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Club Convergence: Do public investments play a role in regional income per capita convergence in Turkey?

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ABSTRACT

This paper aims to examine club, conditional and absolute convergence at regional level under the assumption that public investment can be used as a tool to reduce income disparities. Therefore, following Phillips and Sul (2007, 2009) and Lyncker and Thoennessen (2017), as the first step of the empirical analysis, five convergence clubs and a divergent member are identified in real GDP per capita at Turkey NUTS II level for the period from 2004 to 2019. Additionally, the clubs' basic data reveals three important information. The first information is that regions with high GDP per capita receive more public investment than others. Second information is that the share of public investment is not distributed equally in terms of GDP per capita. Third information is that Clubs 1, 2 and TR10 (İstanbul) (the only divergent member) have higher proportion of public investments on average than others. As a result, public capital is not used as a tool to reduce regional inequalities from the government. At the end of the empirical analysis, the dynamic effects of public capital on growth is analyzed using Sys-GMM estimators. From the results, it has seen that public investment is statistically significant and has a positive effect on growth; however, it has quite low coefficient. Also, findings revealed that there isn't absolute convergence at regional level in Turkey. Therefore, when share of public investments are taken into account, there is conditional convergence. With the existence of club and conditional convergence, public capital should be used much more effectively thanks to its ability to reduce income inequalities and merge clubs, otherwise absolute convergence will not occur.

Keywords: Club Convergence, Conditional Convergence, Public capital, GDP per capita.

JEL Classification Codes: H54, R11, R58.

INTRODUCTION

Numerous theoretical and empirical studies in the literature discuss and try to explain the reason for gaps and differences in the gross domestic product per capita (GDPpc) between countries after the industrial revolution. As a pioneer work, according to Solow (1956, 1957), countries' GDPpc level will tend to converge over time under constant returns to scale and diminishing returns to production. Solow (1956) focused on sources of growth assuming that there is a single sector production in which capital and labor inputs are used and technology is considered exogenous in the model. Findings from studies based on the Solow-Swan model led to two important theoretical improvements. First, since only a small part of the growth can be explained by factor accumulation under the assumption that technology is determined externally, that necessity of including technology endogenously in the model has emerged. Thus, it has been accepted that technology is determined endogenously in the new neoclassical growth theories. Secondly, under a constant saving and population growth rate when capital and labor are considered as substitutes for each other and declining productivity prevails, countries with a lower stock of capital per labor force will have a higher rate of return and therefore grow faster, and vice versa. Countries with higher capital stocks per labor grow more slowly. Therefore, per capita income gaps should tend to decline over time between developed and developing countries and absolute convergence becomes a natural consequence of the neoclassical model.

However, although it has been tested many times, there is often no evidence of absolute convergence in the literature (Barro and Sala-i Martin (1992), Mankiw, Romer, and Weil (1992), Sala-i Martin (1996), Higgins, Levy, and Young (2006), and Young, Higgins, and Levy (2008)). According to Rodrik (2013), contrary to many studies in the literature, it has been revealed that there is absolute convergence, but only in areas with high productivity in modern production rather than in the economy as a whole.

On the other hand, the conditional convergence hypothesis, focuses on the negative relationship between real income and growth rate, after accepting that the structural factors will differ from country to country. Under the assumption of structural

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factors are identical (such as savings, preferences, human and physical capital, technology), according to the conditional convergence there is a negative relationship between growth and initial value of income per capita. Hereby, even if the initial incomes are the same, structural differences cause countries to converge to their own steady states. Finally, countries that differ in their initial level or distribution of structural factors, may cluster around a different steady state equilibrium (Galor, 1996; Aksoy et al 2019). Thus, the absolute convergence displays a single equilibrium to which all countries approach, conversely in the case of conditional convergence, each country approaches its own equilibrium with respect to its own unique structural difference. However, in the case of club convergence, different clubs have different equilibriums, as a consequence there will be different equilibriums according to number of clubs. If there is club convergence, there will be multiple equilibrium (Islam, 2003). According to Bernard and Durlauf (1996), when economies have multiple long run equilibrium, cross sectional tests tend to spuriously reject the null hypothesis of no convergence. In order to avoid spuriously rejecting the null; we use Phillips and Sul (2007) procedure to identify subgroups. In terms of the existence of club convergence, Chatterji (1992), Chatterji and Dewhurst (1996) and Quah (1996, 1997) emphasize that the β-convergence and σ-convergence methodological approaches can yield misleading results. Therefore, club convergence in income is also taken into account in this study, apart from absolute and conditional convergence. On the other hand, a great number of empirical studies have investigated the decisive role of the public capital on economic growth in regional level convergence (see Cook and Munnell, 1990; Holtz-Eakin, 1992; and Lall and Yilmaz, 2001 on USA; Shioji, 2001 on USA and Japan; Mas et al., 1998 on Spain; and Rodríguez-Pose, Psycharis, and Tselios, 2012 on Greece). Furthermore, Barro (1991) and Barro and Sala-i-Martin (1992) investigated the relationship between a country's growth expectations and fiscal policies with models based on the Ramsey framework. Regarding Turkey, while Filiztekin (1998) provides no evidence for the effect of public capital on regional convergence across the country from 1975 to 1995. On the other hand, Önder, Deliktaş, and Karadağ (2007) conclude that public capital affects the per capita GDP, suggesting regional convergence existed in Turkey at NUTS II level for the period of 1980-2001.

