Topics in Middle Eastern and African Economies

Proceedings of Middle East Economic Association

Vol. 25, Issue No. 1, May 2023

The Effect of Innovation on Employment in Turkiye

Asst. Prof. Hakki Kutay BOLKOL
Marmara University Department of Economics, Istanbul, Turkiye
kutay.bolkol@marmara.edu.tr
ORCID: 0000-0002-8979-4462

Assoc. Prof. Ece Handan Guleryuz
Marmara University Department of Economics, Istanbul, Turkiye
ece.guleryuz@marmara.edu.tr
ORCID: 0000-0003-0692-9112

Abstract

In this paper, we examine the impact of innovation on employment in the Turkish labor market between 1991 and 2021 by using monthly patent grants and annual R&D expenditure statistics. We employ ARDL (autoregressive distributed lag) approach to carry out the empirical analysis. Our results differ mainly depending on the analyzed time period and analyzing innovation with two different proxies that give the same result, which is an indication of the robustness of the results. When the long-run model and the short-run model are analyzed separately, it is found that while the effect of innovation on employment is negative in the short-run, it turns out to be positive in the long-run. Thus, during the period 1991-2021 in the Turkish labor market, while innovation might negatively affect employment levels to some extent in the short run, innovation could exert a more structural and sustainable positive impact on employment levels in the long run.

Jel classification: C59, O34, E24, O50

Key words: ARDL Approach, Innovation, Employment, Turkiye

1. Introduction

In this paper, we examine the impact of innovation on employment in the Turkish labor market between 1991 and 2021 by using monthly patent grants statistics. We employ ARDL (autoregressive distributed lag) approach to carry out the empirical analysis. Our results differ mainly depending on the analyzed time period. There are also mixed results in the related literature. Lachenmaier and Rottmann (2011), Piva and Vivarelli (2005) find a positive relationship between innovation and employment in Germany and Italy, respectively. Kancs and Siliverstovs (2020) argue that modest innovators do not create jobs by raising their R&D expenditures, whereas most of the jobs in the economy are created by innovation followers in the EU. Dosi and Mohnen (2019) discuss that there are studies which suggest that product innovation does not lead to job destruction but possibly to a polarization of jobs. Acar and Sever (2022) find out that in the Turkish economy exports of high-tech products, R&D expenditures, and changes in the number of firms may positively affect employment, whereas the number of domestic patent applications seems to affect it negatively.

2. Data

The data for employment was obtained from TURKSTAT (Turkish Statistical Institute). It is a seasonally adjusted monthly employment rate. Patent grants were used as a proxy for innovation. This data was taken from the Turkish Patent and Trademark Office. This data is also monthly data and only valid for the period between 2009 and 2016. In order to eliminate potential seasonal effects, STL (Seasonal and Trend decomposition using Loess) decomposition methodology was applied to patent grants data. Due to the data limitations on the patent grants side, the time period of this analysis is 2009M01-2016M12.

In order to do more up-to-date alternative analysis on the effects of innovation on employment in Turkiye, we tried to use R&D expenditure in place of patent grants. R&D expenditure data was obtained from TURKSTAT and this yearly data is valid for the period between 1990 and 2021. At this stage we also need to go back-to-date data for employment. For this purpose, employment data was obtained from the World Bank. This data is only valid for the period between 1991 and 2021. Consequently, the time period of the alternative analysis is the years between 1991 and 2021.

R&D expenditure data was in nominal terms at the source, so that by using GDP deflator data which is obtained from the World Bank, it was converted into real terms. Using R&D expenditure data in place of patent grants was the best alternative since the correlation between them is 0.9755 and when one period lag of R&D expenditure is used the correlation between them is almost the same, which is 0.9790.

3. Methodology

As for empirical technique, ARDL (autoregressive distributed lag) approach is used. The first reason for using this approach is that it is more effective in analyzing with a low number of observations. Secondly, with the ability to give different optimal lag lengths for different variables, this approach eliminates the potential endogeneity and autocorrelation problem. Akaike information criterion (AIC) was used in model selection since, according to Liew (2004) when the number of observations is relatively low (less than 120) Akaike information criterion gives the best results according to simulations. After defining the integration order of the variables[1], cointegration analysis is done by ARDL Bound test. Unlike other cointegration tests, ARDL Bound test can be applied both for the variables that are integrated of order one and an integrated order of zero or a mixture of them. However, it is not suitable for use in cases where the variables are second or higher order stationary. Lastly, ARDL approach gives long-run and short-run models separately, which can be seen as another advantage of this methodology. The adopted version of the methodology for our study is given in the results section.

