Research Article

The Impact of Technological Advancement on Unemployment in Turkey

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Abstract: Technological advancements have been reshaping industries and economies worldwide. As technology evolves, questions arise about its impact on employment. This study aims to investigate the relationship between technological advancement and unemployment over the period from 1991 to 2020. The objective of this research is to examine the influence of various factors, including Patent Assistance (PA) residents, Gross Domestic Product per capita (GDPpc), Gross Capital Formation (GCF), and the Consumer Price Index (CPI), on the unemployment rate (UEMP). We seek to understand these variables' long-term and short-term effects on unemployment. We utilized data from the World Bank for our analysis. The study employed the Auto Regressive Distributed Lag (ARDL) methodology to explore the dynamics between technological advancement and unemployment. This method allows us to investigate both short-term and long-term relationships. Our analysis revealed interesting insights. In the long run, we observed that GCF and CPI negatively influenced unemployment, indicating that an increase in these variables is associated with a reduction in unemployment. However, PA had a positive impact on UEMP, although this effect was not statistically significant. In the short term, GCF, GDPpc, and CPI all had a negative effect on UEMP. These findings carry important policy implications. They suggest that fostering startups and entrepreneurial ventures can drive technological innovation and job creation. To support this, policymakers should focus on creating an enabling environment for startups by reducing bureaucratic barriers, streamlining business registration processes, and providing financial and mentoring support. Encouraging entrepreneurship has the potential to unleash innovative ideas, create new ventures, and generate employment opportunities, particularly for the youth population.

Keywords: GDP per capita, gross capital formation, consumer price index, technological advancement

1. Introduction

The advancement of technology has impacted sectors and labor markets all across the world, propelling economic growth and cultural change. The effect of technology improvement on employment has evolved into a crucial concern for politicians and scholars as nations work to maintain their competitiveness in the increasingly online and innovation-driven world. Turkey is not an exception to this trend, with its expanding economy and lofty technological advancement aspirations. It is crucial to understand how technological progress affects Turkiye's unemployment rate

when developing effective strategies to encourage inclusive growth and solve the problems posed by technology and digital. Even traditional economists have studied the topic of whether technological advancements would create or destroy jobs. Public policy has long been influenced by the worry that new technology may result in fewer jobs being created. The fundamental justification for this anxiety is the ambiguity around how technologies will affect the labor market. There are several compensating effects that might lessen the initial impact of innovations and make the final result unpredictable (Piva & Vivarelli, 2005). The extent of unemployment and people's chances of finding work are reflected by the unemployment rate, which is a crucial measure of the economy's health and social well-being. To effectively solve unemployment issues and promote inclusive growth, policymakers, academics, and stakeholders must have a clear understanding of the link between technology innovation and the unemployment rate. Through the use of an array of pertinent independent variables, such as the GDP per capita, patent assistance, gross capital formation, and the consumer price index, this study seeks to analyze the effect of technological innovation on the unemployment rate in Turkiye. We may learn more about the complicated link between technological development and unemployment by examining these variables, which will help us understand the possible impacts on the dynamics of the labor market and employment trends. A number of theoretical frameworks offer helpful insights into how technology growth and employment interact to lay the groundwork for this investigation. Joseph Schumpeter, an economist, introduced the creative destruction hypothesis, which highlights the transformational character of innovation. According to this idea, new technologies disrupt current businesses, resulting in the loss of some employment but the development of new possibilities in developing industries. This theory will act as a framework for understanding the possible effects of technological development on Turkiye's unemployment rate. Additionally, this study will refer to previously published works and empirical investigations that have looked at the connection between technology development and labor market dynamics. Studies by Acemoglu and Restrepo (2019) and Autor et al. (2020) draw attention to the diverse impacts of automation and technological development on various workforce sectors, raising the possibility of inequities in the impact on low-skilled employees, youth, and women. Policymakers may create tailored policies to reduce any negative effects and advance equal employment outcomes in the face of technological disruption by taking these details into account. By using the ARDL restricted testing technique in our research, we can examine the kind and existence of the interaction among the variables over the long term, as well as the volatility in the short run and the shifts that take place as the system approaches the long-run equilibrium. We also looked at the rate of change toward long-run equilibrium using the Error Correction Model (ECM). Again this research is vital because technological advances are reshaping economies worldwide, which has altered economies worldwide, generating concerns about the impact on employment. With the rise of automation, artificial intelligence, and other technological breakthroughs, there is rising anxiety about job displacement and unemployment. Understanding the connection between technological innovation and unemployment is critical for governments, corporations, and society to handle the difficulties and possibilities provided by these changes in a proactive manner. The purpose of this research is to address the policy-level issue of controlling the consequences of technology innovation on employment. As technology advances, governments and politicians must devise measures to balance the advantages of technological advancement with the potential for job disruption. They must develop measures to guarantee that technological progress promotes economic growth and job creation rather than worsening it. The sample period of 1991 to 2020 was perhaps chosen to provide a complete assessment of the influence of technology improvement on unemployment over a long period of time. This prolonged time frame permits the research to capture the effects of technical and economic advancements over this time period. It also allows for the detection of trends and patterns in data that may be used to guide policy choices. Furthermore, employing the World Bank's data assures the information's dependability and consistency, which is critical for making sound policy recommendations.

1.1 *Justification of the study*

Turkey's economic environment is unusual, with traditional sectors coexisting with a thriving technological industry. Investigating the influence of technology innovation on unemployment in this context might give insight into the simultaneous existence of two opposing economic forces. Turkey has a big young population that is ready to join the digital economy. Investigating the effects of technological advancement on employment can aid in the development of strategies for maximizing the demographic dividend. The study's findings should help Turkish officials understand how to foster technological innovation while minimizing negative consequences on employment. Balancing prosperity with

social inclusion is a major problem for the country's authorities. Ultimately, the Turkish experience is relevant beyond its boundaries. As technological improvements affect labor markets throughout the world, the lessons learned from Turkey's instance can contribute to a larger discussion about controlling the impact of technology on unemployment.