The impact of public capital on economic growth has been empirically studied by many scholars since Aschauer's (1989) pioneering work. As indicated in the World Development report published in 1994, public capital plays a key role in economic activity, since the former often thought of as the latter's "wheels". Additionally, public capital creates externalities for the economic environment via infrastructure, such as telecommunications, electricity and other types of public investments according to the input-output tables. With these kinds of externalities and their spillover effects, regions are able to enhance their income level. Furthermore, although our study is based on the work of Önder, Deliktaş, and Karadağ (2007), it contributes to the existing literature in a different aspect apart from previous studies. We determine the convergence clubs proposed by Phillips and Sul (2007, 2009) (PS) and discuss the relationship between income of clubs and their share of public investment expenditures. We also scrutinize the existence of conditional convergence under the assumption that the structural disparities occur because of the unequally distributed public investments. Finally, we consider the dynamic structure of the model itself to investigate the role of public capital as a determinant of conditional convergence and we investigate convergence clubs for NUTS II regions in Turkey by using Phillips and Sul (2007, 2009) (PS and PSmerging) and Lyncker and Thoennessen (2017) (LT) procedures.

The study is organized as follows. Section two presents a literature survey for Turkey and third section presents the data and theoretical model. In section four empirical results are discussed. Lastly, section five concludes the study.

LITERATURE REVIEW

This paper is focused on income convergences between regions in Turkey and tests it using the absolute, conditional and club convergences methodologies altogether, also club convergence is used in many different subjects such as the environment, housing prices, export and commercial openness (See: Kılıçaslan and Dedeoğlu (2020), Ulucak (2017), Şahin (2021), Tirgil et al. (2021), Şimdi (2021)). The existence of absolute convergence and conditional convergence has been tested by many studies in Turkey (Filiztekin (1998), Karaca (2004), Erlat (2012), Karaalp and Erdal (2009), Yamanoğlu (2008), Zeren and Yılancı (2011)). However, club convergence has been a prominent issue lately. Therefore, there are very few studies on club convergence in Turkish regions. According to Yazgan and Ceylan (2021) in the period of the study, there are eight convergence clubs, also one divergence club, which means prominent sectors and the close neighborhood are determinants to the emergence of convergence clubs. Karahasan (2020) claims that the regions do not converge on average income, but instead they converge to the different income levels which means that there is club convergence. Also the findings demonstrate that the club convergence process is affected by neighbor regions' income level. A region which has a neighbor with high income level has a higher chance to move to a higher income level. On the other hand the regions located in the poor regions may stay in the same income group or fall to the level of the lower-income groups. Önder et.al (2007) investigate conditional convergence by considering spatial relations in

Turkey for NUTS II regions. Their findings support the conditional convergence hypothesis. Besides, according to the findings, the public capital does not have a significant impact on regional convergence in the models with spatial effects. As in Önder et.al (2007), Gömleksiz et al. (2017) also find that there is convergence at the regional level. Moreover, the results indicate that the role of government, in respect to fixed investment incentives and government investment, is positive in the convergence process. The results of Yıldırım et al. (2009) also support the convergence hypothesis. Besides, as in Önder et. al (2007), this study also reveal that the government expenditures have a significant role to decrease income inequality. However, according to Gerni et al. (2015) there is absolute convergence in the regional incomes of the 26 sub-regions in Turkey. On the other hand, in the conditional convergence analysis created by adding investment incentives as a control variable to the convergence analysis, it has been revealed that investment incentives do not have a positive effect on income convergence among regions. In the analyses made on a provincial basis, it was observed that the 2009-2012 regulations have provided more effective results than the 2004-2008 incentive regulations. Another study supporting this study is made by Abdioğlu and Uysal (2013). According to the results of the study there is no convergence among the gross value added of the regions. Also the results show that the incentive law which was enacted in January 2004 is not effective in reducing income disparities, and income distribution among the regions does not occur effectively and fairly even if new incentives are introduced. Aksoy et al. (2019) test the convergence between Western and Eastern regions of Turkey. Their findings reveal that there is no absolute or conditional convergence, while there are five clubs in the 1987-2001 period and six clubs in the 2004-2001 period. Karagöl et al. (2019) claimed that cities in the clubs move towards their steady states which is specific for the club from their disequilibrium state. This finding can show that the productivity disparities, structural differences and geographical factors could affect the classifications of convergence clubs. On the other hand, findings of Karaca (2018), don't support regional convergence among the regions of Turkey between 1960-2010 period. Karaalp and Erdal (2012) revealed that the agglomeration of industrialization in certain regions has been used for regional income disparities. The findings of the study support the convergence for 73 provinces while agglomeration slows down this process, but the growth of neighboring provinces accelerates this process. Also for 7 regions it has been found that the agglomeration has a positive impact on convergence. Zeren and Yılancı (2011) study the rate of deposit in GDP as an indication of financial development which is used for as a disparity among the regions. Findings of the study support absolute and conditional convergence for the average of the regions. Whereas, at the regional level, there are 17 absolute convergence regions and 25 conditional convergence regions. So it has been concluded that there is a positive effect of deposits on per capita income. Erk et al. (2000) revealed that there was no evidence of convergence between the provinces for the period 1979-1997, on the contrary, there was divergence. At the regional level, except the Marmara region, the other regions are converging. Table 1 covers the summary of final results of the prominent studies in the literature that work on club convergence or unconditional convergence for Turkish regions.

