

## THE IMPACT OF TECHNOLOGY ON EMPLOYMENT AT REGIONAL LEVEL: THE CASE OF TURKEY

### BÖLGESEL DÜZEYDE TEKNOLOJİNİN İSTİHDAM ÜZERİNDEKİ ETKİSİ: TÜRKİYE ÖRNEĞİ

Orkun ÇELİK\* 

#### Abstract

Technology has rapidly improved across the world. It has frequently been discussed whether technology creates employment in the literature. There are two different views on this issue. The first is the labor-friendly view that alleges technological innovation creates new job-area. The second is the labor-saving view that asserts technology substitutes capital to labor. This paper analyzes the impact of technology on employment at regional level for Turkey. The dataset covers over the period 2010-2017 for 12 regions at NUTS-I level. According to the results of the system GMM estimation, there is a remarkable nexus between R&D expenditure and overall, man employment, employment of higher education graduates, unlike woman employment. However, the nexus is the inversed U-shape and is clearer in employment of higher education graduates.

**Keywords:** Technology, Innovation, Employment, Unemployment, Regional Labor Market.

**JEL Codes:** E24, J21, O3, O32, R23.

#### Öz

Dünya genelinde teknoloji hızla gelişmektedir. Teknolojinin istihdam yaratıp yaratmadığıysa literatürde sıklıkla tartışılmaktadır. Bu konuyla ilgili iki farklı görüş vardır. İlki, teknolojinin yeni iş alanları yarattığını iddia eden emek yanlı görüştür. İkinci görüş ise, teknolojinin emek yerine sermayeyi ikame ettiğini ileri süren emek tasarufu görüşüdür. Bu çalışma, Türkiye için bölgesel düzeyde teknolojinin istihdam üzerindeki etkisini incelemektedir. Veri seti, Düzey 1 kapsamındaki 12 bölge için 2010-2017 dönemini kapsamaktadır. Dinamik sistem GMM tahmin yönteminden elde edilen sonuçlara göre, kadın çalışanların istihdamı aksine, araştırma ve geliştirme harcamaları ile genel istihdam, erkek istihdamı ve yüksek öğrenim mezunlu istihdam arasında anlamlı bir ilişki bulunmaktadır. Bununla birlikte, bu ilişki ters-U şeklinde olup, yüksek öğrenim mezunlu istihdamda daha belirgindir.

\* Gümüşhane Üniversitesi, İktisat Bölümü, Email: ocelik@gumushane.edu.tr, ocelikege@gmail.com

**Anahtar Kelimeler:** Teknoloji, Yenilik, İstihdam, İşsizlik, Bölgesel Emek Piyasası.

**JEL Kodları:** E24, J21, O3, O32, R23.

## 1. Introduction

The impact of technology on labor markets has been discussed for a long time. However, the question has re-appeared urgently at the onset of the Industry 4.0. Furthermore, rising of new technologies and the fast pace of innovations have comprised a basis for the concerns that digital revolution could ineradicably change job profiles, eliminating more jobs than it creates (Ebrahim & Darius, 2017, p.2). The last wave of technological change has generated a contentious debate on the future of the world of work. Nowadays, there are two different views about the impact of technological change on jobs. Some researchers believe that the new developments in innovations will destroy jobs at an enormous scale, and predict a jobless future, while optimists are confident that new innovations will awake adjustment and transforming processes that will generate new jobs, and even *golden ages* of job generation (Nübler, 2016, p.1).

The economists divide technological innovations into two groups as product and process innovations. The first commercial production of a completely new product or changes that improve the quality of an existing product are defined as product innovation. Process innovation expresses that production of an existing product with a new process (Taymaz, 1998, p.4). According to Vivarelli (2014; 2015), the R&D expenditures that lead to product innovation are usually labor-friendly, whereas the R&D expenditures that lead to process innovation are generally labor-saving.

The technology and employment nexus have been discussed by many researchers for a long time in the literature. However, in recent years, interest of researchers for this topic has exceedingly increased because of rapid technological progress and increasing unemployment around world. In literature, there are many studies about the topic for developed countries, while they are limited in developing countries such as Turkey.

The studies focusing on developed countries show that pace of technological change on employment varies by industry (Mark, 1987), the impact of technology on employment is positive (Van Reenen, 1997; Ruane & Kearns, 1997; Blechinger et al., 1998; Piva & Vivarelli, 2004; Lachenmaier & Rottmann, 2011; Bogliacino & Vivarelli, 2012; Bogliacino, 2014; Barbieri, Piva & Vivarelli, 2019) and especially in high-tech sectors (Lyons & Luker, 1996; Coad & Roa, 2007; Bogliacino, Piva & Vivarelli, 2012, 2014; Piva & Vivarelli, 2017, 2018; Van Roy, Vértesy & Vivarelli, 2018), there is a spillover impact of university R&D on employment and high technology employment (Acs, Fitzroy & Smith, 1999; 2002), the relationship between R&D spillover and employment is positive (Aldieri, Garofalo & Vinci, 2015; Agovino et al., 2018), the R&D subsidies enhance the number of R&D workers (Afcha & Garcia-Quevedo, 2016), R&D offshoring expenditures positively affect skilled employment (Tamayo & Huergo, 2016) and the impact of R&D intensity on skilled labor is positive (Machin & Van Reenen, 1998). According to Özcan (2019), robotization positively affects employment, but employees

should update their skills. Although the studies generally find that positive impact of technology on employment, there are few studies which find the technology increases unemployment (Feldmann, 2013) or there is no relationship technology and employment (unemployment) (Demir & Alpaslan, 2016; Matuzeviciute, Butkus & Karaliute, 2017) for developed countries.