[1] In order to determine the integration order of the variables, Augmented Dickey Fuller (ADF) and Phillips Perron (PP) unit root tests were used.

5. Results

Firstly, we use monthly patent grants statistics as a proxy for innovation so as to analyze the effects of innovation on employment. The time period of this analysis is 2009M01-2016M12.

Since both variables are integrated of order one (see Table 1), ARDL approach is applicable for the analysis. LEMP stands for Natural logarithm of the employment rate, and LPAT stands for Natural logarithm of the patent grants.

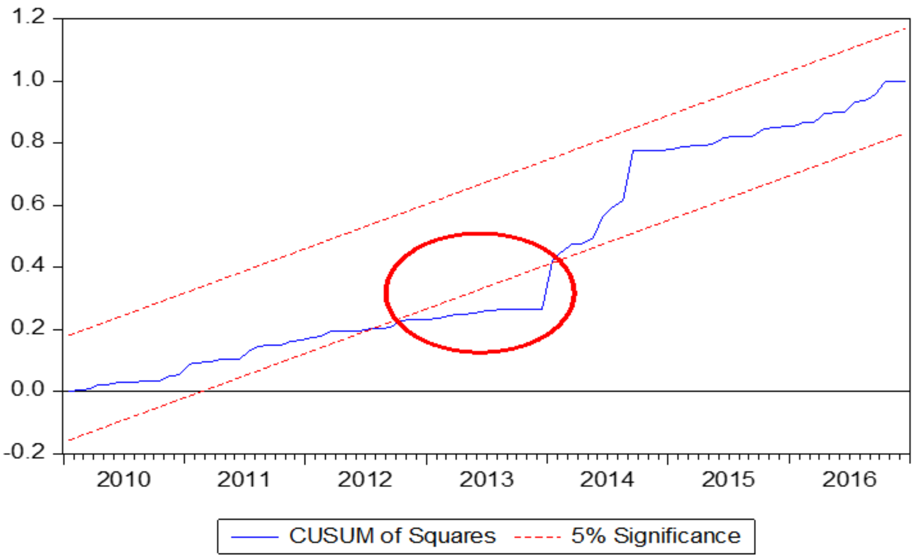
Table 1. Unit Root Tests

Variable Note: D( ) stands for First Difference	**ADF Test Probability Values**			**PP Test Probability Values**			**Decision**
	Intercept	Trend and Intercept	None	Intercept	Trend and Intercept	None	
LEMP	0.1462	0.0256**	0.9967	0.5209	0.3977	0.9968	I (1)
D(LEMP)	0.0001***	0.0002***	0.0001***	0.0000***	0.0000***	0.0000***	
LPAT	0.5876	0.0000***	0.9193	0.0000***	0.0000***	0.7503	I (1)
D(LPAT)	0.0000***	0.0000***	0.0000***	0.0001***	0.0001***	0.0000***	
In the ADF unit root test, the lag length is automatically selected according to the Akaike Information criterion. In the PP unit root test, the Newey-West bandwidth is automatically selected using the Barlett kernel method.							

