an increase in unemployment rates. In their study where they looked into the US economy, Huang and Lin [6] conducted their research using smooth time varying parameter to see the relation between unemployment rates and economic growth. The results of their study show that the Okun coefficient for USA is negative while the Okun Law is valid. Kanca [7] revealed an empirical analysis of the relation between unemployment and economic growth in Turkey for the period between 1970 and 2010. This study concluded that even though the economic growth is one of the factors influencing the unemployment in Turkey, unemployment rate has no impact on economic growth. Stănilă et al. [8] used the panel data approach considering 27 countries in the European Union. By analyzing the changes resulting from the crisis, they investigated the development of some important macroeconomic indicators for the EU. Uzlau et al. [9] analyzed models of the dynamics of total tax collection and social contribution per capita relative to gross domestic product per capita for seven states in Eastern Europe from 2009 to 2018 using linear regression equations. Chakraborty et al. [10] proposed a hybrid approach based on linear and non-linear models to estimate unemployment rates more accurately. Georgiou [11] determined the effect of Covid-19 on unemployment rates with panel data analysis.

The remainder of the study is organized as follows. In section 2, we introduce the fractional regression models for data analysis. In section 3 explains the application of the fractional regression model with unemployment data for OECD countries. Finally, a brief discussion is given in Section 4.

2. MATERIALS AND METHODS

2.1. FRACTIONAL REGRESSION MODELS

The Fractional Regression model (FRM) developed by Papke and Wooldridge [12] overcomes many of the constraints on linear and nonlinear econometric models for bounded dependent variables. The standard FRM model does not require special transformations of data and allows a direct estimate of the conditional expected value of the dependent variable. The parameters estimation of the standard FRM model is based on the semi-maximum likelihood method (QMLE), which produces fully robust and relatively efficient estimates under general linear model conditions.

Let y_{it}, defined fractional response variable in the range [0,1] for the i-th individual and i=1,…,N, at time t, t=1,…T, and x_{it} denote a k-vector of explanatory variables. The conditional expected value for the standard fractional regression model defined by Papke and Wooldridge [12] is as follows:

$$E(y_i|x_i) = G(x_i\theta) \quad (1)$$

Here, θ is a vector of the parameters of interest, G (.) is a nonlinear function limited in the range of $0 \leq G(.) \leq 1$.

The parameters of the model indicated by equation (1) can be estimated by QML method. Generally, logit or probit functional form is defined for G (.).

Alternative features like loglog, cloglog and cauchit models were defined by Ramalho et al. [13].

Exponential fractional regression model given by Ramalho et al. [11] showed at equation 2,

$$y_{it} = G_1[\exp(x_{it}\theta + \alpha_i + v_{it})] \tag{2}$$

Here, $G_1(c)$ is a $G_1(c) = \frac{c}{1+c}$ logit or $G_1(c) = 1 - \exp(-c)$ cloglog model. α_i denotes unobserved heterogeneity that does not change over time and v_{it} shows unobserved heterogeneity that changes over time.

As $H(.) = G_1(.)^{-1}$, equation (3) is obtained from the equation (2),

$$H_1(y_{it}) = \exp(x_{it}\theta + \alpha_i + v_{it}) \tag{3}$$

Here, $H_1(y_{it})$ is a $H_1(y_{it}) = \frac{y_{it}}{1+y_{it}}$ logit or $H_1(y_{it}) = -\ln(1 - y_{it})$ cloglog model.

In this study, we used GMMbgw and GMMpre estimators proposed by Ramolho et al. [14]. Ramalho et al. [13] discussed the fractional panel models, and in their view, the proposed approach provides a more efficient way than Papke and Wooldridge [12] .That's why we preferred the approach of Ramalho et al. [13], and their estimation technique is directly relevant for panel data analysis.