Unlike the developed countries, there are few studies about this issue for the developing countries. Edwards (2004) for the South Africa, Araújo, Bogliacino & Vivarelli (2011) for Brazil, Conte and Vivarelli (2011) for the 23 developing countries find that the technology positively affects employment. Mitra and Jha (2016) evidence that there is no positive relationship between R&D and productivity, while the elasticity of R&D employment is positive in a few of industries of Indian. Cirera and Sabetti (2016) find that the impact of technology on employment is positive, especially low-income countries and the African region, using firm-level data. Karabulut and Shahinpour (2017) indicate that the information and communications technology (ICT hereafter) reduces unemployment for Iran. Okumu, Bbaale & Guloba (2019) conclude that process and production innovation positively affect employment growth for African manufacturing sector. Furthermore, Crespi, Tacsir & Pereira (2019) show that there is a relationship between new product innovations and employment growth, while there is no evidence of displacement impacts because of existing of the process innovations. However, there are a few studies find that technology has no impact on employment (Lundin et al., 2007) or it has negative impact on employment (Jenkins, 2008) for developing countries.

In this process, the R&D expenditures in Turkey are weaker compare to developed countries, and it has high unemployment rate. The share of the R&D expenditure in GDP in Turkey is 0,66 percent on the average. However, the share is 1,76 percent, 1,40 percent, and 0,94 percent in the OECD, the EU-28 and around the world for the period 1996-2017, respectively (WDI, 2019). According to the report of the OECD (2018), the unemployment rate was close to 10 percent in early 2018, against an OECD average of 5,8 percent.

Studies investigating the impact of technology on employment for Turkey are few in the literature. From these studies, Üçdoğruk (2006) shows that the impact of product and process innovator on employment growth is positive especially in low technology industries for the manufacturing sector over the periods 1995-1997 and 1998-2000. Using the dataset of 107 private manufacturing industries for the period 1995-2001, Aksoy (2009) evidences that technology has a positive impact on demand of skilled labor, but the impact is weak. Meschi, Taymaz & Vivarelli (2011) indicate that the R&D expenditures have positive impact on skilled labor in the manufacturing sector for the period 1980-2001. Meschi, Taymaz & Vivarelli (2016) demonstrate that the connected nexus between technology and trade positively affects employment creation in the manufacturing sector over the 1992-2001 period. Lenger (2016) shows that technological change has a positive impact on the administrative employees, while its the impact on production employees in the skilled labor intensive industries in the manufacturing sector is negative over the 1985-1998 period. Aydın (2018) concludes that the technological progress has positive impact on employment of higher education graduates over the period 1981-2015. Kılıçaslan and Töngür (2019) find that the ICT has employment-enhancing

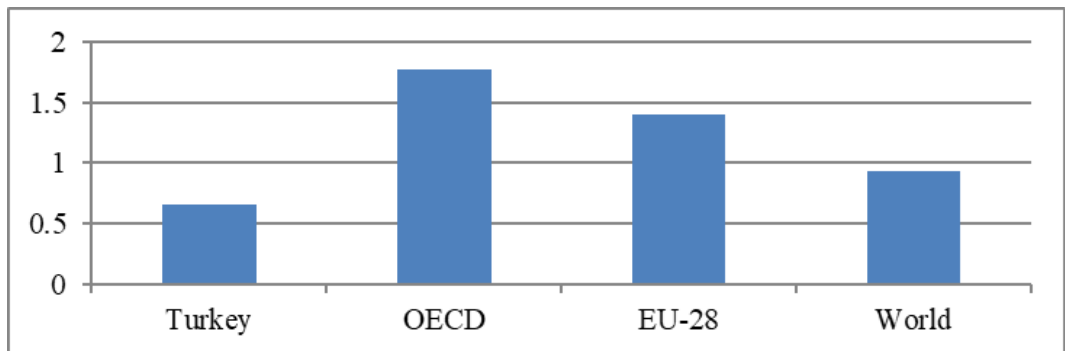
impacts for the manufacturing sector for the period 2003-2013. Moreover, the impact of tangible ICT capital on employment creation is stronger than that of intangible ICT capital in the medium and low technology industries.

Unlike the previous studies, Ansal and Cetindamar Karaomerlioglu (1999) conclude that technology has clearly a negative impact on employment for the chemical and engineering industries over the period 1980-1993. Sumer (2018) shows that there would be significant losses in some occupational categories with routine tasks because of the process of Industry 4.0.

The main aim of this paper is to analyze the impact of technology on employment at regional level for Turkey. The dataset covers the 12 regions at NUTS-I level over the period 2010-2017. For the aim, system GMM method is preferred. The paper unfolds as follows. Section 2 discusses about the relationship between the R&D expenditure and employment in Turkey over the period. Section 3 gives the information about using the model, data, and method. Section 4 shows obtained findings and Section 5 discusses conclusions and makes policy recommendations. This study is expected to contribute to the literature along two dimensions. The first of all, employment level is considered by overall, gender, and education in the regional level for Turkey, unlike the previous studies. The second, as far as is known, there is no study about the relationship between technology and employment at the regional level for Turkey.