1.2 *Research hypothesis*

The research posed some hypotheses subject to testing these hypotheses are formulated as follows;
• H_0: Technological Advancement has little to no influence on the Unemployment rate in Turkiye.
• H_1: Technological Advancement has a significant impact on the Unemployment rate in Turkiye.

1.3 *Research questions*

In this paper, Investigations were carried out to see the short-term and long-term correlation between technological advancement and the Unemployment rate using Turkiye as the research focus. In this paper a number of questions were asked;

i: To what extent does the adoption of advanced technologies in Turkish industries correlate with changes in the unemployment rate over the past decade?

ii: What role does government policy play in mitigating the impact of technological advancement on unemployment in Turkey?

iii: Is technological advancement an important feature to look out for when curbing problems of high Unemployment rate?

1.4 *Significance of the study*

The importance of this research resides in its potential to enlighten decision-makers, economists, and politicians about the substantial effects of technology innovation on employment. Our study provides stakeholders with vital insights into managing unemployment concerns in a more digital and automated world by putting light on the complexities of this connection.

Understanding how technological progress affects the unemployment rate is critical for developing effective policies, aiding worker adaptation, and encouraging innovation. This research adds to the current debate over the future of work and the role of technology, eventually driving attempts to develop long-term job prospects in an ever-changing global economy.

This study is organized as follows: Studies on the connection between technological innovation and unemployment are covered in Section 2, with a particular emphasis on the Turkiye situation. The study's methodology and data sources are described in Section 3. Section 5 highlights the results and their policy implications and Section 4 gives the data analysis and comments.

2. Literature review

The global economy has grown and undergone change as a result of technological innovation. It has the ability to completely alter sectors, boost productivity, and significantly alter employment trends. Researchers, decision-makers, and economists have all shown a keen interest in the relationship between technology innovation and unemployment. Understanding the link between technical development and unemployment is crucial in the case of Turkiye, a nation that is fast developing and places an increasing premium on technology innovation. This study of the literature attempts to examine previous research and offer insights into how Turkiye's unemployment is affected by technological innovation.

2.1 *Technological advancement and labor market dynamics*

The dynamics of the labor market can alter as a result of technological innovation, which has the potential to both generate and eliminate employment. The link between technical development and unemployment in Turkey has been the

subject of several studies. For instance, Özcan and Karaoglan (2017) discovered that technical developments, especially in the industrial sector, have influenced job loss and structural unemployment. Arslan and Okten (2020), on the other hand, made the case that technological development had resulted in skill-biased technological change, increasing the need for skilled labor and decreasing the demand for low-skilled employees.

2.2 *Impact on the demand and supply for labor: labor*

Both the supply and demand of labor in Turkiye are impacted by technological innovation. In their 2018 study, Nader and Yldrm showed how technological advancements have reduced the worker share of revenue and increased productivity. This implies that companies have been using capital instead of workers, which might result in job losses. In addition, Aydemir and Yazici (2019) discovered that technological improvements have changed Turkiye's employment structure, favouring higher-skilled jobs.

2.3 *Empirical review*

According, to Boone (2000). In this study, a model with endogenous innovation form is presented. It has been demonstrated that businesses overinvest in technologies that lower labor costs and underinvest in improving quality because of labor market flaws that cause wages to rise beyond the shadow price of labor. As a result, compared to the social optimum, the market's outcome has poorer long-term growth, more unemployment, and worse well-being. It is further demonstrated that as wages rise it is more motivated to reduce labour. Finally, when competition rises, businesses that perform below average in terms of quality are more motivated to shrink.

Also, Prat (2007) in a common search-matching scenario, this research investigates the link between disembodied technical advancement and unemployment. We discover that the degree of idiosyncratic uncertainty has a substantial influence on the correlation's sign. The study reveals a novel impact whereby an increase in growth increases the workers' outside choice, which in turn increases the endogenous rate of job separation. The capitalization impact is outweighed by the outside option effect for reasonable parameter values, increasing the unemployment rate as a result of disembodied technical advancement.

In addition, technology may only result in improved performance or higher productivity when it is coupled with other resources by human resources in an efficient manner, or when it is used ethically and productively Dauda and Akingbade (2011).

According to Lawless and Anderson (1996), advancement increases employee effectiveness and increases business efficiency. The performance of a company can also be enhanced through technological innovation (Deng et al., 1999). Through training, employees can develop their skills and knowledge more quickly (Chi et al., 1989). Technology growth is directly impacted by staff motivation (Hennessey & Amabile, 1998).

Furthermore, Cang (2017) made use of a cutting-edge state-level macroeconomic methodology to investigate how technology advancements affect employment. This paper finds that although technological advancements have a non-significant impact on employment at the general state level, there are a few factors that determine how well each state's labor market responds to technological changes. It does this by using commercially-supplied Research and Development expenditure as a proxy. More precisely, states that lack urbanization, lack technological sophistication, or have a high proportion of employees engaged in the manufacturing or lodging and food services industries are more affected by unemployment than other states. The findings also imply that, in contrast to the Clinton and Bush Administrations, technological advancements had a greater negative impact on the unemployment rate under the Obama Administration.