*** Stationary at 1% significance level, ** Stationary at 5% significance level, * Stationary at 10% significance level.

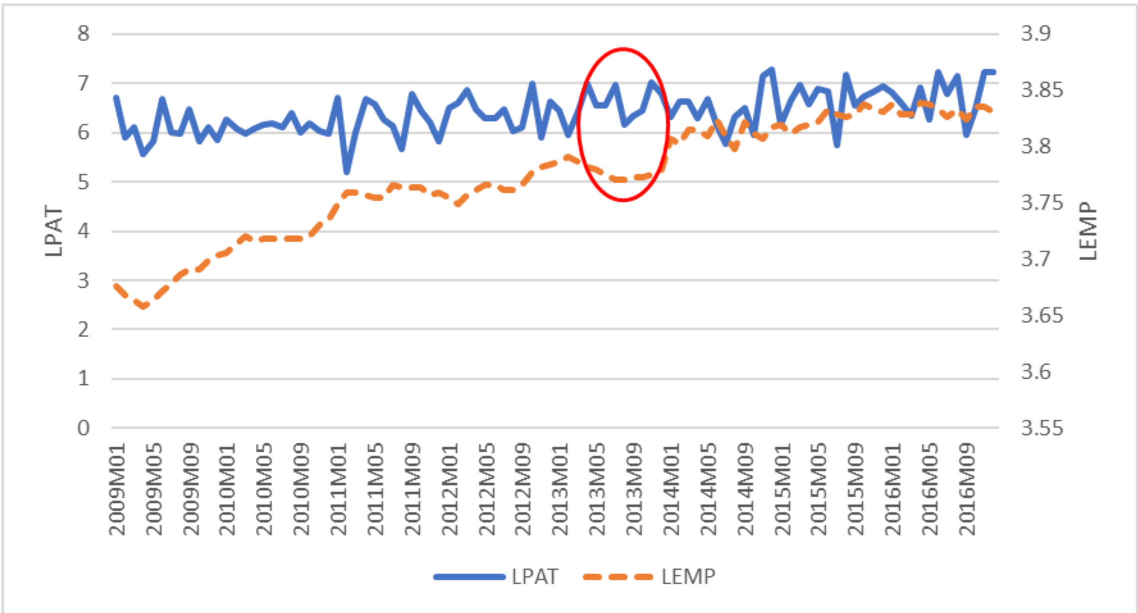
According to CUSUM (cumulative sum) of squares graph in which the stability of the model parameters is examined, the residuals of the model are not completely within the confidence interval, which is an indication of structural break in the analysis (see Figure 1).

Figure 1. CUSUM of Squares



Using a dummy variable for the year 2013 (2013M02 – 2013M11), the break was controlled. When we analyze the break period (shown in a circle in Figure 2), we capture that while there is a convergence (in general, it can be captured that the growth rate of LEMP is higher than the growth rate of LPAT) in the trend of these variables, in the break period, this convergence became reversed for a while. In other words, while the trend of LPAT is relatively stable, in the break period, there is a kind of V-shaped trend in LEMP.

Figure 2. Analyzing Break Period



According to the ARDL Bound test equation, which is adapted to our study, long-term relationship (cointegration relation) was determined in our model examining the effect of innovation on employment. The equation (ARDL (5,6)) is given below.

$$\Delta LEMP_t = \sum_{i=1}^{5} \beta_{1i}\Delta LEMP_{t-i} + \sum_{i=0}^{6} \beta_{2i}\Delta LPAT_{t-i} + \delta_1 LEMP_{t-1} + \delta_2 LPAT_{t-1} + \gamma_1 dummy + constant + u_t$$
(1)

Note: Δ: first difference

$H_0: \delta_1 = \delta_2 = 0; H_A: \delta_1 \neq \delta_2 \neq 0$

According to results, the null hypothesis is rejected and the alternative hypothesis is accepted. This result indicates the existence of a long-run relationship in the model. See Table 2, the F-stat is bigger than the upper bound, which indicates that the null hypothesis is rejected. That means that there is a cointegration relationship.

Table 2. ARDL Bound Test

Critical Values							
		Lower Bound			**Upper Bound**		
F-stat	k	%1	%5	%10	%1	%5	%10
6.098112	1	4.94	3.62	3.02	5.58	4.16	3.51

When the long-run model and the short-run model given below are analyzed separately, it is found that while the effect of innovation on employment is negative in the short-run, it turns out to be positive in the long-run.

The long-run ARDL model results are given in the table below, along with the diagnostic test results. The model has passed all the diagnostic tests. This shows that the model is unbiased and consistent. To summarize these results briefly, there is no serial correlation and heteroskedasticity problem in the correctly constructed model[2]. Also, according to the CUSUM and CUSUM of Squares (more sensitive than CUSUM) graphs, in which the stability of the model parameters is examined, the residuals of the model are within the confidence interval. It shows that the parameters of the model are stable and that there is no structural break in the model, and that it is controlled if it exists, as in our case. Long-run model and the results are given below.