## 2. The R&D and Employment Nexus in Turkey

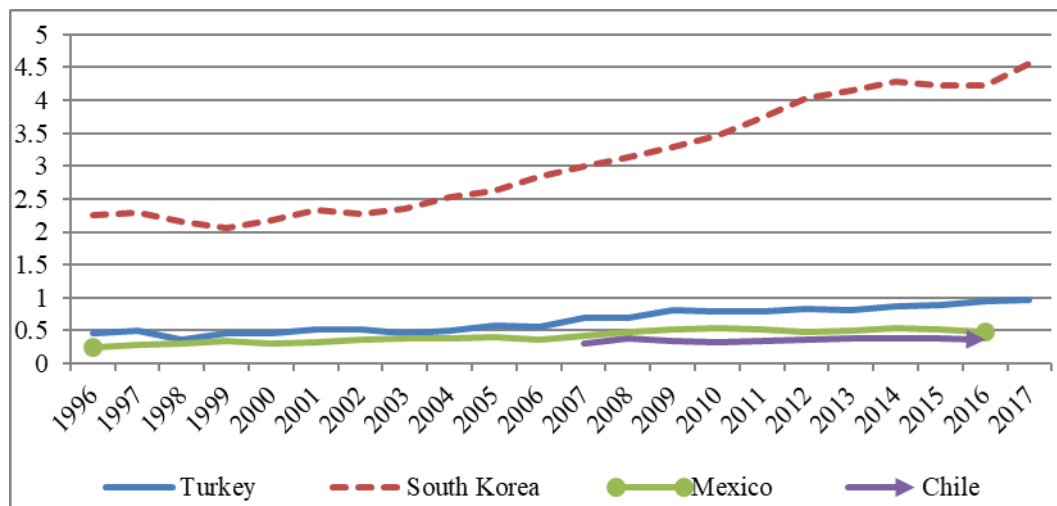
Turkey exhibits distinctive developing country properties in terms of R&D investment activity (Voyvoda & Yeldan, 2015, p.198). According to WDI (2019), the level of R&D expenditure in GDP of Turkey is very low compared to the OECD and EU-28 countries. The share of R&D expenditure in GDP for Turkey is 0,66 percent on the average for the period 1996-2017. This value is 1,76 percent, 1,4 percent, and 0,96 percent for the OECD, the EU countries and the World, respectively. Figure 1 shows the share of R&D expenditure in GDP for Turkey and other countries over the period 1996-2017.



**Figure 1.** The Share of R&D expenditure in GDP (%), average, 1996-2017

Source: WDI (2019)

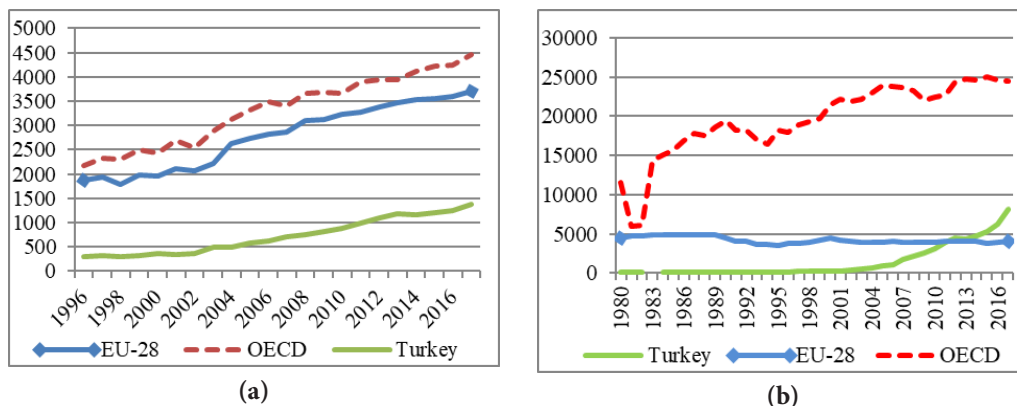
In Figure 2, it can be seen that the share of R&D in GDP of Turkey has slightly increased during the period 1996-2017. Although there are no significant difference between Turkey, Mexico, and Chile, the R&D expenditure in South Korea prominently has increased.



**Figure 2.** The Share of R&D expenditure in GDP for Turkey and emerging market economies (%)

Source: WDI (2019)

Although the share of R&D expenditure in GDP of Turkey is weak compare to other countries, the target in 2023 Economic Goal of Turkey is 3 percent. Hence, it should leap forward a great scientific (Lehmann, 2011, p.3). Figure 3 indicates innovation indicators of Turkey, the EU-28 and the OECD countries. In part (3a), the number of researchers in R&D for Turkey is below the EU-28 and the OECD average over the period 1996-2017. In part (3b), patent applications in the EU-28 are relatively constant, while there is an upward trend in Turkey and OECD countries since 1980's.



**Figure 3.** Innovation indicators of Turkey, the EU-28, and the OECD countries

Source: WDI (2019). Note: (a) Researcher in R&D (per million people), (b) Patent applications (residents).

Moreover, Turkey has efficiency problem in R&D activity. Aybarç and Selim (2017) evidence that the most effective countries are Germany, Italy, South Korea, Netherlands, Spain, and Sweden in the OECD countries. However, Turkey is the lowest efficiency country in terms of R&D activities.

