Multivariate Adaptive Regression Splines (Mars) Method For Unemployment in OECD Countries

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Abstract: Unemployment is one of the most important macroeconomic problems in all countries and it is very important task for identification of the key determinants of it. Therefore, in recent years determining the factors affecting the unemployment is attracting the researcher. In this study, the factors affecting unemployment in Organization for Economic Co-operation and Development (OECD) countries were tried to be determined. In this context, data for the years 2000-2017 were analyzed by using MARS method. For each year, we estimated the Multivariate Adaptive Regression Splines (MARS) models and we tracked the effective predictors. According to our findings, the indicators Gross domestic product (Gdp), tax revenue rate, long term interest rate, saving rate and inflation usually have a significant impact on the unemployment rates. The annual growth rate of import, export and exchange rate do not influence the unemployment ratios. Besides these results, the industrial production, the industrial value added and current account balance are influential for a few years.

Çok Değişkenli Uyarlanabilir Regresyon Eğrileri Yöntemi ile OECD Ülkelerindeki İşsizlik

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Öz: İşsizlik tüm ülkelerde en önemli makroekonomik problemlerden biridir ve işsizliğin temel göstergelerinin belirlenmesi oldukça önemlidir. Bu nedenle son yıllarda işsizliği etkileyen faktörlerin belirlenmesi araştırmacıların ilgisini çekmiştir. Bu çalışmada OECD ülkelerindeki işsizlik oranlarını etkileyen faktörler belirlenmeye çalışıldı. Bu bağlamda 2000-2017 yıllarına ait veriler MARS metodu kullanılarak analiz edildi. Her bir yıl için MARS modelleri tahmin edildi ve etkili olan açıklayıcı değişkenler değerlendirildi. Sonuçlara göre Gayrı safi yurt içi hasıla (Gsyih), vergi gelir oranı, uzun vadeli faiz oranı, tasarruf oranı ve enflasyon göstergeleri genellikle işsizlik oranları üzerinde önemli bir etkiye sahiptir. Yıllık ithalat büyüme oranı, ihracat ve döviz kuru oranları işsizlik oranlarını etkilememektedir. Bu sonuçların yanı sıra, sanayi üretimi, sanayi katma değeri ve cari işlemler dengesi birkaç yıl için etkili bulunmuştur.

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1. Introduction

Unemployment is one of the most important macroeconomic problems in all countries. The reason why unemployment is such an important problem is that it is the source of both economic and social problems. Unemployment affects not only the unemployed individuals but also their families and social order in a vast scale. The imbalance in income distribution increases with unemployment and social serenity decreases. Unemployment may occur in many countries, from region to region, from sector to sector or from industry to industry. It comes to existence in the economic structures of countries with different characteristics according to different development levels. If the reason of unemployment is examined according to the level of development

of countries, it can be said that due to the lack of capital in underdeveloped countries, lack of qualified labor force, high population rate and low investment causes unemployment. In developed countries, it can be said that unemployment is caused by advanced technologies. When the studies about unemployment are examined, there are many studies that take into account the economic variables that determine the unemployment. Gatti and Voubourg [1] examined the relationship between labor and financial factors in order to reveal the financial determinants of unemployment by using the data of 1980-2004 for 18 OECD countries. They concluded that there was a strong relationship between labor market and financial factors by using the generalized moment method. Gyekye and Kyei [2] attempted to determine the determinants of unemployment for 2008 by using principal components and clustering analysis for Limpopo province in South Africa. Güriş and Yaman [3] analyzed the factors affecting unemployment in OECD countries with panel data models. They decided that the model in which the crisis puppet was included was the most fitted econometric model. According to the results of this model, it is observed that the variable with the most decreasing effect on unemployment in terms of OECD countries is the investment rate, while economic growth, inflation, budget deficit and current account balance have a decreasing effect on unemployment. Bayrak and Tatli [4] used panel data analysis to determine the factors affecting youth unemployment rate in OECD countries.

According to this study, while the economic growth rate, inflation and domestic gross savings adversely affect youth unemployment, it has been concluded that labor productivity positively affects youth employment. Bruno et al. [5] demonstrated the short and long-term effects of financial crises on youth unemployment in OECD countries by applying dynamic panel data analysis. Uzunkaya et al. [6] determined the factors affecting the economic growth rate in the USA using Multivariate Adaptive Regression Splines (MARS) models. It was concluded that there is a positive relationship between private investment, government spending and net exports. In recent years, there are many studies about the MARS model, which is commonly used in the fields of economics and finance. Some of these are [7, 8 and 9].