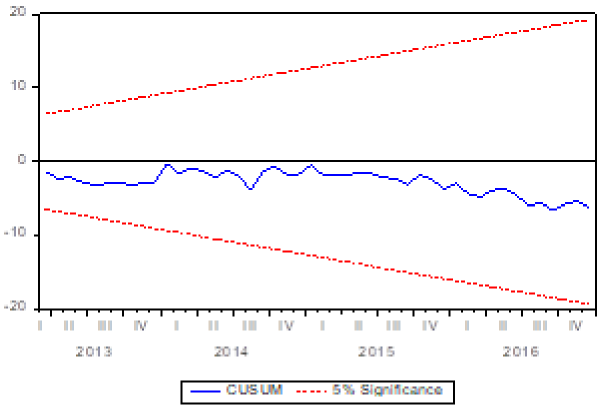
$$LEMP_t = \sum_{i=1}^{5} \beta_{1i} LEMP_{t-i} + \sum_{i=0}^{6} \beta_{2i} LPAT_{t-i} + \gamma_2 dummy + constant + u_t \quad (2)$$

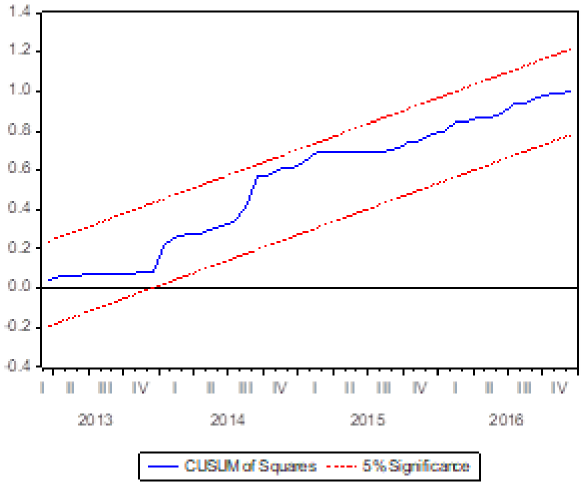
Table 3. ARDL Long-run Results

Dependent Variable: LEMP		
Variable	**Coefficient**	**Diagnostic Tests**
LEMP(-1)	0.802775*** (0.108297)	**Serial Correlation Test** Breusch-Godfrey LM Test Chi-square (2) Prob. Value: 0.2761
LEMP(-2)	-0.006371 (0.136786)	
LEMP(-3)	0.403958*** (0.133009)	**Heteroskedasticity Test** Breusch-Pagan-Godfrey Chi-square (13) Prob. Value: 0.5555

[2] Ramsey Reset Test results provide the information that the model was correctly constructed. In other words, the model is not misspecified.

LEMP(-4)	-0.500563*** (0.144304)	**Regression Specification Error Test (RESET)** Ramsey Reset Test [1] Prob. Value: 0.1342
LEMP(-5)	0.207656** (0.108433)	**Cusum & Cusum of Squares Test**
LPAT	-0.000895 (0.002125)	
LPAT(-1)	0.002144 (0.002034)	
LPAT(-2)	0.004741** (0.002084)	
LPAT(-3)	-0.000471 (0.002094)	
LPAT(-4)	0.003478** (0.002016)	
LPAT(-5)	-0.000828 (0.002023)	
LPAT(-6)	0.005165*** (0.001997)	
DUMMY	-0.004302** (0.002210)	
CONSTANT	0.266625*** (0.084205)	
$R^2 = 0.983109$ $\bar{R}^2 = 0.980219$		





Note: Values in parentheses () below the coefficients indicate standard errors. *** indicates significance at 1%, ** at 5%, * at 10%.

The long-term coefficient of the patent variable, whose standard errors were calculated using the delta method as in Pesaran and Shin (1998), using the long-term model is given in the Table 4. The long-term coefficients are obtained by dividing the sum of the coefficients of the independent variable to one minus the sum of the coefficients of the dependent variable (Gujarati, 1999: 58). Normally distributed standard errors cannot be obtained due to the presence of non-stationary variables in the model. In this case, inferences made using t-statistics will not be valid. For this reason, the standard error of the long-term coefficient of the patent variable was calculated using the delta method. The specified calculations are made automatically by the EViews 10 program.

Table 4. ARDL Long-run Coefficients

Dependent Variable: LEMP	
Variable	**Coefficient**

LPAT	0.144065*** (0.032505)

Note: Values in parentheses () below the coefficients indicate standard errors. *** indicates significance at 1%, ** at 5%, * at 10%.

As it can be captured from Table 4, patent grants variable which is a proxy for innovation, effects employment positively in the long-run.