All these indicators demonstrate that significant and effective R&D incentives should be made in Turkey. In perspective R&D incentive, tax credit is applied in France, the UK, Ireland, Spain and Netherlands, while tax deduction is used in Belgian and Italy. In general, countries prefer tax credit rather than tax deduction. In R&D incentive system of Turkey, there is tax deduction (Çetin & Işık, 2014, p.92).

The report of the OECD (2018) suggests that modernizing the several R&D incentives schemes based on cost-benefit analyses, and attributing international best applications to enhance take-up and efficiency of tax subsidies and endowments for Turkey. The public supports for R&D substantially and positively influence R&D investments of private sector in Turkey (Özçelik & Taymaz, 2008). This process directly influences economic growth and employment.

According to the study of Erdil and Ertekin (2017), Turkey has four key structural challenges for achieving 2023 Economic Goal, namely productivity, growth, employment, and investment. Hence, R&D activity should be labor-friendly. Otherwise, unemployment will be deepened, and also productivity and economic growth will be affected negatively.

The trends of R&D expenditure and employment in Turkey are shown in Figure 4. The employment and R&D expenditure have upward trend since 2003. In this process, employment increases by 0,33 percent, whereas share of the R&D expenditure in GDP improves by 1,13 percent.

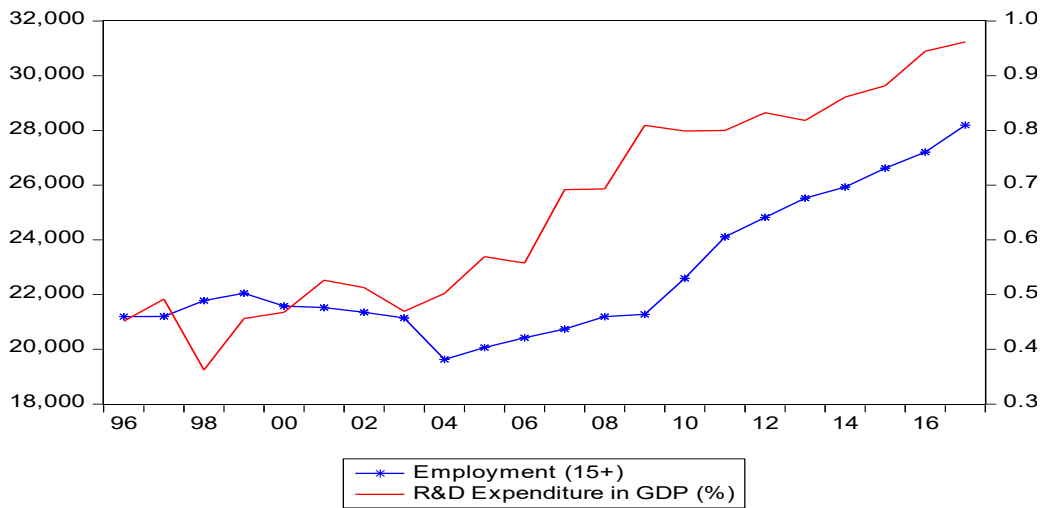
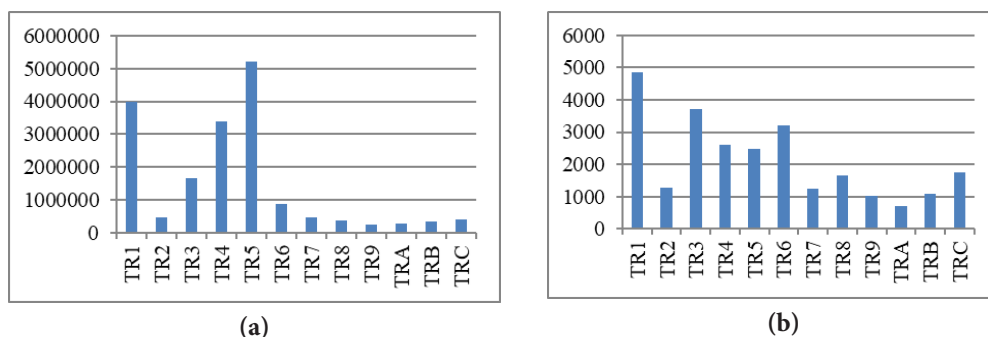


Figure 4. Trends of R&D expenditure and employment in Turkey, 1996-2017

Source: WDI (2019) and TURKSTAT. Right axis shows R&D expenditure in GDP. Left axis indicates number of employment.

Furthermore, there are regional differences in Turkey in terms of the R&D activities and employment. In Figure 5, it is shown the regional distribution of the R&D expenditure and employment level of Turkey at NUTS-I level over the period 2010-2017. In Turkey, R&D expenditure and employment have concentrated in the West regions. These values in the East regions are low, compared to the West regions (such as TR1, TR3 TR4, and TR5).



**Figure 5.** Regional distributions of the R&D expenditure and employment, 2010-2017

**Source:** TURKSTAT. **Note:** (a) R&D Expenditure (TL), (b) Employment (thousand, person). TR1 (İstanbul), TR2 (Bati Marmara), TR3 (Ege), TR4 (Doğu Marmara), TR5 (Bati Anadolu), TR6 (Akdeniz), TR7 (Orta Anadolu), TR8 (Bati Karadeniz), TR9 (Doğu Karadeniz), TRA (Kuzeydoğu Anadolu), TRB (Ortadoğu Anadolu), TRC (Güneydoğu Anadolu).

