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The Importance of Creating a Competitive Advantage and Investing in Information Technology for Modern Economies: an ARDL Test Approach from Turkey

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Abstract The information age is one of the most talked about and argued topics in recent years. In this study, the importance of creating a competitive advantage in terms of economies in today's world is examined by using Turkish case. Causing a competitive advantage, "information" leads to differences among economies with its productivity effect. These new knowledge-based economies aim at sustainable growth and high productivity targets. In respect to the will of a knowledge-based economy to dominate the market and to lead this market, the distinguishing factors in the competition start to gain importance. Economies that want to create a competitive advantage are able to pull up their welfare level and realize their targets for being information societies in proportion to the importance they give to these factors. Research results show that information technology positively impacts the economic growth of Turkey in the short run and negatively in the long run.

Keywords IT investment · R&D investment · Economic growth · Knowledge · ARDL

JEL Codes C22 · O3

Introduction

The information age emerged as a result of information communication and technology revolution. The information age reminds the world that it is a big market, popular culture, technological, and similar developments, and these aspects influence life. Besides, the relationship between technology and knowledge concepts that causes or accelerates the information age is effective. For this reason, knowledge is one of the most important economic powers through using technology. Thus, the level of knowledge is the greatest challenge against economies. By this challenge, the

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developments that mostly affected economies can be seen as technological developments. The aim of this study is to argue about competiveness by using knowledge and the effects of technological developments on economies. For this purpose, competitive advantage in the information age was explained, the relationship with economy was set, and the positive and negative effects of technological developments were mentioned.

Knowledge as a Production Factor

Products such as computer software, media and entertainment content, new pharmaceuticals, and online commerce and banking services belong to the knowledge economy. Despite great diversity of functions and technologies, their common characteristic is that their production requires a relatively high intellectual input (knowledge) and depends less on the traditional production factors of labor and land. However, there is also an increasing knowledge content in the production and marketing of traditional products such as food, textiles, or tourism [48].

According to World [48], the difference between traditional production factors and knowledge as a production factor is that the latter is a systemic factor, a result of interlinked socioeconomic elements. These elements, which comprise the "four pillars" of a knowledge economy, are as follows:

- The innovation policies, institutions, and incentives necessary for the development and commercialization of domestic and foreign innovations—that is, for the creation of a national innovation system
- Human resource development—specifically, the development of a national education system generating a pool of knowledge specialists and a technology literate work force
- Information and communication technologies (ICT)
- A business environment conducive to the development of a knowledge economy

The Transformation of Knowledge from R&D Investment Process to IT Investment Process

The technological capabilities of a country are critical to its competitive advantage [40]. In other words, a country's technology level is about the level of development of that country. For this reason, R&D capabilities that define a country's technology are some of the most important variables [45].

When the R&D investment process has succeeded and created innovation, a patent can be requested that will provide the firm with property rights over knowledge from which it can exclude other countries. At this point, the firm can exploit the innovation by undertaking additional investments that would create a product that can be sold in the market or sell the innovation by granting the rights of exploitation to other countries in exchange for a royalty [6].

Table 1 shows the average of R&D investment data from 1990 to 2009 period. Figure 1 shows countries' rations of R&D investment for G8, G20, BRICK, and BRICKT from 1990 to 2009 period.

Table 1 The average of R&D investment for G8, G20, BRICK, and BRICKT (dollar)

The average of R&D investment	G8[a]	G20[b]	BRICK[c]	BRICKT[d]
1990–1994	19.14272	12.09019	8.943181	7.231268
1995–1999	19.61042	14.06385	12.95027	11.03025
2000–2004	20.74520	26.49400	18.64492	16.02851
2005–2009	17.25072	14.54026	16.4548	13.91756
1990–2009	19.1873	16.7971	14.2483	12.0519

Source: OECD, 1990–2009, retrieved 19 April 2011 from http://stats.oecd.org

[a] France, Germany, Italy, Japan, the UK, the USA, Canada, and Russia

[b] Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, Saudi Arabia, South Africa, Republic of Korea, Turkey, UK, USA, The European Union

[c] Brazil, Russia, India, China, Republic of Korea.

[d] Brazil, Russia, India, China, Republic of Korea, Turkey

Literature Review

Earlier studies on information technology (IT) investment and economic growth have already been summarized by Dedrick et al. [8] (see also "Appendix," Table 9). Wang [47] investigated the relationship between ICT on economic growth of Taiwan in the period of 1980–1995. Results from the study strongly support one of the recurring views shared by Asian NII leaders: The payoff effect of ICT on economic growth can be achieved only through a robust national information infrastructure that supports ICT adoption and applications.