However, according to the short-run model, the effect of innovation on employment is negative in the short-run (see table 5: D(LPAT(-1)), D(LPAT(-2)), D(LPAT(-3)), D(LPAT(-5)) are statistically significant and negative in sign.). Error Correction Term (ECT) indicates that there is short-run adjustment to long-run equilibrium as it is significant and negative in sign. This means that any disturbance that causes a deviation from long-run equilibrium that comes from the employment side (dependent variable side) will get corrected by 9% (coefficient value of ECT) in the next period. Short-run model and its results is given below.

$$\Delta LEMP_t = \sum_{i=1}^{5} \beta_{1i} \Delta LEMP_{t-i} + \sum_{i=0}^{6} \beta_{2i} \Delta LPAT_{t-i} + \gamma_2 dummy + \lambda ECT_{t-1} + u_t \quad (3)$$

Table 5. ARDL Short-run Results

Dependent Variable: LEMP	
Variable	**Coefficient**
D(LEMP(-1))	-0.104681 (0.113561)
D(LEMP(-1))	-0.111052 (0.000099)
D(LEMP(-1))	0.292907*** (0.087189)
D(LEMP(-1))	-0.207656** (0.113561)
D(LPAT)	-0.000895 (0.000099)
D(LPAT(-1))	-0.012084*** (0.087189)
D(LPAT(-2))	-0.007343** (0.113561)
D(LPAT(-3))	-0.007815** (0.000099)
D(LPAT(-4))	-0.004337 (0.087189)
D(LPAT(-5))	-0.005165*** (0.113561)
DUMMY	-0.004302** (0.000099)
ECT(-1)	-0.092545*** (0.087189)
$R^2 = 0.357442 \quad \overline{R^2} = 0.266825$	

Note: Values in parentheses () below the coefficients indicate standard errors. *** indicates significance at 1%, ** at 5%, * at 10%.

Secondly, we used annual R&D expenditure statistics as a proxy for innovation to investigate the effect of innovation on employment. The time period of this analysis is the years between 1991 and 2021.

Since both variables are integrated of order one (see Table 6), ARDL approach is applicable also for this analysis. LEMP stands for Natural logarithm of the employment rate, and LRND stands for Natural logarithm of the R&D expenditures.