The R&D and innovation performance of Turkey is difference at level NUTS-I, NUTS-II, and NUTS-III. Accordingly, the most innovative region for NUTS-I is Marmara region. For NUTS-II, it is TR10 (İstanbul) region. In city level, the most innovative cities are İstanbul, Ankara, and İzmir, respectively (Belgin & Avşar, 2019).

### 3. Econometric Strategy

#### 3.1. Model and Data

The main aim of this paper is to investigate the impact of technology on employment at regional level for Turkey. For the aim, the dynamic labor demand model is considered (Van Reenen, 1997; Piva & Vivarelli, 2004; Meschi, Taymaz & Vivarelli, 2011; Lachenmaier & Rottmann, 2011; Bogliacino & Vivarelli, 2012; Bogliacino, Piva & Vivarelli, 2012; Piva & Vivarelli, 2018; Kılıçaslan & Töngür, 2019). This model is adjusted at regional level for Turkey. Here,

*Model I*

$$\ln emp_{i,t} = \beta_0 + \gamma \ln emp_{i,t-1} + \beta_1 \ln rd_{i,t} + \beta_2 \ln rd_{i,t}^2 + \beta_3 \ln ind_{i,t} + \beta_4 \ln serv_{i,t} + \beta_5 to_{i,t} + \varepsilon_{i,t} \quad (1)$$

*Model II*

$$\ln wom_{i,t} = \beta_0 + \gamma \ln wom_{i,t-1} + \beta_1 \ln rd_{i,t} + \beta_2 \ln rd_{i,t}^2 + \beta_3 \ln ind_{i,t} + \beta_4 \ln serv_{i,t} + \beta_5 to_{i,t} + \varepsilon_{i,t} \quad (2)$$

Model III

$$\lnman_{i,t} = \beta_0 + \gamma \lnman_{i,t-1} + \beta_1 \lnrd_{i,t} + \beta_2 \lnrd_{i,t}^2 + \beta_3 \lnind_{i,t} + \beta_4 \lnserv_{i,t} + \beta_5 to_{i,t} + \varepsilon_{i,t} \quad (3)$$

Model IV

$$\lngrademp_{i,t} = \beta_0 + \gamma \lngrademp_{i,t-1} + \beta_1 \lnrd_{i,t} + \beta_2 \lnrd_{i,t}^2 + \beta_3 \lnind_{i,t} + \beta_4 \lnserv_{i,t} + \beta_5 to_{i,t} + \varepsilon_{i,t} \quad (4)$$

Where, *i* denotes region. *t* is time and  $\varepsilon_{it}$  is error term. Moreover,  $\lnind_{i,t}$ ,  $\lnserv_{i,t}$ ,  $to_{i,t}$  are control variables. The technology indicators can be achieved as from 2010 year at regional level in Turkey. Therefore, the dataset covers the 12 regions at NUTS-I level over the period 2010-2017. It cannot be extended because of restricted accessibility of the R&D expenditure data. All variables are obtained from TURKSTAT database. Table 1 presents description of variables.

**Table 1.** Description of variables

	Variables	Description	Unit	
Dependent	$\lnemp_{i,t}$	number of overall employment (log)	TP	
	$\lnwom_{i,t}$	number of woman employment (log)	TP	
	$\lnman_{i,t}$	number of man employment (log)	TP	
	$\lngrademp_{it}$	number of employment of higher education graduates (log)	TP	
	Variables	Description	Unit	Expected Sign
Independent	$\lnemp_{i,t-1}$	lagged one period of $\lnemp_{i,t}$	TP	+
	$\lnwom_{i,t-1}$	lagged one period of $\lnwom_{i,t}$	TP	+
	$\lnman_{i,t-1}$	lagged one period of $\lnman_{i,t}$	TP	+
	$\lngrademp_{i,t-1}$	lagged one period of $\lngrademp_{it}$	TP	+
	$\lnemp_{i,t-2}$	lagged second period of $\lnemp_{i,t}$	TP	+
	$\lnwom_{i,t-2}$	lagged second period of $\lnwom_{i,t}$	TP	+
	$\lnman_{i,t-2}$	lagged second period of $\lnman_{i,t}$	TP	+
	$\lngrademp_{i,t-2}$	lagged second period of $\lngrademp_{it}$	TP	+
	$\lnrd_{i,t}$	log of the R&D expenditure	Thousand TL	+
	$\lnrd_{i,t}^2$	square of $\lnrd_{i,t}$	Thousand TL	-
	$\lnind_{i,t}$	the share of industry sector in GDP (log)	Ratio	-
	$\lnserv_{i,t}$	the share of service sector in GDP (log)	Ratio	+
	$to_{i,t}$	Trade openness	Ratio	+/-

**Note:** TL: Turkish Lira, TP: Thousand person.  $to_{i,t} = (\text{import}_{i,t} + \text{export}_{i,t}) / \text{GDP}_{i,t}$ . Using effective exchange rate from the New Electronic Data Delivery System (NEDDS) database, Dollar is converted to Turkish Lira.