In this study, the MARS model, which has become popular in recent years, has been used in determining the factors affecting unemployment for 35 OECD countries. The remainder of the study is organized as follows. In section 2, we introduce MARS models for data analysis. The section 3 explains the application of the MARS model with unemployment data for OECD countries. Finally, a brief discussion is given in Section 4.

2. Material and Method

2.1. Multivariate Adaptive Regression Splines (MARS) Model

The MARS method uses smoothing splines to control the non-parametric error variance in determining the relationship between dependent and independent variables. In this case, the obtained equation will have a bent structure instead of a straight line. Bend points are called knots. When drawing more than two dimensional extensions, basic functions are required for each extension. The basic function selects the regions that will change the original data to zero [10]. Thus, this method first divides the data stack into regions and regions are based on the data. The MARS method creates a regression equation for each region [11]. MARS regression model is defined as,

$$f(x) = \sum_{i=1}^{k} c_i B_i(x_i) + \varepsilon$$

where B_i is a function from a set of basis function, c_i the coefficient vector and ε indicates the random error term.

The basis function features:
• Constant term can be taken as “1” to reduce bias
• The basic function for linear and nonlinear expansion is used in two ways:

$h(x) = \max(0, x - t)$ or $h(x) = \max(0, t - x)$ where t is a constant [12].

After determining both the basic functions and the knots, the functions with the highest estimation performance are determined by the least squares method [13]. Model selection is based on Generalized Cross Validation (GCV) measurement [14].

$$GCV = \sum_{i=1}^{n} \frac{(y_i - \hat{y})^2}{(1 - C(M)/n)^2}$$

where $\hat{y}$ indicates the predicted values and $C(M)$ shows a penalty measure which is related with the number of selected parameters.

3. Results

In this part, we implemented MARS models to uncover the possible determinants of the unemployment rates in OECD countries. Since MARS can be used as a modeling technique for time series without any stationary assumption, we preferred MARS for constructing the models. MARS can also select the relevant variables so it becomes possible to identify the main characteristic variables related with unemployment ratio.

Table 1. Description of the variable

Variable	Explanation
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 dollar)

Table 1 denotes the explanation of the variables used for the implementation part. We selected eleven different macroeconomic indicators as the independent variables which can have effect on the unemployment rates. We collected the data set for OECD countries from the website https://data.worldbank.org/.

Table 2. Selected variables by the MARS models for each year

Year	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}
2000	+	+	-	-	-	-	-	-	-	-	-
2001	+	+	-	-	-	-	-	-	-	-	-
2002	+	+	-	-	-	-	-	-	-	-	-
2003	+	+	-	-	-	-	-	-	-	-	-
2004	+	+	-	-	+	-	-	-	-	-	-
2005	+	+	-	-	-	+	-	-	-	-	-
2006	+	+	-	+	-	-	-	-	-	-	-
2007	+	-	-	+	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	-	-	+
2009	-	-	+	-	-	-	-	-	-	-	-
2010	+	-	+	-	-	+	+	-	-	-	-
2011	-	-	-	+	+	-	-	-	-	-	-
2012	-	-	-	+	+	-	-	-	-	-	-
2013	-	-	-	+	+	-	-	-	-	-	-
2014	-	-	-	-	+	+	-	-	-	-	-
2015	+	-	-	-	-	+	-	-	-	-	-
2016	-	-	-	-	+	+	-	-	-	-	-
2017	-	-	-	-	-	-	+	-	-	-	-

Table 2 shows the selected variables by MARS model which have direct effect on the unemployment rates in OECD countries. We report the chosen determinants for each year. The symbol "+" represents the related variable as selected and "-" represents as not selected. Mostly, we observe that Gdp, tax revenue rate, long term interest rate, saving rate and inflation have significant impact on the unemployment rates.

Until 2006, the indicators Gdp and tax revenue have affected the unemployment rates permanently. The industrial production and the industrial value added rate are only effective for two years. The current account balance is only selected for 2008. However, annual growth rate of import, export and exchange rate were not selected for all the years.