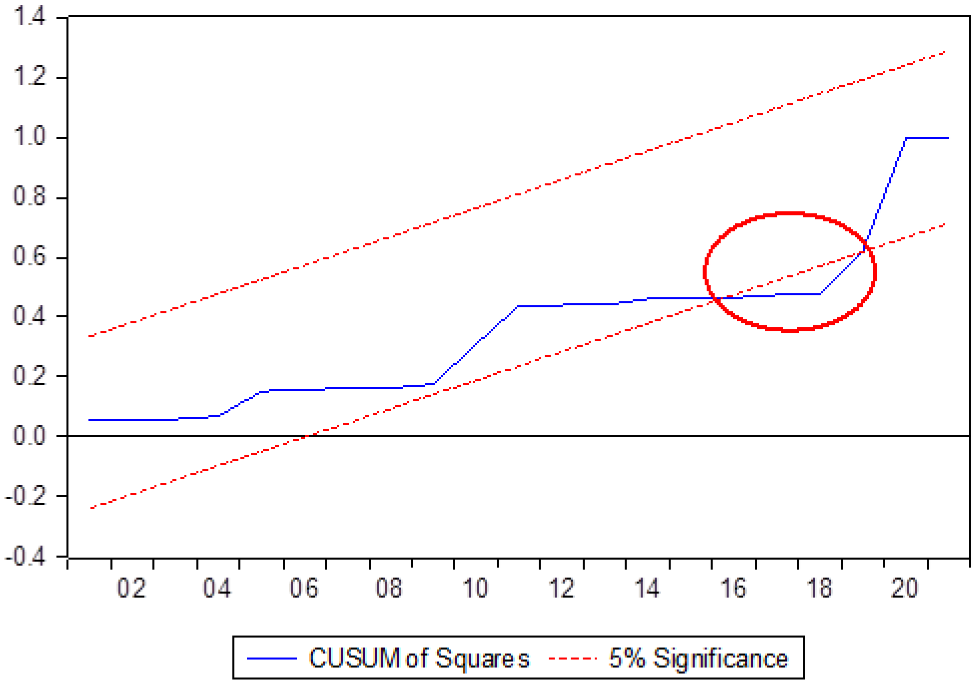
Table 6. Unit Root Tests

Variable Note: D( ) stands for First Difference	**ADF Test Probability Values**			**PP Test Probability Values**			**Decision**
	Intercept	Trend and Intercept	None	Intercept	Trend and Intercept	None	
LEMP	0.0889*	0.0234**	0.3327	0.2951	0.7052	0.2308	I (1)
D(LEMP)	0.0012***	0.0058***	0.0001***	0.0012***	0.0060***	0.0001***	
LRND	0.9899	0.0503**	0.9992	0.9999	0.0007***	0.9999	I (1)
D(LRND)	0.0000***	0.0002***	0.5413	0.0000***	0.0000***	0.0001***	
In the ADF unit root test, the lag length is automatically selected according to the Akaike Information criterion. In the PP unit root test, the Newey-West bandwidth is automatically selected using the Barlett kernel method.							

*** Stationary at 1% significance level, ** Stationary at 5% significance level, * Stationary at 10% significance level.

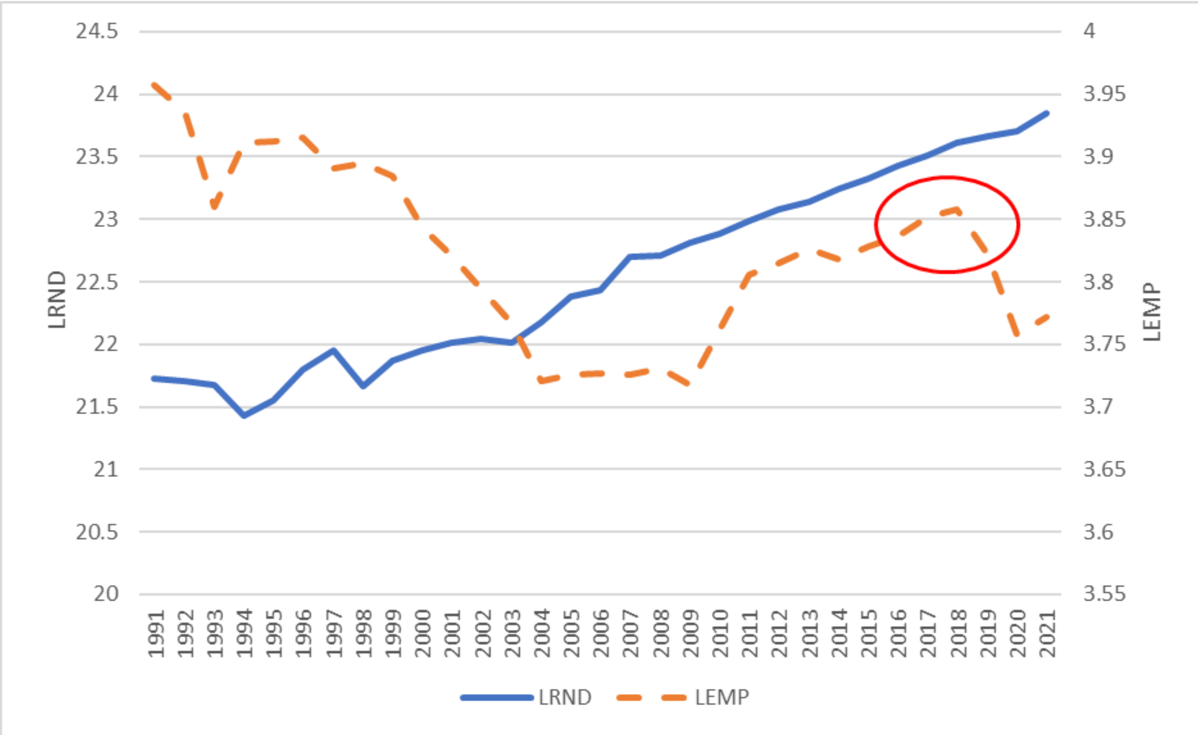
According to CUSUM (cumulative sum) of squares test result, there is a structural break in the analysis (see Figure 3).

Figure 3. CUSUM of Squares



Using a dummy variable for the indicated break period (2016-2019) in Figure 3 eliminates the structural break problem in the data. When the break period is analyzed (shown in a circle in Figure 4), it can be captured that there is a kind of inverted V-shaped trend in LEMP while LRND is relatively stable in that period.