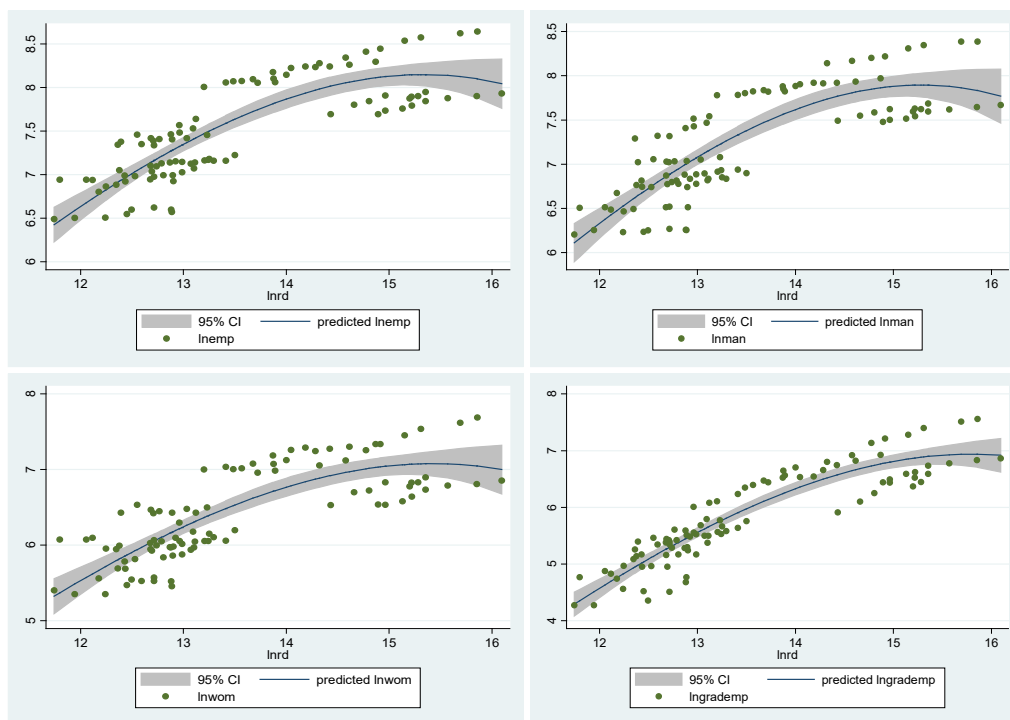


Table 2 shows that man employment is bigger than woman employment on average in Turkey for the period. Moreover, the share of the service sector in GDP is higher than the industry sector.

**Table 2.** Descriptive statistics

Variable	Obs	Mean	Std. Dev	Min	Max
lnemp	96	7,506	0,571	6,489	8,642
lnwom	96	6,408	0,606	5,352	7,688
lnman	96	7,237	0,598	6,205	8,389
lngrademp	96	5,835	0,809	4,277	7,559
lnrd	96	13,535	1,115	11,745	16,092
ind	96	0,256	0,069	0,117	0,428
serv	96	0,511	0,058	0,406	0,635
to	96	0,228	0,199	0,026	0,811

Figure 6 indicates the distribution of R&D expenditure and overall, man, woman employment and employment of higher education graduates for Turkey, using TURKSTAT data. Accordingly, it is seen that the nexus between the R&D expenditure and employment is the inverse U-shape for all employment types. When the R&D expenditure increases, employment goes up, as well. However, this raise is limited until a particular point.



**Figure 6.** Distribution of R&D expenditure and employment for Turkey

Source: TURKSTAT

### 3.2. Method

The dynamic panel estimation methods are considered to investigate the technology and employment nexus at regional level in Turkey. Hereunder, dynamic model which is estimated by OLS will induce biased findings because of the existing of unobserved heterogeneity (Lachenmaier & Rottmann, 2011, p.212). For solving this problem, Arellano and Bond (1991) suggests using GMM estimation. However, a short time dimension of the panel and/or a strong persistence in the time series induces decrease in efficiency of the difference GMM (GMM-Diff) estimator (Conte & Vivarelli, 2011).

Especially, Bond (2002) indicates that GMM-Sys is more efficient than the GMM-Diff one, if the panel is short in time and if it includes persistent time series (Piva & Vivarelli, 2004). Accordingly, the GMM-Sys method is preferred because of the presence of large (N) and small (T). Recently, many studies have considered the method. For instance, Piva and Vivarelli (2004), Araújo, Bogliacino & Vivarelli (2011), Meschi, Taymaz & Vivarelli (2011), Conte and Vivarelli (2011), Lachenmaier and Rottmann (2011), Bogliacino and Vivarelli (2012), Piva and Vivarelli (2018), Kılıçaslan and Töngür (2019). Furthermore, all models are estimated by `xtabond2` code (Roodman, 2009) in Stata 13.

### 4. Empirical Findings

In this section, empirical findings are presented. The study of Lachenmaier and Rottmann (2011) is followed as econometric strategy. The basic AR(2) models of employment are firstly estimated to compare the findings of different estimators, Table 3 indicates the results of AR(2) regression in different methods (OLS, fixed impact (FE), GMM-Diff, and GMM-Sys).