Again, Matuzeviciute et al. (2017) in their article, the consequences of technological advancement on employment in the short and long-term are compared. It proposes a straightforward model of frictional unemployment that captures the detrimental consequences of technological development on employment, including creative destruction. Long-term, quicker technology advancement speeds up job obsolescence, which lowers the equilibrium employment level.

Correspondingly, Susskind (2017). Susskind looked at the claims that because machines will replace workers in some technical advancements, there will be a rise in unemployment. According to others, technological advancements can enhance working conditions and have a decreasing impact on unemployment because each one creates new job opportunities. His paper's objective was to investigate how innovation affects unemployment. Using the panel threshold model, data from 12 EU nations with high and low levels of innovation were examined from 1998 to 2015. Both

high and low regimes of innovation have impacts that will raise unemployment. In both regimes of innovation level, technological advancement raises the unemployment rate in both nation groupings.

Further, Lydeka and Karaliute (2021) the authors assessed the Effect of Technical Innovations on Unemployment in the European Union Countries and utilized data from 28 member states of the EU from 1992 to 2016 to examine the relationship between technological advancements and the unemployment rate. A panel data system's dynamic two-step Generalized Method of Moments (GMM-SYS) was used to estimate the model. The findings of combining 12 distinct estimations of the model with each other imply that technical advancements can sometimes have an impact on unemployment.

Finally, Lima et al. (2021) in their research work examined the conversation about the scale of the impact of automation by identifying the key societal effects it will have and outlining the appropriate responses. In order to do this, they looked at the literature on technological unemployment that has been published since 2000 and was located in Scopus and Web of Science, providing an academic perspective on the steps that must be taken to address the social effect of automation. Our findings synthesize the causes, effects, and remedies for technological unemployment that have been reported in the literature. We also discovered that the writers are primarily from developed economies like the United States, Europe, and New Zealand and that the literature is primarily focused on the fields of philosophy, sociology, and economics.

Also, Udeagha and Breitenbach (2023). There is a substantial resemblance between the study on the effect of fiscal decentralization on carbon dioxide emissions in South Africa and the study on the influence of technological innovation on unemployment. Both studies investigate the intricate link between policy actions and economic and environmental impacts. While the first study emphasizes the potential for fiscal decentralization to lead to a "race to the top" in environmental standards, lowering carbon emissions, the second study emphasizes the importance of fostering innovation-driven industries and promoting technological advancement in order to create job opportunities. Both situations highlight the importance of government policy and decentralization. The findings imply that a strategic approach to policymaking can result in favorable consequences regarding environmental protection or job creation.

Futhermore, Udeagha and Breitenbach (2023) two essential factors emerge in the shifting landscape of economic development and sustainability: the influence of technical improvement and the requirement to solve environmental concerns. The research on the impact of technological advances on unemployment digs into the complex link between innovation and employment, emphasizing the significance of strategic governmental interventions to adapt to a changing labor market. Simultaneously, environmental sustainability research emphasizes the need for innovation, particularly eco-innovation, and judicious economic decentralization in mitigating ecological damage and working toward environmental goals. Both studies highlight the critical importance of technology, innovation, and deliberate policy design in accomplishing larger socioeconomic and environmental goals, providing useful insights for politicians and scholars alike. The data used in the paper were sourced from the World Bank database.

3. Data, theoretical framework, and methodology

The authors employed the secondary source of data collection to gather information for the regression analysis. The World Bank database Indicators provided the paper with data. The investigation is designed to last 30 years, starting in Turkiye in 1991 and finishing in 2020. The data collected were annual time series data. Unemployment Rate (UEMP) as the dependent variable, Patent (PA), GDP per capita (GDPpc), Gross Capital Formation (GCF), and Consumer Price Index (CPI) are the independent variables. Thus, the model of this study is presented as:

$$UEMP = f(PA, GDPpc, GCF, CPI) \tag{1}$$

The log of each variable is considered to control for outliers (Somoye et al., 2022). Thus, equation 1 will be:

$$LUEMP = \alpha_0 + \beta_1 LPA_t + \beta_2 LGDPpc_t + \beta_3 LGCF_t + \beta_4 LCPI_t + \Phi_t \tag{2}$$

$\beta_1 - \beta_4$ are the coefficients of the independent variables; α_0 is the intercept; t is the time period, and Φ_t is the error

term.

3.1 *Measurements of variables*

Table 1 includes the variables, related definitions, and source of them.

Variable	Notation	Measurement Scale	Source
Unemployment Rate	UEMP	The unemployment rate is a ratio of the number of unemployed individuals to the total labor force. It has a true zero point, making it a ratio scale.	World Bank Indicator
Patent Assistance	PA	Patent Assistance usually refers to assistance, direction, or services given to people, companies, or other entities when applying for and maintaining patents. A patent is a type of intellectual property that gives the owner of the patent temporary exclusivity over an invention.	World Bank Indicator
Gross Capital Formation	GCF	The whole value of new physical assets-such as buildings, machinery, and equipment-that are acquired by families, enterprises, and governments is known as gross capital formation. It's quantified using a ratio scale.	World Bank Indicator
GDP per capita	GDPpc	GDP per capita is the total Gross Domestic Product of a country divided by its population. It has a true zero point, making it a ratio scale.	World Bank Indicator
Consumer Price Index	CPI	The Consumer Price Index (CPI) calculates how much urban consumers have spent on average over time for a market basket of goods and services. Because there is no clear interval scale interpretation for the disparities between index values, it is usually regarded as ordinal.	World Bank Indicator

3.2 *The creative destruction theory*

Joseph Schumpeter, an economist, did in fact advance the creative destruction idea. His 1942 paper "Capitalism, Socialism, and Democracy" established this idea. In order to promote economic growth and development, Schumpeter highlighted the significance of innovation, entrepreneurship, and the dynamism of the capitalist system. A vital aspect of Schumpeter's notion of creative destruction is the continual introduction of new goods, innovations, and models of business that displace and disturb the status quo. While simultaneously generating new possibilities and advancing the economy, this continual innovation kills old sectors, employment, and economic institutions (Schumpeter, 1942). He thought that entrepreneurs were essential to this process. Entrepreneurs are those who challenge the existing quo by introducing innovative ideas, goods, and procedures to the market. Their inventive acts promote economic transformation and growth by upending established industries and creating new ones. According to the hypothesis of creative destruction, while this process may cause short-term disruptions like job loss and failures of businesses, it ultimately promotes long-term economic growth. New technology and creative methods are adopted, which boosts productivity, improves efficiency, and creates further sources for job creation and financial activity.