Figure 4. Analyzing Break Period



It is found that the alternative model has a trend as it enters the model statistically significantly. According to the ARDL Bound test equation, which is adapted to our study, long-term relationship (cointegration relation) was determined in our model examining the effect of innovation on employment. The equation (ARDL (1,3)) is given below.

$$\Delta LEMP_t = \sum_{i=1}^{1} \beta_{1i}\Delta LEMP_{t-i} + \sum_{i=0}^{3} \beta_{2i}\Delta LRND_{t-i} + \delta_1 LEMP_{t-1} + \delta_2 LRND_{t-1} + \gamma_1 dummy + constant + trend + u_t \quad (4)$$

Note: Δ: first difference

$H_0: \delta_1 = \delta_2 = 0;\ H_A: \delta_1 \neq \delta_2 \neq 0$

According to results, the null hypothesis is rejected and the alternative hypothesis is accepted. This result indicates the existence of a long-run relationship in the model. See Table 7, the F-stat is bigger than the upper bound, which indicates that the null hypothesis is rejected. That means that there is a cointegration relationship.

Table 7. ARDL Bound Test

		Critical Values					
		Lower Bound			Upper Bound		
F-stat	k	%1	%5	%10	%1	%5	%10
11.278691	1	8.74	6.56	5.59	9.63	7.3	6.26

When the long-run model and the short-run model given below are analyzed separately, like what is found in the first analysis, it is found that while the effect of innovation on employment is negative in the short-run, it turns out to be positive in the long-run.

The long-run ARDL model and its results are given in the table below, along with the diagnostic test results. The model has passed all the diagnostic tests. This shows that the model is unbiased and consistent.

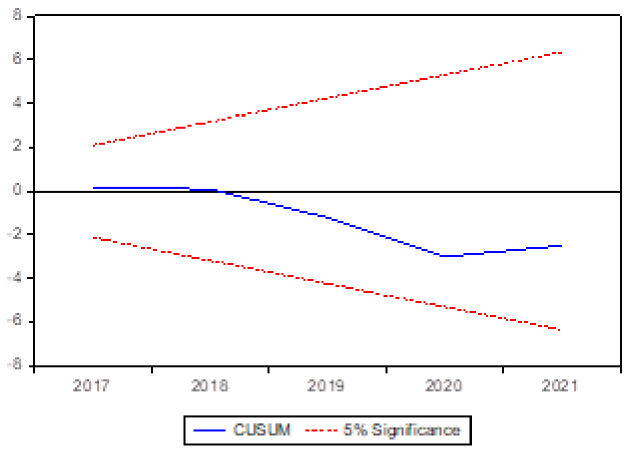
$$LEMP_t = \sum_{i=1}^{1} \beta_{1i} LEMP_{t-i} + \sum_{i=0}^{3} \beta_{2i} LRND_{t-i} + \gamma_2 dummy + constant + trend + u_t \quad (5)$$

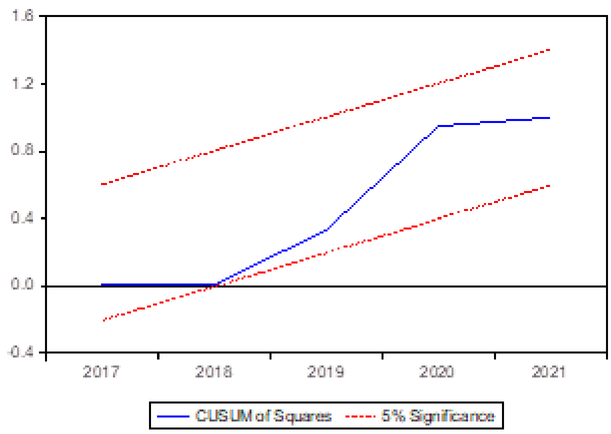
Table 8. ARDL Long-run Results

Dependent Variable: LEMP		
Variable	**Coefficient**	**Diagnostic Tests**
LEMP(-1)	0.661777*** (0.090915)	**Serial Correlation Test** Breusch-Godfrey LM Test Chi-square (2) Prob. Value: 0.3062
LRND	0.068788 (0.048175)	
LRND(-1)	0.075230 (0.046501)	**Heteroskedasticity Test** Breusch-Pagan-Godfrey Chi-square (7) Prob. Value: 0.3751
LRND(-2)	0.043955 (0.047066)	**Regression Specification Error Test (RESET)** Ramsey Reset Test [1] Prob. Value: 0.5650