Pohjola [39] investigated the relationship between technology investment and economic growth in a cross section of 39 countries in the period 1980–1995 by

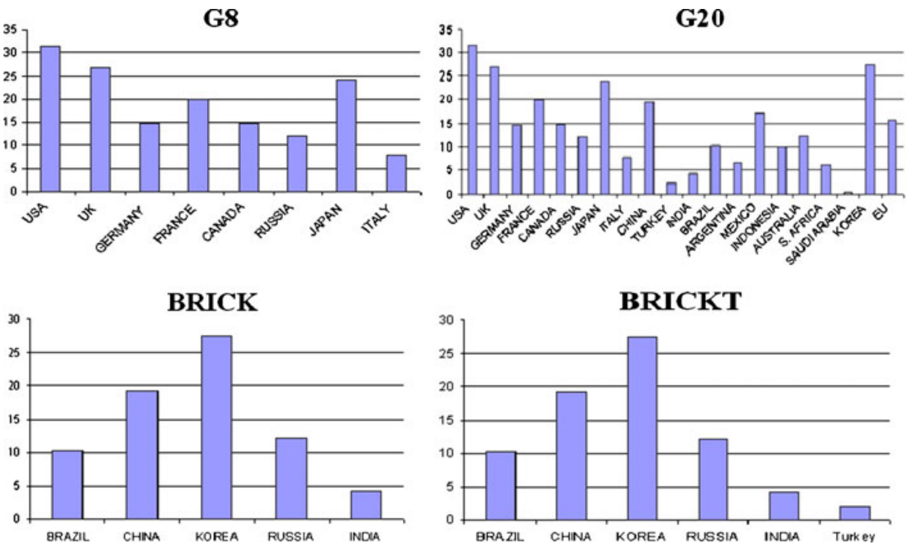

Fig. 1 G8, G20, BRICK, and BRICKT countries R&D investment from 1990 to 2009. Source: OECD, 1990–2009, retrieved 19 April 2011 from http://stats.oecd.org

applying explicit model of economic growth, the augmented version of the neoclassical (Solow) growth model. The results based on the full sample of 39 countries indicate that physical capital is a key factor in economic growth in both developed and developing countries.

Bresnahan [4] found evidence that information technology has key features related to key structures of the macroeconomic and microeconomic approaches to growth. The main conclusion of his study is that there is scope for public policy and business policy innovations to affect technical progress (and thus growth) through a wide variety of incentive-altering mechanisms.

Edwards [12] investigated the relationship between technology and economic growth in the Latin American nations. The results show that investment in complementary areas will be required to take full advantage of the new technologies.

Dedrick et al. [8] found evidence that the impact of IT investment on labor productivity and economic growth is significant and positive. For many Internet-related firms, the returns to IT investment are real, and innovative firms continue to lead to others in economy.

Hassan [18] examined the important factors that contribute to foreign direct investment (FDI) and economic growth in the world and compares them with those of Middle East and North Africa (MENA) countries by using a panel data of 95 countries and eight MENA countries over 1980–2001 period. FDI brings host countries capital, productive facilities, new technology, and modern management know-how. Information and communication technology (ICT) is essential to growth, necessary to develop a country's productive capacity in all sectors of the economy, and links a country with the global economy and ensures competitiveness. This paper finds both growth, and FDI are related to a host of macroeconomic, ICT, and globalization variables.

Yoo [46] investigated the impacts of IT investment on growth using a cross-country analysis based on data from 56 developing countries for the years 1970–1998. The results show that IT investment significantly contributes to economic growth in the developing world. In other words, investment in physical capital, population growth, and the human capital seem to be quite important in accounting for economic growth in developing countries.

DPT [11] prepared a report that shows information and communication technologies must be used effectively in order to ensure sustainable economic growth and competitiveness. Kanamori and Motohashi [25] focused on the role of IT on economic growth in Japan and Korea from 1985 to 2004. In both countries, the information technology industry is an important source of economic and productivity growth from the output side. In addition, active IT investments are supposed to lead to substantial IT capital service contribution to economic growth from the input side.

Kim [26] investigated the relationship between IT and economic growth in Brazil by using time series analysis. According to this study, the role of IT in the economic development of nations is still controversial.

Pazarlıoğlu and Gürler [34] investigated the relationship between telecommunication infrastructure and economic growth and productivity of Turkey in the period 1990–2004 by using panel data analysis. The potential role that may be played by information and telecommunication technologies in promoting economic productivity and growth, especially in low-income countries, is currently attracting considerable attention.

Antonopoulos and Sakellaris [1] investigated the relationship between information and communication technology investments to Greek economic growth. The results show that IT investments are the driving forces behind the resurgence of growth in the developed countries during recent years.

Bucek [5] investigated the relationship between ICT and economic growth of E25 countries in the period 2004–2007. The results show that narrowing the living standards between European countries and regions would to a large extent be determined by the amount of investment into ICT, education, R&D, and other ICT infrastructures in the years to come.

Erdil et al. [16] investigated the impact of ICT on economic growth for 131 underdeveloped and developing countries by using a panel dataset for the period of 1995–2006. This paper finds that ICT has positive and significant effect on economic growth even after the use of some control variables.

Darrat and Al-Sowaidi [7] investigated the role of information technology and financial deepening in Qatar's fast growing economy. Their analysis follows the vector error correction modeling technique that is capable of exploring long-run relations and short-run causal dynamics. The main conclusion of their study is that IT is relatively more important than financial development for propelling long-run growth. However, they find financial development, rather than IT, to be more critical for enhancing economic growth over the short-run horizon.