The creative destruction hypothesis developed by Schumpeter has had a considerable impact on our knowledge of economic dynamics as well as on following studies and discussions on technical advancement, entrepreneurship, and innovation. It offers a framework for examining how changes in economic conditions, technological development, and the growth of marketplaces for goods services and jobs interact.

The notion of technology-related unemployment originated from the long-held belief that labor markets might be disrupted by technical improvements, an idea supported by traditional economic theories such as those of Keynes and Schumpeter. Bennion (1943). These ideas contend that the adoption of new technology may make some skills outdated

and cause changes in the nature of work. This viewpoint has been modified by recent contributions from academics like Acemoglu and Restrepo (2020). who have highlighted that the influence of technology on employment depends on several aspects including skill complementarity and worker flexibility. These hypotheses are consistent with the concept that technical advancements have a major impact on the unemployment rate. This theory suggests that the dynamics of the labor market may be significantly impacted by technological advancements.

Patents are recognized by innovation theories, such as those put forth by Mowery and Teeceet (2008) as markers of intellectual activity and technical advancement. In addition to providing legal protection, patents are regarded as indicators of innovation and future economic growth. Building on this theoretical basis, the idea of Patent Assistance as a stand-in for technical progress implies that higher patent activity translates into higher levels of creativity and technological complexity. The theory that technological progress, measured by the labor force participation rate, has a major effect on unemployment rates is consistent with theories of innovation. These theories suggest that higher levels of invention, as evidenced by patent assistance, have an effect on the labor market. See Figure 1.
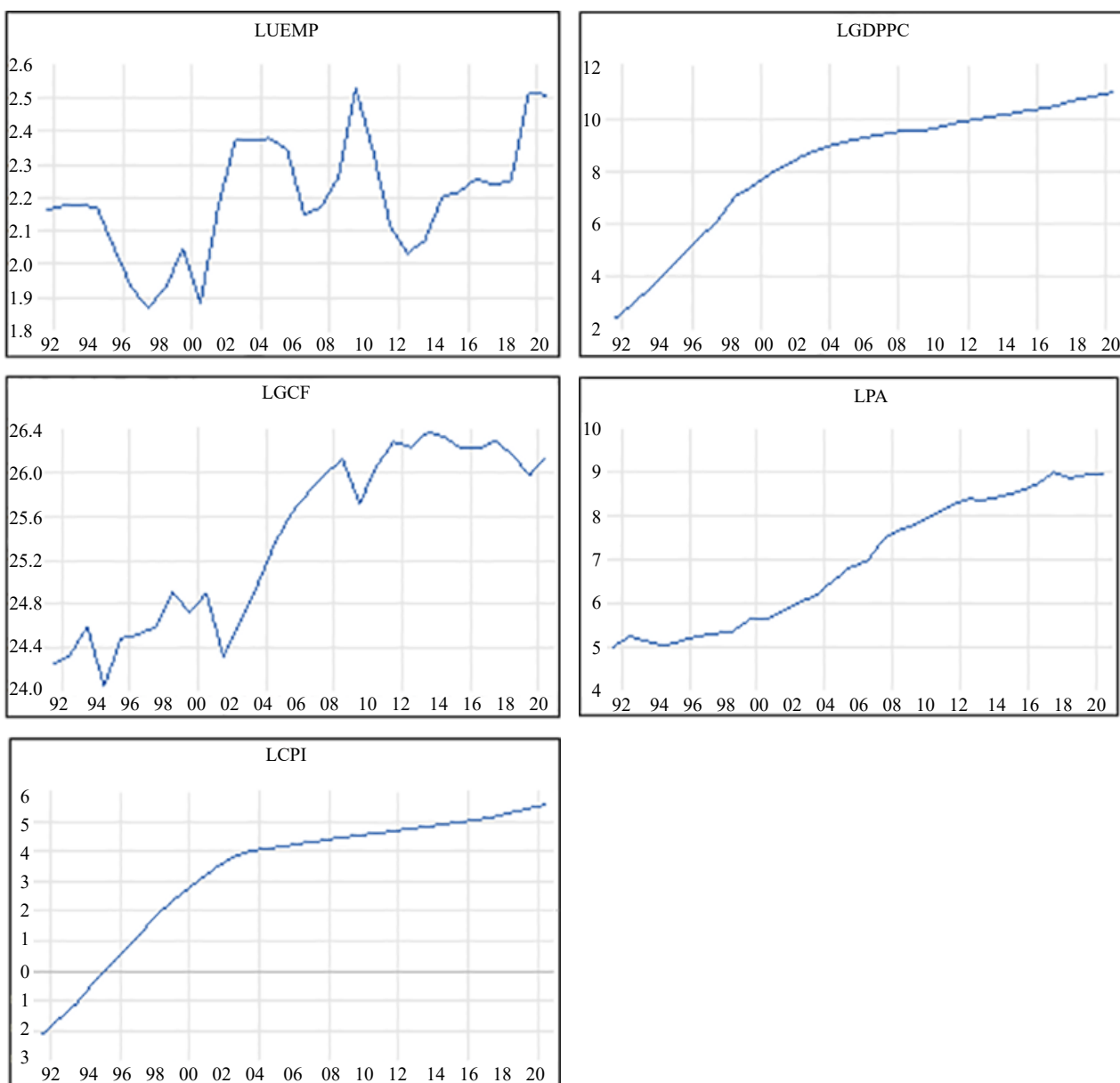