For detailed information on the estimators, researchers can read the relevant work on Ramalho et al. [14]. GMMbgw and GMMpre estimators are given respectively as follows:

$$H_1(y_{it}) - \frac{\overline{H_1(y_i)}}{\exp(x_i\theta)}\exp(x_{it}\theta) = \exp(x_{it}\theta + \alpha_i)\left[\exp(v_{it}) - \frac{\overline{\exp(x_i\theta + v_i)}}{\exp(x_i\theta)}\right] \equiv {v_{it}}^{bgw} \tag{4}$$

$$\frac{H_1(y_{it})}{\exp(x_{it}\theta)} - 1 = \exp(\alpha_i + v_{it}) - 1 \equiv {v_{it}}^{pre} \tag{5}$$

3. RESULTS AND DISCUSSION

3.1. APPLICATION PART

In this study, panel data was used that belongs to period of 2000-2017 for 35 OECD countries (Organization for Economic Cooperation and Development) and all the data was compiled from [15]. The properties of the variables are given in Table 1. We used the same variables for each year. The analyzes were performed using R software's 3.5.2 version. In addition, there were missing observations in the data set and these missing observations were estimated using the interpolation function from the "imputeTS" package in the R software. After the missing observations were estimated, the factors that affect unemployment for OECD countries were determined by the FRM model method using " frmpd " package from the R software.

Table 1. **Description of the variables.**

Variable	Description
y (response variable)	Unemployment rate (% of GDP)
x_1	Gross domestic product (GDP-per capita)
x_2	Tax revenue rate (% of GDP)
x_3	Industrial production (2005=100)
x_4	Long term interest rate
x_5	Saving rate (% of GDP)
x_6	Inflation
x_7	Industrial value-added rate (% of total value added)
x_8	Annual growth rate % of import
x_9	Annual growth rate % of export
x_{10}	Exchange rate (national currency units/US dolar)
x_{11}	Current account balance (% of GDP)

Table 1 shows the description of the response variable and explanatory variables. The explanatory variables were chosen among several macroeconomic indicators that may have potential influence on the unemployment rates [16-18].

Table 2. **Normality test results**

Test type	Test statistic
Shapiro test	0.833***
Lilliefors test	0.125***
Pearson test	227.057***
Anderson Darling test	24.350***

** Significant at the 0.05 probability level*
*** Significant at the 0.01 probability level*
**** Significant at the 0.001 probability level*

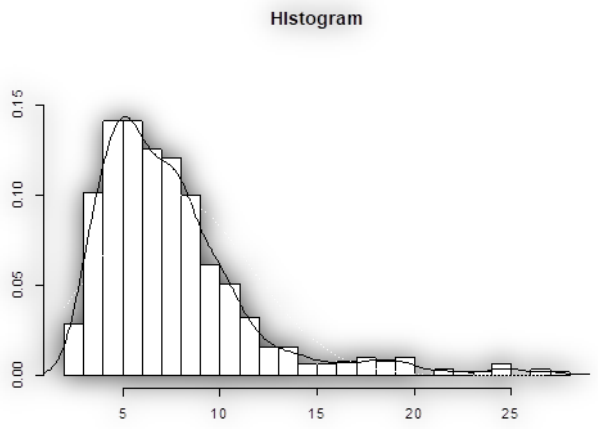

Figure 1. The histogram of the unemployment rate.

Table 2 shows the normality test results. All type of test display that the response is not normally distributed. The Fig. 1 also points out to the non-normality of the response variable. Due to the range of unemployment rate (0,1) and non-normality, it is more appropriate to use another method. Therefore, fractional regression with panel data model was employed due to the nature of unemployment rate.

Using the explanatory variables, panel regression equation is written as follows:

$$log\left(\frac{y_{it}}{1-y_{it}}\right) = \beta_0 + \beta_1 X_{1_{it}} + \beta_2 X_{2_{it}} + \beta_3 X_{3_{it}} + \beta_4 X_{4_{it}} + \beta_5 X_{5_{it}} + \beta_6 X_{6_{it}} + \beta_7 X_{7_{it}} + \beta_8 X_{8_{it}} + \beta_9 X_{9_{it}} + \beta_{10} X_{10_{it}} + \beta_{11} X_{11_{it}}$$

$$i = 1,2,\dots,35 \;\; t = 2010,2011,\dots,2017$$

We estimated the panel regression coefficients ($\beta_1, \beta_2, \ldots, \beta_{11}$) considering GMMpre and GMMbgw models.