Yapraklı [44] investigated the relationship between information and communications technology and economic growth of Turkey in the period 1980–2008. According to the results, economic growth is positively effected by ICT in the short and long run. However, it is observed that the contribution of ICT to the economic growth is less than that of other product factors in Turkey.

Yaylalı et al. [45] investigated the relationship between R&D and economic growth of Turkey in the period 1990–2010. R&D and economic growth figures are compiled from data sets to analyze the results, and the long-term R&D investment in expenditure one-way affect on economic growth has been identified. The direction of this R&D investment in expenditure relating to economic growth has been observed to be true.

The Case of Turkey

Growth of GDP per Capita in Turkey

In the 1980s by transforming its adopted economic policy from import substitution growth into export oriented growth, Turkey took its place among the countries adopting and applying neo-liberal economy policies under International Monetary Fund–World Bank supervision. The first outcomes of this transformation were the liberalization of trade and the free movement of capital. The question is whether the relative stability in some economic variables monitored in recent years after the long post-1980 period of high inflation rates, high interest rates, and great fluctuations in exchange rates and gross financial crises are sustainable or not necessary [9] (Fig. 2).

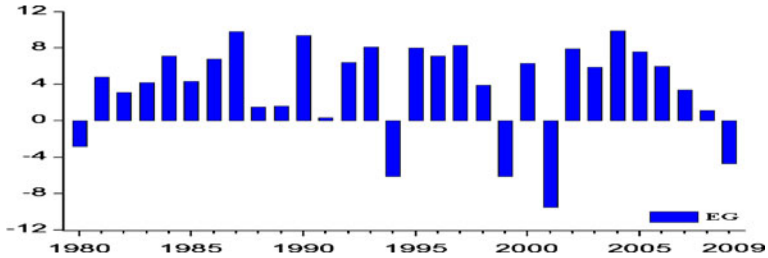

Fig. 2 GDP per capita in Turkey, 1980–2009. Source: Turkish Statistical Institute [43]

The gross domestic product (GDP) of Turkey in 2009 is lower than the previous year. From 1980 until 2009, Turkey' average GDP growth was about 4.30% reaching high of 9.90% in 2004 and low of −9.50% in 2001 crisis. The economy of Turkey in 2009 is the 16th largest in the world. Turkey is a market-oriented economy where private individuals and business firms make most of the decisions [43].

Outlook for Turkey's Economy Profile

Turkey remains stable at 61st position. Turkey benefits from its large market, which is characterized by intense local competition (15th) and reasonably sophisticated business practices (52nd). The country also benefits from reasonably developed infrastructure (56th), particularly roads and air transport infrastructure, although ports and the electricity supply require upgrading. In order to further enhance its competitiveness, Turkey must focus on improving its human resources base through better primary education and better healthcare (72nd), addressing the inefficiencies in the labor market (127th) and reinforcing the efficiency and transparency of public institutions (90th) [49]. World Competitiveness Ranking of 2010–20011 is shown in Table 2.

According to the Global Competitiveness Report, released by the World Economic Forum (WEF) on 2010, Switzerland, Sweden, and Singapore are the world's most competitive economies. On the other hand, Turkey remains stable at 61st position. Turkey benefits from its large market, which is characterized by intense local competition (15th) and reasonably sophisticated business practices (52nd). The country also benefits from reasonably developed infrastructure (56th), particularly roads and air transport infrastructure, although ports and the electricity supply require upgrading. In order to further enhance its competitiveness, Turkey must focus on improving its human resources base through better primary education and better healthcare (72nd), addressing the inefficiencies in the labor market (127th) and reinforcing the efficiency and transparency of public institutions (90th) [49].

The Stage of Turkey in Global Competitiveness

Recently, the WEF introduced Global Competitiveness Index to rank the countries. The World Economic Forum categorizes the countries into three main categories: factor-driven, efficiency-driven, and innovation-driven. The stage of Turkey in global competitiveness is efficiency-driven. Figure 3 shows stage of development scale for Turkey [49].

Table 2 World Competitiveness Ranking (2010–2011)

Country/economy	GCI 2010–2011 and 2009–2010		
	GCI 2010–2011		GCI 2009–2010
	Rank	Score	Rank
Switzerland	1	5.63	1
Sweden	2	5.56	4
Singapore	3	5.48	3
USA	4	5.43	2
Germany	5	5.39	7
Japan	6	5.37	8
Finland	7	5.37	6
The Netherlands	8	5.33	10
Denmark	9	5.32	5
Costa Rica	56	4.31	55
Azerbaijan	57	4.29	51
Brazil	58	4.28	56
Vietnam	59	4.27	75
Slovak Republic	60	4.25	47
Turkey	61	4.25	61
Sri Lanka	62	4.25	79
Russian Federation	63	4.24	63
Uruguay	64	4.23	65
Jordan	65	4.21	50

Source: WEF [49]

GCI Global Competitiveness Index

In the allocation of countries to the stages, the following criteria are taken into account [42]:

1. If the country's GDP per capita is below US $2,000 or the fraction of its export in the form of primary goods is above 70%, the country belongs to the factor-driven stage.
2. If a country has a per capita income between US $3,000 and US $9,000 and does not export more than 70% in primary goods, it belongs to the second stage.
3. If a country has more than US $17,000 per capita income and less than 70% of the export in primary goods, it belongs to the third stage.
4. Countries with income per capita between US $2,000 and 3,000 are said to be in transition from stage 1 to stage 2.
5. Countries with income per capita between US $9,000 and 17,000 are said to be in transition between stages 2 and 3.