**Table 3.** Results of AR (2) regressions of employment

	OLS	FE	GMM-Diff	GMM-Sys
<i>lnemp (-1)</i>	1,092*** (0,000)	0,774*** (0,000)	1,058*** (0,000)	1,099*** (0,000)
<i>lnemp (-2)</i>	-0,081 (0,431)	0,025 (0,719)	-0,076 (0,478)	-0,093 (0,111)
<i>Cons.</i>	-0,058 (0,23)	1,531** (0,021)	-	-0,029
<i>lnwom (-1)</i>	1,127*** (0,000)	0,833*** (0,000)	0,935*** (0,000)	1,126*** (0,000)
<i>lnwom (-2)</i>	-0,134** (0,041)	-0,053 (0,498)	-0,049 (0,391)	-0,154** (0,022)
<i>Cons</i>	0,077 (0,52)	1,452*** (0,001)	-	0,218 (0,431)
<i>lnman (-1)</i>	0,889*** (0,000)	0,663*** (0,000)	0,954*** (0,000)	0,909*** (0,000)
<i>lnman (-2)</i>	0,126 (0,31)	0,253** (0,027)	0,105 (0,413)	0,104 (0,326)
<i>Cons</i>	-0,098*** (0,003)	0,632* (0,062)	-	-0,078*** (0,005)
<i>lngrademp (-1)</i>	0,84*** (0,000)	0,717*** (0,000)	0,748*** (0,000)	0,838*** (0,000)
<i>lngrademp (-2)</i>	0,158 (0,226)	0,173* (0,088)	0,208** (0,052)	0,134** (0,044)
<i>Cons</i>	0,104 (0,23)	0,734 (0,112)	-	0,25** (0,037)
<i>N</i>	72	72	60	72

**Note:** p-values are in parentheses. \*\*\* p < 0,01, \*\* p < 0,05, \* p < 0,1.

Table 3 presents that the coefficients of the lagged dependent variables add to a sum of 1,011 in the first column, 0,799 in the second column, 0,982 in the third column and 1,006 in the fourth column for overall employment. The results of AR(2) for woman employment show that coefficients of the lagged dependent variables are 0,993 for the OLS model, 0,78 for the fixed impacts model, 0,886 in the GMM-Diff model and 0,972 in the GMM-Sys estimation. The results for man employment indicate that the coefficients of the lagged dependent variables are 1,015 for the OLS model, 0,916 for the fixed impacts model, 1,059 in the GMM-Diff model and 1,013 in the GMM-Sys estimation. Moreover, the findings for high education employment indicate that the coefficients of the lagged dependent variables are 0,998 for the OLS model, 0,89 for the fixed impacts model, 0,956 in the GMM-Diff model and 0,972 in the GMM-Sys estimation.

The results generally show that coefficients in the GMM-Sys estimation are between the upper bound of the OLS model and the lower bound of the fixed impacts and the GMM-Diff model

(Lachenmaier & Rottmann, 2011). Hence, it is preferred the GMM-Sys estimation with robust standard errors.

Table 4 demonstrates that results of the labor demand model estimation. It is investigated the impact of the technology on overall employment at regional level for Turkey in Model I estimation. Accordingly, the first lag of dependent variable ( $lnemp_{i,t-1}$ ) is statistically significant, while the second lag ( $lnemp_{i,t-2}$ ) is not significant. The model is stable, because a sum of dependent variable is less than one. There is a positive nexus between technology ( $lnrd$ ) and overall employment. Accordingly, a one percent increase in  $lnrd$  leads to go up overall employment by 0,273 percent. Unlike Ansal and Cetindamar Karaomerlioglu (1999), this result is consistent with Van Reenen (1997), Aksoy (2009), Piva and Vivarelli (2004), Lachenmaier and Rottmann (2011), Bogliacino, Piva & Vivarelli (2012; 2014), Cirera and Sabetti (2016), Piva and Vivarelli (2017), Aydın (2018), and Okumu, Bbaale & Guloba (2019). However, this relationship is the inversed U-shape. Hence, a rise in the square of  $lnrd$  leads to decrease overall employment. This result is not in line with Bogliacino (2014).

**Table 4.** Results of the labor demand model estimation

Variables	(I)	(II)	(III)	(IV)
lnemp (-1)	0,992*** (0,000)			
lnemp (-2)	-0,025 (0,724)			
lnwom (-1)		0,929*** (0,000)		
lnwom (-2)		-0,024 (0,658)		
lnman (-1)			0,857*** (0,000)	
lnman (-2)			0,135 (0,122)	
lngrademp (-1)				0,737*** (0,000)
lngrademp (-2)				0,186*** (0,005)
lnrd	0,273* (0,089)	0,51** (0,015)	0,179* (0,085)	0,754*** (0,000)
lnrd <sup>2</sup>	-0,009* (0,09)	-0,019** (0,016)	-0,006* (0,08)	-0,026*** (0,001)
ind	0,0063 (0,96)	-0,01 (0,976)	0,062 (0,447)	0,169 (0,492)
serv	0,072 (0,493)	0,139 (0,625)	0,079 (0,407)	0,335 (0,299)
to	0,084** (0,022)	0,226*** (0,005)	0,043* (0,083)	0,168*** (0,000)
Cons	-1,757* (0,089)	-3,509*** (0,013)	-1,264* (0,072)	-5,103*** (0,000)
Wald Test	196083,68*** (0,000)	16647,03*** (0,000)	238538,88*** (0,000)	137005,64*** (0,000)
Sargan Test, p-value	0,471	0,604	0,209	0,401
Hansen Test, p-value	1,000	1,000	1,000	1,000
AR (1) test, p-value	0,02	0,063	0,019	0,026
AR (2) test, p-value	0,114	0,056	0,469	0,565

**Note:** \*\*\*  $p < 0,01$ , \*\*  $p < 0,05$ , \*  $p < 0,1$ . The one-step version of the GMM-Sys is considered in estimation of the model (Blundell & Bond, 1998; Piva & Vivarelli, 2004). Endogenous instrumental variables are the first lag of *lnemp*, *lnwom*, *lnman*, *lngrademp*, *lnrd*, *lnrd*<sup>2</sup>. Exogenous instrumental is trade openness (*to*).