Figure 1. Trends of variables

The figure shows; that the unemployment rate is the proportion of the labour force that is jobless and actively looking for work at a given time, the graph depicts the unemployment rate's changes throughout time. Beginning in the early 1990s, there is a general increasing tendency, which is followed by a slow drop until around 2000. There was a minor uptick from 2000 to 2010, which was followed by a declining trend till 2019. The unemployment rate does, however, slightly increase in 2020. Overall, the trend indicates a pattern of varied variations, but with a recent general decreasing tendency.

Secondly, Governments offer inventors or assignees of patents exclusive rights over their creations. They offer innovative and beneficial innovations and legal protection by prohibiting unauthorized use, production, or sale of the invention the trend in the statistics for patents over time indicates a growth in the number of patents issued. Although the values may change from year to year, overall there is an upward trend, which suggests that innovation and intellectual property protection are on the rise.

Thirdly, the nation's economic output per citizen is measured by its gross domestic product (GDP) per capita. It is the total value of all products produced in a nation over a specific time period divided by the population. The graph shows a steady increase in GDP per capita. There are swings, especially during economic downturns like the 2008-2009 financial crisis. Nevertheless, the overall trend indicates a consistent rise over time. This is a sign of economic expansion and an increase in either the median income or the general well-being of the populace.

Fourthly, Gross Capital Formation, commonly referred to as an investment, is the sum of the value of new capital goods purchased in an economy during a certain time period, such as construction, machinery, and equipment. It shows the amount of capital accumulation and investment. The graph shows that gross capital formation is generally growing. Despite some variations, the general pattern reveals a long-term increase in investment and capital accumulation. This implies an increase in spending on infrastructure, physical resources, and production capability.

Fifth, the Consumer Price Index is an estimate of how prices consumers pay for a selection of products and services have changed on average over time. It is used to compare price levels over various time periods in order to measure inflation and the buying power of money. The graph shows that the consumer price index is on the rise, which reflects inflationary pressures. The values steadily climb over time, showing an increase in the general level of prices. Increased demand, supply-side restrictions, or monetary policy are just a few examples of variables that might have an impact on inflationary pressures.

3.3 *ARDL model*

The ARDL model proposed by Pesaran et al. (2001), which is very suitable for small sample sizes, is given as follows:

$$\Delta \text{LUEMP}_t = \alpha_{0j} + \sum_{i=1}^{p} \beta_{ij} \Delta \text{LPA}_{t-1} + \sum_{i=1}^{q1} \beta_{2j} \Delta \text{LGDPpc}_{t-1} + \sum_{i=1}^{q2} \beta_{3j} \Delta \text{LGCF}_{t-1}$$

$$+ \sum_{i=1}^{q3} \beta_{4j} \Delta \text{CPI}_{t-1} + \text{ECT} + \mu_i + \varepsilon_{it} \tag{3}$$

Where LUEMP represents the unemployment rate in the paper the dependent variable; PA represents patent assistance, GDPpc represents Gross Domestic Product per capita, GCF represents Gross Capital Formation CPI represents the Consumer price index (2010 = 100). β_1, β_2, β_3 and β_4 are the coefficients of the variables. β_0 is the constant and ε_{it} is the error term. The apriori expectation is PA is predicted to have a negative impact on LUEMP ($\beta_1 < 0$) GDPpc is expected to impact LUEMP negatively ($\beta_2 < 0$), GCF is predicted to have a negative impact on LUEMP ($\beta_3 < 0$), ECT represents the Error Correction Terms and CPI is predicted to have a negative impact on LUEMP ($\beta_4 < 0$).

4. Results and interpretation
4.1 *Descriptive statistics*

In Table 2, LGCF has the highest mean, median, maximum, and minimum values at 25.40817, 25.6776, 26.37115,

and 24.0506, respectively. LUEMP has the lowest mean, median, and maximum values at 2.196629, 2.177135, and 2.527966 respectively, while LCPI has the lowest minimum at -2.12928. LUEMP, and LPA both have a positive skew at 0.040512, and 0.023832, while LGDPpc, LGCF, and LCPI are negatively skewed at -1.03271, -0.24581, and -1.13686 respectively. Also, all variables' kurtosis values are platykurtic since they are less than 3. In addition, LUEMP, LPA, and LGCF are normally distributed at 0.860874, 0.190923, and 0.178924, while LGDPpc and LCPI are not normally distributed at 0.068179 and 0.039513 respectively. The RADAR chart is presented in Figure 2.