In order to switch to a higher stage, a country should focus on the top five factors showing the largest difference between the average values of the higher stages and the value of the country of interest [42].

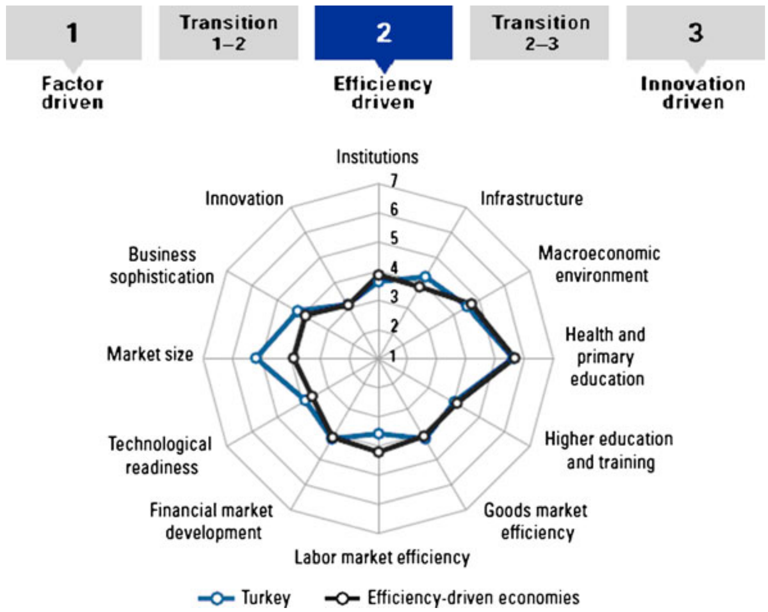

Fig. 3 Stage of development for Turkey. Source: WEF (World Economic Forum) [49]

According to the WEF, the countries having a GDP below a threshold level are accepted as stage 1 countries, and their key factors are assumed to be the basic requirement factors. However, this is a non-compensatory approach, and there may be some countries showing very good performance in term of basic requirements while still having a low level of GDP. Therefore, it may be unfair to assign a country to a stage based solely on its GDP level, and it may more accurate to use a compensatory approach for this purpose. On the other hand, a country may be unfairly rewarded due to its high GDP level although it has poor performance even in term of its basic requirement factors. For example, The USA does not score well in term of basic requirements. However, it is the world's leader in both efficiency enhancers and innovation and sophistication factors. This is mainly due to the fact that the USA is in the third stage of development and the weight of the basic requirements is relatively minor. Therefore, the high values that it receives from the other two sub-indexes put this country in the leading position [42].

This paper is organized as follows: "Literature Review" section contains a brief literature review. Model, data series, methodology, and empirical results are presented in "The Case of Turkey" and "Model and Data Series" sections. Concluding remarks take place in "Method and Empirical Results" section.

Model and Data Series

The aim of the empirical analysis is to determine whether there is any evidence of causality between economic growth and information technology investment in the long and short run for Turkey. The data of information technology investment and economic growth rates are used for the period of 1980–2009 (Fig. 4).

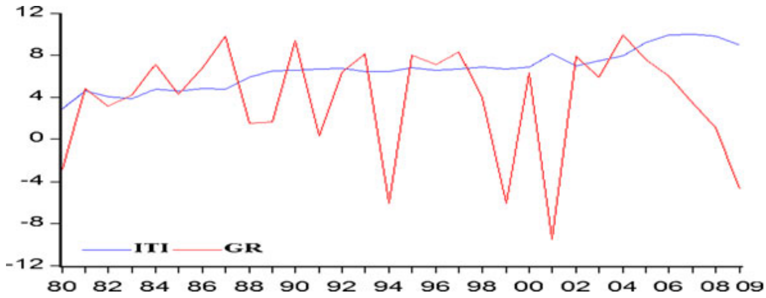

Fig. 4 The information technology investment on economic growth for Turkey (1980–2009)

The model in the study is the following:

$$GRt = \alpha_1 + \alpha_2 \mathrm{LITI_t} + \mu_t$$

GR represents the annual economic growth rate in real terms
LGR represents the annual economic growth rate in natural logarithms
ITI expresses information technology investment
LITI expresses information technology investment in natural logarithms

These data are compiled from Central Bank (CBRT) Electronic Data Delivery System, Turkish Statistical Institute, and Organisation for Economic Co-operation and Development (OECD) for the 1980–2009 periods. Each of the variables is purified from seasonal variations, and the estimation was made between economic growth and information technology investment on main macroeconomic variables.