Table 3. The estimated MARS equations for all the years

Year	Equation of the MARS model
2000	$6.6954 + 0.0005 \times \max(0, 19515.8 - x_1) + 5.9557 \times \max(0, x_2 - 32.4280) - 0.3241 \times \max(0, 33.3580 - x_2) - 8.6515 \times \max(0, x_2 - 33.3580) + 3.0381 \times \max(0, x_2 - 36.2420)$
2001	$5.9445 + 0.0003 \times \max(0, 28981.3800 - x_1) - 0.4305 \times \max(0, 32.8380 - x_2)$
2002	$6.1436 + 0.0003 \times \max(0, 30482.1500 - x_1) - 0.4131 \times \max(0, 33.2270 - x_2)$
2003	$6.3862 + 0.0003 \times \max(0, 30787.4100 - x_1) - 0.3819 \times \max(0, 33.1180 - x_2)$
2004	$6.2727 + 0.0003 \times \max(0, 32249.9300 - x_1) - 0.4539 \times \max(0, 31.2080 - x_2)$
2005	$6.2408 + 0.0003 \times \max(0, 33331.1100 - x_1) - 0.4192 \times \max(0, 31.2120 - x_2) - 0.8407 \times \max(0, x_6 - 2.0120)$
2006	$7.3499 + 0.0004 \times \max(0, 25827.95 - x_1) - 6.794248e-05 \times \max(0, x_1 - 25827.95) - 0.3092 \times \max(0, 30.8310 - x_2) - 0.91422 \times \max(0, x_4 - 4.411)$
2007	$6.0099 + 0.0002 \times \max(0, 27822.6500 - x_1) - 1.0809 \times \max(0, x_4 - 4.4900)$
2008	$6.7045 - 0.1630 \times \max(0, x_{11} - (-4.9960))$
2009	$7.3405 + 0.2317 \times \max(0, 84.8790 - x_3)$
2010	$4.9416 + 0.0003 \times \max(0, 35007.7 - x_6) + 0.4065 \times \max(0, x_3 - 93.3670) + 0.3680 \times \max(0, 99.9950 - x_3) - 1.2946 \times \max(0, x_6 - 1.5250) - 0.3589 \times \max(0, x_7 - 18.4190)$
2011	$9.1197 + 0.9126 \times \max(0, x_4 - 4.9800) - 0.2771 \times \max(0, x_5 - 1.3830)$
2012	$8.7691 + 0.9024 \times \max(0, x_4 - 3.3790) - 0.2922625 \times \max(0, x_5 - 2.0240)$
2013	$9.1590 + 2.3136 \times \max(0, x_4 - 3.8280) - 0.3651 \times \max(0, x_5 - 2.5250)$
2014	$4.8413 + 0.5182 \times \max(0, 7.7500 - x_5) + 6.9380 \times \max(0, 0.6200 - x_6)$
2015	$7.3330 + 5.5423 \times \max(0, 0.2920 - x_6) - 0.5271 \times \max(0, x_{11} - 1.1620)$
2016	$4.3191 + 0.8834 \times \max(0, 4.3070 - x_5) - 0.0805 \times \max(0, x_5 - 4.307) + 3.3488 \times \max(0, 0.8910 - x_6) + 0.8974 \times \max(0, x_6 - 0.8910)$
2017	$7.8287 - 0.2959 \times \max(0, x_7 - 19.0585)$

Table 3 shows the MARS equations which are obtained yearly for OECD countries. Within the MARS equations, it is possible to perform prediction according to any selected year.

Also, the MARS equation enables the prediction with a few macroeconomic indicators. However, the use of these equations has a representative value in terms of prediction because we have all the values for each year.

4. Discussion and Conclusion

Unemployment is a crucial indicator for all over the world and it is very important task to identification of the key determinants of it. In accordance with this purpose, we used MARS models to discover the correlates of the unemployment ratios between 2000 and 2017 in OECD countries. For each year, we estimated the MARS models and we tracked the effective predictors. According to our findings, the indicators Gdp, tax revenue rate, long term interest rate, saving rate and inflation usually have a significant impact on the unemployment rates in OECD countries. The annual growth rate of import, export and exchange rate do not influence the unemployment ratios. Besides these results, the industrial production, the industrial value added and current account balance are influential for a few years. Thus, these variables cannot be considered as the main factors of the unemployment rates.

GDP should be increased to reduce unemployment rates. The increase in national income should have the qualities to contribute to employment. Countries should increase their production levels. Employment-friendly sectors, particularly tourism and textiles, mining, and sectors capable of creating employment should be supported. Sanzoa et al. (2017) have demonstrated the negative effects of taxes on economic growth if the tax burden exceeds 30% in 20 OECD countries. Negative effects on economic growth indirectly increase unemployment rates. Unemployment rates can be reduced by lowering tax income rates. In order to prevent unemployment, it is generally recommended to increase national income, lower tax income rates and improve economic growth performance.

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