Table 2. Descriptive statistics

|	LUEMP	LPA	LGDPPC	LGCF	LCPI
Mean	2.196629	6.960621	8.248143	25.40817	3.255319
Median	2.177135	6.905157	9.272351	25.6776	4.233245
Maximum	2.527966	9.008836	11.00212	26.37115	5.573004
Minimum	1.868103	4.997212	2.43275	24.0506	-2.12928
Std. Dev.	0.176619	1.495188	2.512037	0.800878	2.257962
Skewness	0.040512	0.023832	-1.03271	-0.24581	-1.13686
Kurtosis	2.517167	1.372995	2.823919	1.415204	3.003838
Jarque-Bera	0.299615	3.311771	5.371241	3.441585	6.46227
Probability	0.860874	0.190923	0.068179	0.178924	0.039513
Observations	30	30	30	30	30
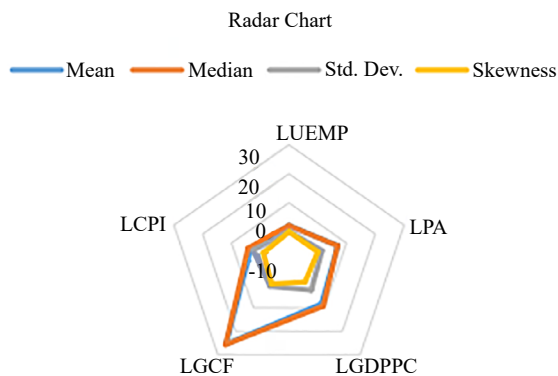
Figure 2. RADAR Chart

4.2 *Unit root test*

The unit root tests, specifically the Augmented Dickey-Fuller (ADF) test and the Phillips-Peron (PP) test, were employed to examine the stationarity properties of the variables in your study. Stationarity is crucial in time series analysis as it ensures stable statistical properties over time. The results of both tests indicate that all variables are stationary at a mix of level I(0) and first difference I(1). This suggests that the variables exhibit stable behavior after differencing, indicating the absence of unit roots. The stationary nature of the data provides a solid foundation for conducting further analysis and making reliable forecasts. See Table 3.

Table 3. Unit root test

ADF				PP			
Variables	T-Statistics	Prob	Integration	Variables	T-Statistics	Prob	Integration
LUEMP	-4.492213	0.0014	I(1)	LUEMP	-5.177895	0.0002	I(1)
LPA	-4.402496	0.0017	I(1)	LPA	-4.578489	0.0011	I(1)
LGDPpc	-3.260734	0.0272	I(0)	LGDPpc	-6.317022	0.0000	I(0)
LGCF	-6.725843	0.0000	I(1)	LGCF	-6.719783	0.0000	I(1)
LCPI	-4.420727	0.0017	I(0)	LCPI	-6.239974	0.0000	I(0)

4.3 *ARDL bounds test*

Table 4 shows evidence of long-run co-integration. This is because F-statistics (7.003240) is greater than the lower bound or I(0) and the upper bound I(1) values at 0.05 level of significance. As a result of a co-integrating relationship, the long and short-run ARDL model can be examined.

Table 4. ARDL bounds test

		Sign	Lower Band	Upper Band
F-statistic	7.003240	10%	2.2	3.09
k	4	5%	2.56	3.49
-	-	1%	3.29	4.37

4.4 *ARDL long-run analysis*

The findings in Table 5 indicate that, over the long term, LGCF has a negative relationship with unemployment and as Gross capital formation begins to grow the unemployment rate in Turkey reduces by 54.64%. The Consumer Price Index has a negative relationship with the unemployment rate as CPI increases by a percent change in the long run unemployment drops by 67.75%. The ARDL long-run results show that Technological advancement does not influence unemployment basically because technological advancement is not meant to kick people out of employment but to improve, and make life easier. The ARDL long-run test agrees with the results found by Cang (2017) in his paper investigating the impact of technological advancement on employment. The long run results of this show that although patent assistance shows a level of positive impact on unemployment in Turkiye, it's non-significant.

Table 5. Long-run analysis

Variable	Coefficient	Std. Error	T-Statistics	Prob*
C	13.2373	3.615473	3.661292	0.0021**
LPA	0.070798	0.1123	0.630439	0.5373
LGDPPC	0.610735	0.355308	1.718886	0.1049
LGCF	-0.54648	0.170308	-3.20875	0.0055**
LCPI	-0.67751	0.366251	-1.84985	0.0829***

4.5 Short-run analysis

The ARDL short-run analysis provides insights into the relationship between various variables and labor force participation rate (LUEMP). The findings indicate that LUEMP is influenced by several factors. The constant term suggests a positive baseline level of labor force participation. An increase in LUEMP positively affects itself, indicating a self-reinforcing effect.

However, variables such as patent assistance (LPA) and consumer price index (LCPI) do not show significant relationships wlabourith LUEMP in the short run. On the other hand, a decrease in gross domestic product per capita (LGDPpc) and gross capital formation (LGCF) leads to a decrease in LUEMP after a lag of two periods, suggesting an inverse relationship between economic performance and force participation.

According to the Table 6, the error correction model (ECM) highlights the dynamic adjustment process, indicating that any deviations from the long-run equilibrium are corrected by 88% in the short run. Overall, these findings provide valuable insights into the factors influencing labor force participation in the short term, contributing to a better understanding of the dynamics in the labor market. According to your findings, "LPA" has a positive correlation with the outcome variable, with a coefficient of 0.062329. It can be argued that your results support the idea that technological advancements can reduce unemployment when combined with Susskind's findings that technological advancements increase the unemployment rate in both high and low regimes of innovation (Susskind, 2017) and your positive coefficient for "LPA" as a proxy for technological advancement (although not significant). The following papers by past authors support the findings of this paper; this paper included Acemoglu and Restrepo (2019), Auto et al. (2015), and Brynjolfsson and McAfee (2014). These papers provide valuable insights into the relationship between technology and employment dynamics, supporting the idea that technological advancements can have mixed effects on unemployment rates depending on various factors.