Method and Empirical Results

The aim of this method is to use the autoregressive distributed lag (ARDL) approach to cointegration and error correction models, to determine whether there is any evidence of causality between economic growth and information technology investment in the long and short run. To empirically analyze the long-run relationships and dynamic interactions among the variables of interest, the model has been estimated by using the bounds testing (or ARDL) cointegration procedure, developed by Pesaran et al. [36]. The advantage of this methodology compared to the non-linear three-stage least square technique, which is widely used by most fiscal response studies, is that it allows the distinction between short-run and long-run effects of aid [27].

The ARDL procedure is adopted for the following three reasons: Firstly, the bounds test procedure is simple. As opposed to other multivariate cointegration techniques such as Johansen and Juselius, it allows the cointegration relationship to be estimated by ordinary least squares (OLS) once the lag order of the model is identified. Secondly, the bounds testing procedure does not require the pretesting of the variables included in the model for unit roots unlike other techniques such as the

Johansen approach. It is applicable irrespective of whether the regressors in the model are purely *I* (0), purely *I* (1) or mutually cointegrated. Thirdly, the test is relatively more efficient in small or finite sample data sizes. The first step in the ARDL bounds testing approach is to estimate equation of the VECM by OLS in order to test for the existence of a long-run relationship among the variables by conducting an *F* test for the joint significance of the coefficients of the lagged levels of the variables, i.e., as a second step long-run model can estimate and then the stationarity status of all variables to determine their order of integration [17].

Unit Root Test

Johansen and Juselius [23], Johansen [22], and Engle and Granger [14] approaches require that the variables have the same order of integration. This requirement often causes difficulty to the researchers when the system contains the variables with different orders of integration. To overcome this problem, Pesaran and Shin [37] and Pesaran et al. [36] proposed a new approach known as ARDL for cointegration test that does not require the classification of variables into *I* (0) or *I* (1) [41].

Stationarity means that the mean and the variance of a series are constant through time and the autocovariance of the series is not time varying [13]. A test of stationarity is important to set up the specification and estimation of the correct model since a wrong choice of transformation of the data gives biased results and has consequences for wrong interpretation [14]. Hence, the first step is to test the order of integration of the variables. Integration means that past shocks remaining undiluted affect the realizations of the series forever and a series has theoretically infinite variance and a time-dependent mean [13].

Stationarity is very important for time series analysis. In time series analysis, the stationarity of the series is examined by unit root tests. A time series is stationary if its average and variance do not change in time and if the common variance between two periods depends not on the calculated period but on the distance between the periods [20]. In the formation of econometric models, it is important to test stationary of time series data to set up an appropriate methodology [14]. In the study, Dickey and Fuller [10] and Phillips and Perron [38] test used for stationarity level of the series and the optimal lags selected for the truncation lag for the augmented Dickey–Fuller (ADF) and Philips–Perron (PP) test based on the Akaike information criterion. The ADF and PP test were used to determine whether the variables used in regression equations are stationarity or not. ADF and PP results are shown in Table 3.

As seen from Table 2, the GR series is stationary in level but the ITI series is stationary in the first difference. In other words, the GR series is *I* (0) and ITI series is *I* (1).

Cointegration Test

The conventional method of Johansen cointegration test needs to assure that variables are all nonstationary and integrated at the same order, whereas the bound test

Table 3 ADF and PP unit root test results

Variables	ADF		PP	
	Level	First difference	Level	First difference
LGR	−6.040349[a]	–	−6.026868[a]	–
LITI	−2.671452	−4.446372[a]	−2.690978	−5.084324[a]
1%	−3.679349	−3.689194	−3.679322	−3.689194
5%	−2.967767	−2.971853	−2.967767	−2.971853
10%	−2.622989	−2.625121	−2.622989	−2.625121

ADF augmented Dickey–Fuller, *PP* Philips–Perron

[a] Denotes for 1% significance level

procedure has the advantage that it can be applied irrespective of whether the variables are *I* (1) or *I* (0) [32]. In developing economies such as Turkey, as shown in Table 3, economic time series data are likely to be nonstationary. Granger and Newbold [19] showed that studying with nonstationary series, a spurious regression problem could be encountered. The complications with model may develop as a consequence of the spurious regression phenomenon first described by Granger and Newbold [19], caused by nonstationary trends in time series data. The mean, variance, and autocorrelation of the series are in general nonconstant through time, and the coefficient of determination (R2) may simply capture correlated trends and reflect nonstationary residuals.