The impact of trade openness on overall employment is statistically significant and positive. Unlike Asaleye et al. (2017), this result is consistent with Casacuberta, Fachola & Gandelman (2004), Meschi, Taymaz & Vivarelli (2011; 2016), and Assaf (2018). According to the results of the diagnostic test, Wald test confirms the model is valid. The Sargan/Hansen test for joint validity of the instrument variables is standard after the GMM estimation (Roodman, 2009, p.119). The Sargan/Hansen

test shows that instruments are significant. Furthermore, the two tests of validity of estimators show both the absence of serial correlation, AR (1) is significant and AR (2) is not (Blundell & Bond, 1998).

Model II presents that impact of technology on woman employment at regional level for Turkey. The first lag of dependent variable is significant, while the second lag is insignificant. Moreover, total of these variables are less than one, so the model is stable. However, estimators are not significant, because AR (2) is not significant in this model. Hence, there is correlation between variables.

It is investigated that the impact of technology on man employment at regional level for Turkey in Model III. The first lag of dependent variable is significant, while the second lag is insignificant. The total of lagged dependent variables is less than one, so the model is stable. The relationship between technology and man employment is the inverse U-shape. The trade openness has positively affected man employment. The Wald, Sargen/Hansen tests supports the results. For testing serial correlation, AR (1) and AR (2) are employed. AR (1) is significant, while AR (2) is not. Therefore, there is no correlation problem between variables.

It is researched that the impact of technology on employment of higher education graduates at regional level for Turkey in Model IV. The first and second lags of dependent variables are significant and total of these are less than one, so the model is stable. The magnitude of these coefficients is so similar in all our following studies. Lachenmaier and Rottmann (2011) use two lags of dependent variables. They find the first lag lies between 0,679 and 0,744, while the second lags are between 0,13 and 1,55. The relation between technology and employment of higher education graduates is strongly significant. A one percent increase in *lnrd* leads to go up employment of higher education graduates by 0,754 percent. This result is consistent with Van Reenen (1997), Piva and Vivarelli (2004), Lachenmaier and Rottmann (2011), Bogliacino, Piva & Vivarelli (2012; 2014), Piva and Vivarelli (2017), and Aydın (2018). However, this relationship is the inversed U-shape.

The square of *lnrd* is statistically significant and negative. Hence, a one percent rise in *lnrd*<sup>2</sup> leads to go down employment of higher education graduates by 0,026 percent. This result is not in line with Bogliacino (2014).

The trade openness has positively affected employment of higher education graduates. Accordingly, a one unit increase in trade openness (*to*) leads to go up employment of higher education graduates by 0,168 units. Unlike Asaleye et al. (2017), this result is consistent with Casacuberta, Fachola & Gandelman (2004), Meschi, Taymaz & Vivarelli (2011, 2016) and Assaf (2018). Using the diagnostic test after the estimation, the results are checked. The Wald, Sargan/Hansen tests are statistically significant. While AR (1) test is statistically significant, AR (2) is not.

Unlike previous studies, the square of the innovation variable (*lnrd*) is used to analyze, whether the labor demand model is linear in this study. The results suggest that there is an inverse U-Shape relationship between technology and employment at regional level for Turkey. This impact is clear in the employment of higher education graduates

## 5. Conclusion and Discussion

This paper examines the impact of technology on employment at the regional level for Turkey over the period 2010-2017. According to the results of the system GMM, there is a significant relationship between technology and overall, man employment, and employment of higher education graduates. This relationship is the inversed U-shape. Especially, the technology has significantly a strong impact on employment of higher education graduates. These results are in line with Meschi, Taymaz & Vivarelli (2011; 2016) and Aydın (2018). Furthermore, the trade openness has positively affected employment. This result is supported by Casacuberta, Fachola & Gandelman (2004), Meschi, Taymaz & Vivarelli (2011; 2016), and Assaf (2018). Moreover, the significant results statistically could not be obtained for woman employees. This may arise from woman labor force participation rate is lesser than that of man in Turkey.

In the light of these findings, in order to achieve 2023 Economic Goal, Turkey should increase public and private investments in terms of the R&D. These investments should be labor-friendly. In order for the existing employment to be compatible with the technology, the qualifications of the employees should be increased. Otherwise, many unqualified people will lose jobs and existing unemployment will increase, as the R&D expenditure increases.

Additionally, politicians should determine primary sectors that contribute to directly employment and growth. Later, they should invest to these sectors. Tax credit policy should be applied such as Netherlands, France, and the UK. The discrepancies and prosperities of region should be considered in the R&D polices.

Finally, university-industry-government collaborations should be further increased in determining the R&D policies. In this context, amount and scope of financial supports should be enhanced for scientific projects in public and private sector.

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