Table 6. Short-run analysis

Variable	Coefficient	Std. Error	T-Statistics	Prob*
C	11.65385	3.758241	3.10088	0.0069**
LUEMP	0.630367	0.122022	5.166029	0.0001**
LPA	0.062329	0.10226	0.60952	0.5507
LGDPpc(-2)	-0.514574	0.195392	-2.63355	0.0181**
LGCF	-0.481106	0.159501	-3.016322	0.0082**
LCPI	-1.659965	0.874691	-1.897773	0.0759*
ECM	-0.88038	0.118548	-7.426339	0.0000**
Adj R-squared	0.801247	-	Prob(F-statistics)	0.000016
F-Statistics	11.48155	-	Durbin-Watson	1.568047

4.6 Diagnostic tests

The serial correlation-LM test results in Table 7, showed that the probability is greater than 0.05 level significance. Thus, we can conclude that there is no autocorrelation between the variables used in this study. In the Heteroskedasticity test, the null hypothesis is rejected since the probability value, which is 0.9062, is higher than the standard 5% level of significance. The normality test showed that variables are normally distributed as the probability is greater than 0.05. The graph in Figure 3 shows that the model is stable and reliable at a 5% level of significance. This is so because the blue line represents the variables and is between the significant red lines.

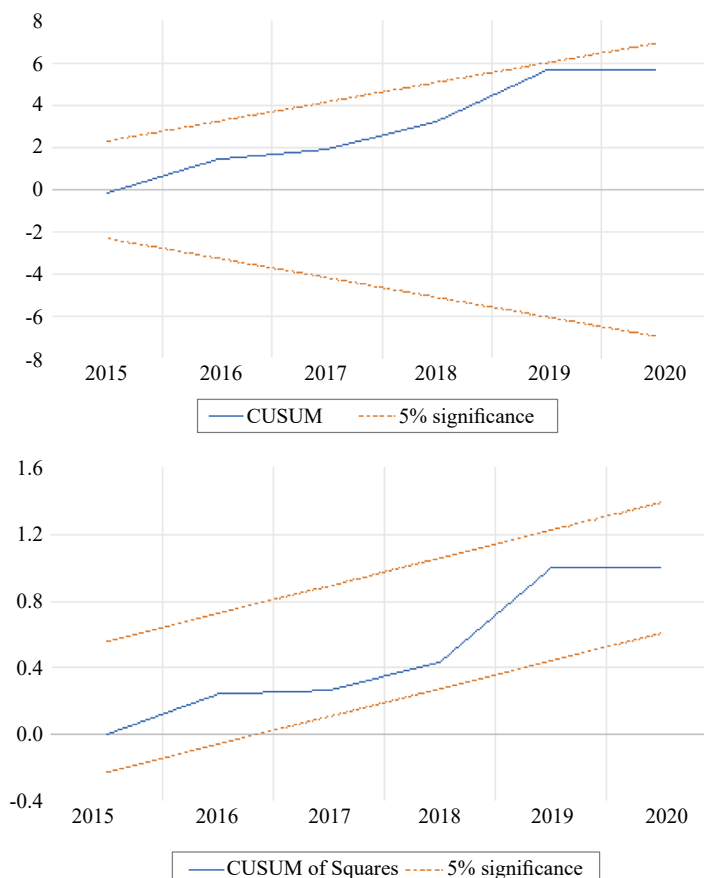| Normality Test		Serial Correlation LM Test		Heteroskedasticity Test	
Jarque-Berra	Prob.	F-statistic	Prob. F (2, 14)	F-statistic	prob. F (22, 9)
1.387087	0.499802	0.811619	0.464	0.437641	0.9062

Figure 3. CUSUM and CUSUM of Sq: Source Eviews 12

4.7 Discussion of results and link to research hypothesis

- H_0: Technological Advancement has little to no influence on the Unemployment rate in Turkiye.
- H_1: Technological Advancement has a significant impact on the Unemployment rate in Turkiye.

In the long run, this hypothesis is supported by showing that in the long run, technology does not influence the unemployment rate in Turkiye, and this may be a result of the slow acceptance of AI and other high-tech sectors like fintech in the region. The coefficient for LPA is not statistically significant at the 0.05 level, suggesting that, in the short run, changes in patent assistance are not associated with significant changes in the unemployment rate. Therefore, based on this analysis, there is no strong evidence to reject the null hypothesis that technological advancement, as proxied by LPA, has little to no influence on the unemployment rate in Turkiye in the short run.

5. Conclusion and policy recommendations

This paper examined the correlation between Turkey's unemployment rate and technological advancement using the ARDL methodology from 1991 to 2020. Unemployment Rate (UEMP) as the dependent variable, Patent Assistance residents (PA), GDP per capita (GDPpc), Gross Capital Formation (GCF), and Consumer Price Index (CPI) are the independent variables. The data employed in this research is from the World Bank. The Bounds test result showed evidence of long-run co-integration. In the long-run, GCF and CPI affect UEMP negatively, in the short run GDPpc, GCF, and CPI all have a negative effect on the unemployment rate. It is advised that the government and regulatory that the research shows that patent assistance (PA), which is a proxy for technical innovation, has a positive effect but is statistically insignificant. Policymakers should prioritize and encourage investment in R & D in order to fully realize the promise of technological innovation in lowering unemployment. Turkey should improve its technical prowess and promote employment growth in innovative industries by directing resources towards R & D activities, encouraging academic-industry partnerships, and supporting innovation-driven businesses.

The findings of this study agree with Cang (2017) uses a cutting-edge state-level macroeconomic methodology to investigate how technological advancements affect employment. This paper finds that although technological advancements have a non-significant impact on employment at the general state level.