When the spurious regression problems are encountered among the series that contains unit root, a variety of methods have been proposed to find a solution to this problem. One of these methods is to take the difference of the series. In contrast, taking the difference method does not only erase the effects of persistent shocks on the variable in the past periods but also may erase the long-term relationships besides the shocks. Therefore, the regression between the series that are made stationary by this method would not explain the long-term relationship due to the terminated information belonging to long term. This has been the starting point of the cointegration analysis. In the cointegration approach developed by Engle and Granger [14], time series which are not stationary in level but stationary in their first difference may be modeled in their level state, and by this way, long-term information loss can be prevented. However, this approach is invalid if there are more than one co integration vector. On the other hand, the bound test eliminates this problem. To examine the long-run relationship between economic growth and information technology investment, we employ the bounds testing approach to cointegration, developed by Pesaran et al. [36]. The bounds procedure can be applied to models consisting of variables with an order of integration less than or equal to one. This approach, hence, rules out the uncertainties present when pretesting the order of integration [29].

The first main advantage is that the bounds test approach is applicable irrespective of whether the underlying regressors are purely *I* (0), purely *I* (1), or mutually cointegrated [37]. Thus, because the bounds test does not depend on pretesting the order of integration of the variables, it eliminates the uncertainty associated with pretesting the order of integration [35]. Second, the unrestricted error correction model (UECM) is likely to have better statistical properties than the two-step Engle–Granger method because, unlike the Engle–Granger method, the UECM does not push the short-run dynamics into the residual terms [2, 3, 33]. The other major advantage of the bounds test approach is that it can be applied to studies that have a small sample size. It is well-known that the Engle and Granger [14] and Johansen [21, 24] methods of cointegration are not reliable for small sample sizes, such as that in the present study [30].

UECM was adapted to the study as follows:

$$\Delta_{\mathrm{ITI}_t} = \alpha_0 + \alpha_1 t + \sum_{i=1}^{m} \alpha_{2i}\, \Delta_{\mathrm{ITI}_{t-i}} + \sum_{i=0}^{m} \alpha_{3i}\, \Delta_{\mathrm{LGR}_{t-i}} + \alpha_4 \mathrm{ITI}_{t-1} + \alpha_5 \mathrm{LGR}_{t-1} + \mu_t \qquad (2)$$

The bounds test for examining evidence for a long-run relationship can be conducted using either the F test or the t test. The F test tests the joint significance of the coefficients on the first period lagged levels of the variables. The approximate critical values for the F test are obtained from Pesaran et al. [36]. The asymptotic distribution of critical values is obtained for cases in which all regressors are purely I (1) as well as when the regressors are purely I (0) or mutually cointegrated [31].

The F test is applied on first period lags of dependent and independent variables to test the existence of the cointegration relationship. The calculated F statistics are compared with bottom and top critical values in table of Pesaran et al. [36]. If the calculated F statistics is lower than Pesaran bottom critical value, there is no cointegration relationship between the series. If the calculated F statistics are between the bottom and top critical values, no exact opinion can be made, and there is a need to apply other cointegration test approaches. If the estimated F statistics are higher than the upper bound of the critical values, then there is a cointegration relationship between series. After finding the cointegration relationship, ARDL models can establish in order to determine short- and long-run relationship between the series. T represents trend variable and m represents number of lag in UECM model. The optimal lags were selected based on the Akaike information criteria, Schwarz, and Hannan–Quinn critical values [15].

The duration of the lag which provides the smallest critical value is identified as the model's duration of lag. However, if the model established with the duration of lag in which the selected critical value is the smallest involves an autocorrelation, the duration of lag, which gives the second smallest critical value, is taken. If the autocorrelation problem still continues, this process is sustained until the problem is solved. Optimal lag was taken as 4 according to Akaike information criteria because of data set is yearly and, after performing an LM test, no autocorrelation problem has been observed [15]. Criteria and test values are given in Table 4.

After the number of lags is determined, cointegration between series is investigated by the bound test approach. F test statistics calculated with UECM model is

Table 4 Statistics for selecting the lag order

m	AIC	SB	$X^{2^{BG}}$
1	9.652354	8.460340	9.826756[a]
2	9.330095	8.364320	9.672012[b]
3	9.219999	8.218803	9.487263[c]
4	8.769660[a]	7.947397[a]	7.659709[a]

$X^{2^{BG}}$ Breusch–Godfrey is autocorrelation test statistics

[a] One percent indicates significant level and autocorrelation between error terms

[b] Five percent indicates significant level and autocorrelation between error terms

[c] Ten percent indicates significant level and autocorrelation between error terms

compared with the table bottom and top critical levels in Narayan and Narayan [28]. Table 5 shows the limits of bound test results.

K is the number of independent variable in Eq. 2, and critical values were taken from [36] (Table CI(V)). If the estimated *F* statistics are higher than the upper bound of the critical values, then there is a cointegration relationship between series. Now, among a series of long- and short-term cointegration, relationships were determined to identify relationships. An ARDL model will be constructed between series in order to determine short- and long-run cointegration relationship.