Table 3. The panel model results

Regressor		GMMpre Model				GMMbgw Model		
		Coefficient	SE	t-value		Coefficient	SE	t-value
Intercept		-1.447	0.402	**-3.597*****		-	-	-
x_1		-0.002	4.61E-04	**-3.558*****		5.30E-05	2.96E-04	0.179
x_2		0.002	0.010	0.238		-0.004	0.008	-0.424
x_3		-0.002	0.003	-0.713		-0.013	0.002	**-5.271*****
x_4		0.002	0.014	0.123		0.010	0.006	1.739*
x_5		-0.027	0.008	**-3.566*****		-0.024	0.009	**-2.649*****
x_6		-0.019	0.007	**-2.731*****		-0.021	0.004	**-4.896*****
x_7		-0.014	0.010	-1.404		-0.003	0.007	-0.443
x_8		0.003	0.002	**1.739***		0.009	0.004	2.528**
x_9		-4.00E-05	1.50E-05	**-2.737*****		-1.70E-05	1.00E-06	**-11.649*****
x_{10}		0.006	0.049	0.129		-0.012	0.013	-0.916
x_{11}		0.013	0.011	1.219		0.032	0.005	**6.925*****

***** *Significant at the 0.05 probability level*
*** Significant at the 0.01 probability level*
****Significant at the 0.001 probability level*

Table 3 shows the panel model results for both two models. According to the GMMpre model; GDP, saving rate, inflation, growth rate of import and export have significant effect on unemployment rates. When examining the GMMbgw model, we can see that industrial production, saving rate, inflation, growth rate of import-export, and current account balance significantly influences the unemployment rates. Eventually, there are four main significant determinants of unemployment rates which two fractional panel model's compromise: saving rate, inflation, growth rate of import and export. Also, the sign of the model coefficients is the same for two models so the effects of these factors share the same way. When interpreting the results, we observe that the saving rate, inflation and growth of export have an opposite effect on the unemployment rates whereas the growth of the import has the same directional effect.

4. CONCLUSIONS

Unemployment is one of the macroeconomic problems of developed and developing countries. One of the most important indicators of a country's economic growth and development levels is unemployment. The phenomenon of unemployment is important for countries as a problem with both economic and social dimensions. For this reason, countries apply policies to combat unemployment according to the cyclical structure and structural characteristics. However, it is important for all the countries to determine the factors causing unemployment as well as the implementation of policies aimed at eliminating the unemployment problem.

Although there are several potential indicators, only some of them can significantly influence the unemployment rates. To investigate the significant determinants, we attempted to construct fractional panel data regression models. We limited this study within OECD countries. Thus, al the inferences cover the OECD countries. Factors affecting unemployment for OECD countries were determined by the GMMpre and GMMbgw from FRM methods.

According to the GMMpre model; GDP, saving rate, inflation, growth rate of import and export have significant effect on unemployment rates. When examining the GMMbgw

model, we can see that industrial production, saving rate, inflation, growth rate of import-export, and current account balance significantly influences the unemployment rates. Eventually, there are four main significant determinants of unemployment rates which two fractional panel model's compromise: saving rate, inflation, growth rate of import and export. Based on the fractional regression coefficients, we conclude that the increment of saving rate and growth rate of export positively assists to decrease the unemployment levels. Besides that, the growth rate of import has a negative influence on the unemployment. The inflation has a positive effect on unemployment and this fact is well-known in the literature.

However, after a certain level of the inflation, it causes the increment of unemployment rate. For this reason, the governments should control the inflation in an optimal level. In fact, our findings are compatible with previous results in the literature. Consequently, we suggest to the OECD countries to overcome the troubles such as the income distribution inequality and the external dependence for struggling with unemployment problem.

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