The conclusions of this study have substantial significance for Turkey and beyond, given the changing environment of technology and its delicate interaction with employment. While our findings show that patent assistance (PA), as a proxy for technological innovation, had a statistically modest beneficial effect on unemployment, they highlight the essential significance of R & D expenditure. In recent times, the economic environment is increasingly defined by innovation-driven industries in which technological breakthroughs play a critical role. As a result, our findings emphasize the necessity of cultivating a culture of innovation inside the country. Policymakers in Turkey are being urged to emphasize and stimulate R & D investment, recognizing that innovative enterprises and academic-industry collaborations are potent engines of economic growth and employment. These initiatives are critical not just to realizing the promise of technological innovation in reducing unemployment, but also to ensuring Turkey's worldwide competitiveness. While our findings support the assumption that technological developments may not have a large influence on employment at the state level, they highlight the transformational potential of a targeted approach to innovation and technology in transforming the employment landscape in the coming years. As technology advances, nations may realize their full potential for long-term economic development and prosperity via smart investments and synergistic cooperation.

Numerous studies evaluating how technology affects unemployment frequently use general metrics or indicators. However, this work uses Log of Patent Assistance (LPA) in a novel way to provide a sophisticated stand-in for technical progress. This decision offers a distinct perspective on the dynamics of technological effect and allows for a more detailed analysis of how patent activity affects unemployment. This paper presents the Error Correction Model (ECM) in recognition of possible endogeneity problems in the link between technological development and the unemployment rate. It differs in that it addresses issues with bidirectional causation and strengthens the robustness of the calculated correlations with an analytical sophistication. Although many studies examine how technology innovation affects unemployment on a global scale, this research just analyzes Turkiye. By focusing on this particular setting, the study offers insights that are distinctive to Turkiye's distinct economic, social, and technical landscape, providing localized information that may guide focused policy responses. This research integrates the most recent theoretical frameworks to place itself at the forefront of modern economic theory. The incorporation of contemporary input from academics Autors, Acemoglu, and Restrepo guarantees that the study is not just based on traditional economic theories but also adaptable to the changing landscape of economic and technical debate.

5.1 *Policy recommendations*

• A competent staff is frequently needed for technological innovation in order to fully use new technology and boost production. Through specialized educational and training initiatives, policymakers should concentrate on improving technology literacy and digital literacy within the workforce. Turkey can develop its human capital and increase its employability in the digital economy by providing people with the skills they need to adapt to technological changes.

• Entrepreneurial endeavours and startups have the ability to spur technical advancement and job growth. By

lowering administrative hurdles, expediting the business registration procedure, and offering financial and mentorship help, policymakers should foster an atmosphere that is enabling for entrepreneurs. Encouragement of entrepreneurship may release creative ideas, launch new businesses, and produce job possibilities, especially for young people.

• The spread of innovations, information exchange, and technology transfer can all be facilitated by closer industry-academia partnerships. Partnerships and platforms for collaboration between academic institutions, research organizations, and for-profit businesses should be encouraged by policymakers. Turkey can speed up the adoption and application of technical advancements, resulting in the creation of jobs across a range of industries, by building an environment that promotes information sharing and applied research.

• Industry sectors with a strong potential for technological innovation and employment growth should be identified and supported by policymakers. By offering focused financial incentives, allowing access to finance, and developing specialized infrastructure and clusters, this may be accomplished. Turkey can establish itself as a center for cutting-edge industries, luring investments and creating job possibilities, by concentrating on businesses like information technology, sophisticated manufacturing, renewable energy, and digital services. Policymakers should place a high priority on inclusion and equity to make sure that the advantages of technological innovation are felt by all facets of society. By enhancing internet connectivity and granting access to digital tools and resources in disadvantaged regions, efforts should be made to close the digital gap. In order to empower people from underprivileged backgrounds and make it easier for them to participate in the digital economy, policymakers should also emphasize reskilling and up-skilling initiatives.

• For future research, although Log of Patent Assistance (LPA) was used in this study as a stand-in for technical advancement, more in-depth analysis of other metrics or indices that provide a more complete picture of technological progression may be explored in future studies. A more comprehensive knowledge of the technical landscape may be obtained by investigating developments in other industries and taking qualitative characteristics of innovation into consideration.

• Although the emphasis of this study is Turkiye, comparative analyses conducted in other nations may improve the generalizability of the results. Analyzing the impact of technical developments on unemployment in various economic environments can reveal trends, differences, and possible worldwide policy consequences.

Turkey can take advantage of technological innovation's potential to boost employment, promote economic growth, and produce a workforce that is prepared for the future by putting these policy ideas into practice. These policies have to be developed and put into action in a thorough and coordinated way, taking into account the unique opportunities and problems present in the Turkish environment. To make sure that policies are effective in reducing unemployment and fostering equitable growth, regular monitoring, review, and modification will be required.

5.2 *Limitation to the study*

The study was faced with various limitations but still doesn't contradict the results as the use of the auto-regressive lag model for regression shows an advanced method was utilized in the methodology aspect of the study. The following are some limitations of the study.

i. The reliability, availability and quality of the data utilized have a significant impact on the study's conclusions. The dependability of the results may be impacted if the data-gathering procedure has flaws or if it contains obsolete, erroneous, or incomplete information.

ii. The study's conclusions are predicated on a few premises that are part of the economic model used. Real-world economic processes are complicated, and assumptions about linearity, constant parameters, and other model requirements could not adequately represent this.

iii. It seems that short-term dynamics are the study's main emphasis. Analyses that focus just on the near term may miss structural changes or longer-term consequences that might become apparent over longer time horizons.

iv. Although the emphasis of this study is Turkiye comparative analyses conducted in other nations may improve the generalizability of the results. Analyzing the impact of technical developments on unemployment in various economic environments can reveal trends, differences, and possible worldwide policy consequences.

Conflict of interest

The authors declare no competing financial interest.

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