Autoregressive Distributed Lag

ARDL model will be suitable to proceed with the long-run analysis between the variables and the optimal lags selected based on the Akaike information criterion (AIC) (Table 6).

$$\Delta \mathrm{GR}_t = \alpha_0 + \alpha_1 t + \sum_{i=1}^{m} \alpha_{2i} \mathrm{GR}_{t-i} + \sum_{i=0}^{n} \alpha_{3i} L\ \mathrm{ITI}_{t-i} + \mu_t \tag{3}$$

Long-Run Relationship

The long-term coefficients obtained from ARDL (1, 2) are in Table 7. Results in Table 7 show a significant relationship between economic growth and information technology investment in the long term. The information technology investment

Table 5 Bound test results

K	10% significance level critical values		5% significance level critical values		1% significance level critical values	
F statistics	*I*(0)	*I*(1)	*I*(0)	*I*(1)	*I*(0)	*I*(1)
10.26	8.170	9.285	5.395	6.350	4.290	5.080

K number of independent variables in Eq. 2. Critical values are extracted from Narayan [29]

Table 6 ARDL model estimation results

Variable	Coefficient	T statistics
GR(−1)	−0.239	−2.581949[a]
LITI	1.069	5.8982[b]
LITI(−1)	−0.801	−2.284[a]
LITI(−2)	−0.588	−2.377[a]
C	4.506393	3.689[b]
T	0.046	3.478[b]
	Diagnostic test results	
R^2	0.79	
$\overline{R}^2$	0.69	
X^2_{BG}	0.540 [0.312]	
$\chi^2_{\mathrm{JB(2)}}$	1.2790 [0.49]	
$\chi^2_{\mathrm{WHITE(1)}}$	3.243 [0.06]	
$X^2_{\mathrm{RAMSEY(1)}}$	2.544 [0.13]	

X^2_{BG} autocorrelation, χ^2_{JB} normality, χ^2_{WHITE} heteroscedasticity, X^2_{RAMSEY} model specification error test statistics

[a] Significant at 5%

[b] Significant at 1%

coefficient is statistically significant and negative. In other words, as can be seen from Table 7, the variables in the model are found statistically significant.

Short-Run Relationship

For determining the short-run relationship between the variables, the error correction model based upon the ARDL approach is established as follows:

$$\Delta \mathrm{GR}_t = \alpha_0 + \alpha_1 t + \alpha_2 \mathrm{EC}_{t-1} + \sum_{i=1}^{m} \alpha_{3i} \Delta \mathrm{GR}_{t-i} + \sum_{i=0}^{n} \alpha_{4i} \Delta L\ \mathrm{ITI}_{t-i} + \mu_t \tag{4}$$

In Eq. 4, EC_{t-1} is one period lag value of error terms that are obtained from the long-run relationship. The coefficient of EC_{t-1} shows how much of the disequilibrium in the short run will be eliminated in the long run (Table 8).

Table 7 Long-run relationship results

Variables	Coefficient	T statistics
LITI	−0.399	−3.531[a]
C	2.794	4.465[a]
T	0.032	3.766[a]

[a] One percent indicates significant level

[b] Five percent indicates significant level

[c] Ten percent indicates significant level

Table 8 Based on the ARDL approach error correction results

Variable	Coefficient	*T* statistics
DLITI	1.2170	5.8244[a]
DLITI(−1)	0.6717	2.3342[b]
C	5.3176	3.5958[a]
T	0.3342	3.3431[a]
ECT(−1)	−0.9727	−7.65550[a]

[a] One percent indicates significant level

[b] Five percent indicates significant level

The error correction coefficient ECT (−1) has been found between 0 and 1 with a negative sign and is also statistically significant. The error correction term ECT (−1) measures the speed of adjustment to restore equilibrium in the long run. The coefficient of −0.97 implies that a deviation from the long run is corrected by about 97% in the next period. This result supports Narayan's [31] study.

Conclusions and Policy Implications

This paper examines the role of Turkey's competitive advantage in the information age by using an ARDL model over the period of 1980–2009 of Turkey. Economic growth and information technology investment variables used in empirical analysis were different orders of integration ($I(0)$ and $I(1)$). After finding the order of integration, our findings suggested that there is a positive relationship in short run and a negative relationship in the long run between economic growth and information technology investment for Turkey.

Traditional economic relations have been changing with the emergence of new economies in terms of both forms and content. As the temporal and locational differences in universal scale evaporate, productivity and efficiency increase. Technological developments and improvements influence structures and functions of societies.

According to the results of this study, as long as the G20 countries transform the R&D investment process to IT investment process by making use of the knowledge transformation, they will be capable of reaching the level of G8 countries. Thus, for a country with economic development objectives, increasing the level of technology R&D should be very important.

IT investments have a positive impact on Turkey's economic growth in the short run and a negative impact in the long run. IT investments are also the main reason for the increased growth rates of total factor productivity. The results confirm Pohjola's [39] conclusion that information technology plays a significant role in the current economic growth of developed countries but that it does not yet seem to have made a substantial contribution in developing countries.