		Cusum & Cusum of Squares Test
LRND(-3)	0.061229 (0.037998)	
DUMMY	0.017300 (0.015008)	
CONSTANT	-3.957504*** (1.144994)	
TREND	-0.022646*** (0.005290)	
$R^2 = 0.920604$ $\bar{R}^2 = 0.892815$		

Cusum & Cusum of Squares Test





Note: Values in parentheses () below the coefficients indicate standard errors. *** indicates significance at 1%, ** at 5%, * at 10%.

The long-term coefficient of the R&D expenditures is given in the table below.

Table 9. ARDL Long-run Coefficients

Dependent Variable: LEMP	
Variable	**Coefficient**
LPAT	0.736798*** (0.202189)

Note: Values in parentheses () below the coefficients indicate standard errors. *** indicates significance at 1%, ** at 5%, * at 10%.

As it can be captured from Table 9, the R&D expenditures variable, which is a proxy for innovation, affects employment positively in the long-run.

The short-run model and its results are given below. However, according to the short-run model, the effect of innovation on employment is negative in the short-run (see table 10: D(LRND(-1) and D(LRND(-2) are statistically significant and negative in sign.). Like in the first analysis done with patent grants, ECT is statistically significant and negative in sign which indicates that there is a short-run adjustment to long-run equilibrium. In other words, any deviation from long-run equilibrium that comes from the employment side (dependent variable side) will be corrected by approximately 34% in the next period.

$$\Delta LEMP_t = \sum_{i=1}^{1} \beta_{1i} \Delta LEMP_{t-i} + \sum_{i=0}^{3} \beta_{2i} \Delta LRND_{t-i} + \gamma_2 dummy + \lambda ECT_{t-1} + trend + constant + u_t \quad (6)$$

Table 10. ARDL Short-run Results

Dependent Variable: LEMP	
Variable	**Coefficient**
D(LRND)	0.068788 (0.042717)
D(LRND(-1))	-0.105184*** (0.040083)
D(LRND(-2))	-0.061229* (0.036579)
DUMMY	0.017300 (0.013368)
CONSTANT	-3.957504*** (0.812863)
ECT(-1)	-0.338223*** (0.069497)
$R^2 = 0.547786$ $\overline{R}^2 = 0.418582$	

Note: Values in parentheses () below the coefficients indicate standard errors. *** indicates significance at 1%, ** at 5%, * at 10%.

The results obtained from the second analysis are very consistent with the first analysis, which indicates that although the effect of innovation on employment in the short-run is negative, the long-run effect is positive.

6. Conclusion

When the long-run model and the short-run model given above are analyzed separately, it is found that while the effect of innovation on employment is negative in the short-run, it turns out to be positive in the long-run. Thus, during the period 1991-2021 in the Turkish labor market, while innovation might negatively affect employment levels to some extent in the short run, innovation could exert a more structural and sustainable positive impact on employment levels in the long run.

References

Acar, M., & Sever, E. (2022). The Effect of Innovation on Employment: An ARDL Bounds Testing Approach for Turkey 1. Sosyoekonomi, 30(51), 33-52.

Dosi, G., & Mohnen, P. (2019). Innovation and employment: an introduction. Industrial and Corporate Change, 28(1), 45-49.

Gujarati, D. (1999). Basic Econometrics, Forth Edition. McGrow, Hill.

Kancs, D. A., & Siliverstovs, B. (2020). Employment effect of innovation. Empirical Economics, 59(3), 1373-1391.

Lachenmaier, S., & Rottmann, H. (2011). Effects of innovation on employment: A dynamic panel analysis. International journal of industrial organization, 29(2), 210-220.

Liew, V. K. S. (2004), Which lag length selection criteria should we employ?, Economics bulletin, 3(33), s.1-9.

Pesaran, H. H., & Shin, Y. (1998). Generalized impulse response analysis in linear multivariate models. Economics letters, 58(1), 17-29.

Piva, M., & Vivarelli, M. (2005). Innovation and employment: Evidence from Italian microdata. Journal of economics, 86(1), 65-83.