Appendix

Table 9 Selected firm-level studies of IT returns

Study	Data sample	Findings
IT and firm performance		
Strassmann (1990)	38 US companies	No correlation between IT spending and firm performance
Loveman (1994)	60 business units in 20 US companies	IT investments add nothing to output
Barun et al. (1995)	Same as Loveman (1994)	IT improves intermediate output if not final output
Brynjolfsson and Hitt (1993)	Large US manufactures	Gross marginal product of IT is over 50% per year in manufacturing
Brynjolfsson and Hitt (1995)	Large US manufactures	Firm effects account for half of productivity benefits of earlier study
Lichtenberg(1995)	US firms, 1989–1991	IT has excess return; 1 IS employee can be substituted for 6 non-IS employees without affecting output
Brynjolfsson and Hitt (1996)	367 large US firms	Gross return on IT investments of 81%. Net return ranges from 48% to 67% depending on depreciation rate
Hitt and Brynjolfsson (1996)	370 US firms	IT investments increase firm productivity and consumer welfare, but not profitability
Dewan and Min (1997)	300 large US firms	IT is a net substitute for both capital and labor, and shows excess returns relative to labor input
Black and Lynch (1997)	1,621 US manufacturing establishments	Productivity not affected by presence of a particular management practice, but by implementation, especially degree of employee involvement. Non-managerial use of computers related to productivity
Brynjolfsson et al. (1998)	Sample of fortune 1,000 US firms, 1987–1994	The stock market value of $1 of IT capital is the same as $5–20 of other capital stock
Gilchrist et al. (2001)	Sample of fortune 1,000 US firms	IT productivity is greater in IT producer firms than in user firms and in durable manufacturing
Greenan et al. (2001)	French firms	Gross returns to IT investment are positive and greater than returns to non-IT investment
Organizational complements and IT returns		
Brosnahan et al. (2002)	400 large US firms, 1987–1994	The effects of IT on labor demand are greater when IT is combined with particular organizational investments.
Brynjolfsson et al. (1998)	Sample of US firms 1996	Decentralized organizational practices, in combination with IT investments, have a disproportionate positive effect on firm market value.
Ramirez et al. (2001)	200+US firms, 1998	Firm use of employee investment and total quality management enhances IT returns.
Francalanci and Galal (1998)	52 US life insurance companies, 1986–1995	Productivity gains results from worker composition (more information workers) and IT investments.
Deveraj and Kehli (2002)	8 hospitals, over 3 years	IT investments combined with business process reengineering positively and significantly influences performance
Tallon et al. (2000)	300+US firms, 1998	Perceived business value of IT is greater when IT is more highly aligned with business strategy
US studies		
Oliner and Sichel (2000), Jorgensen and Stiroh (2000)	1973–1999	IT investment contributed one half of GDP and labor productivity growth between 1995 and 1999 and contributed moderately during earlier periods. IT contributes to productivity in the T-using and producing sector
Stiroh (2001a, b)	61 industries, 1987–1999	IT-using industries show productivity acceleration during 1995–1999. IT-intensive industries show larger productivity gains than non-IT-intensive ones
Council of Economic Advisors (2001)	1973–1999	IT investment contributed about one half of the acceleration in productivity growth of 1995–1999 over 1973–1975. IT-intensive industries in non-goods producing industries show MFP gains
Obert Gordon (1999, 2000)	1972–1999	IT investment contributes positively to MFP growth, but all in the IT producing and other durable industries rather than in the IT-using industries

Table 9 (continued)

Study	Data sample	Findings
Jorgenson (2001)	1948–1999	IT investment contributed more than one half of the 1% increase in economic growth since 1995. About one half the productivity growth since 1995 has occurred in IT-using industries as well
Nordhaus (2001)	16 industries 1978–1998	Labor productivity acceleration in 1995–1998 is not narrowly focused on a few new economy sectors
Jorgenson and Stiroh	1958–1992; 1985–1992	IT investment associated with 0,5% incremental economic growth
Oliner and Sichel (1994)	1970–1992	IT investment too small to have substantial economic IT associated with 0.16–0.28% additional effects, economic growth
Roach (1987, 1989, 1991)	1970–1987	Large increase in IT investment per worker in services sector appears along with decrease in measured output per worker
The country and cross-country studies		
Schreyer (1999)	G7 countries 1990–1996	IT contributes significantly to productivity growth in all 7 countries, but the magnitude differs across countries
Daveri (2000)	18 OECD and EU countries, 1992–1997	IT added to GDP growth in the 1990s for all countries studied, but the contribution in EU countries was smaller than in other industrialized countries. Within the EU, differences in IT contribution to growth were also due to lower IT investment
Pohjola (2001)	39 countries, 1980–1995	IT investment shows 80% gross returns for OECD countries, nothing significant for developing countries
Kraemer and Dedrick (1994)	12 Asia-Pacific countries, 1984–1990	IT investment positively correlated with GDP and productivity growth
Dewan and Kraemer (1998, 2000)	36 countries 1987–1993	IT positively correlated with labor productivity in developed countries, but not in developing countries
Kraemer and Dedrick (2001)	43 Countries 1985–1995	Growth in IT investment correlated with productivity growth. Level of IT investment (percent of GDP) not correlated with productivity growth

Source: Dedrick et al. [8]

EU European Union

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