DATA AND THE THEORETICAL MODEL

The regional per capita gross domestic product is obtained from Turkish Statistical Institute (TURKSTAT) for the period from 2004 to 2020 and as a public investment expenditure, initial funds of investment programs are extracted from the Republic of Turkey Ministry of Development for the period from 2004 to 2019. However, after 2018, the Ministry of Development was abolished and joined the Presidency of the Republic of Turkey Strategy and Budget Department. Yet, the Strategy and Budget Department still maintains the data. The collected data tested club convergence and regional convergence at 26 sub-regions by using panel data for the period 2005-2019. Due to the lags in the mathematical model, we lost an observation to test conditional convergence, so the data started with the year 2005. In addition, as a result of the lack of public investment data for the year 2020, 2019 was determined as the final year. The nominal regional GDP data in the Turkish Lira currency are transformed into real regional gross domestic product in 2009 prices using the GDP deflator (2009=100).

The regional public investments are calculated as the share of the region in the total public expenditures of that year. In other words, regional public capital is the share of total public investment expenditures in the year.

As can be seen from the Table 1, TR 10 (İstanbul) has the highest real GDP per capita in 2019 (6236.31 TL), while TR C2 (Trabzon, Ordu, Giresun) has the lowest value (1466.27 TL). Compared to the data of the real GDP per capita as a proportion of Turkey's average in 2019 or share of total GDP better reflect the inequality between regions. TR 10 has the highest value for the data GDP per capita as a proportion of Turkey's average. Other regions with higher values than Turkey's average are TR 51 (Ankara), TR 42 (Kocaeli, Sakarya, Düzce, Bolu, Yalova), TR 21 (Tekirdağ, Edirne, Kırklareli), TR 31 (İzmir), TR 41 (Bursa, Eskişehir, Bilecik) and TR 61 (Antalya, Isparta, Burdur). Moreover, TR 10 (İstanbul) with 13 percent has the highest share of total public investment in 2019 and it has highest share of total public investment on average with 17 percent . Other regions with higher values after TR 10 (İstanbul) are TR 41 (Bursa, Eskişehir, Bilecik), TR 51 (Ankara), TR 90 (Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane), TR63 (Hatay, Kahramanmaraş, Osmaniye), TR 31 (İzmir), TR 42 (Kocaeli, Sakarya, Düzce, Bolu, Yalova) respectively. As can be seen from the data in the table,

Table 1: Summary of the Literature for Turkey.

Writer(s)	Region/ Data	Date	Theoretical Model	Method	Findings
Yazgan and Ceylan (2021)	NUTS II	2004-2018	Club Convergence	Phillips and Sul (2007)	There is club convergence.
Karahasan (2020)	NUTS III	1975-2017	Club Convergence	Spatial Markov Chain	Mixed Results exist.
Aksoy et al. (2019)	NUTS-III	1987-2001 2004-2017	Club Convergence	Phillips and Sul (2007)	There is club convergence.
Karagöl et al. (2019)	NUTS-III	2004-2017	Club Convergence	Phillips and Sul (2007)	There is club convergence.
Önder et al. (2007)	NUTS-I	1980-2001	Conditional Convergence	Panel Spatial Analysis	There is conditional convergence.
Karaca (2018)	NUTS-II	1960-2010	Absolute Convergence	Cross-Sectional Analysis, Panel Data Analysis.	There is no absolute convergence.
Gömleksiz et al. (2017)	NUTS-II	2004-2014	Conditional Convergence	Panel Data Analysis	There is conditional convergence.
Gerni et al. (2015)	NUTS-II and NUTS-III	2004-2012	Absolute Convergence and Conditional Convergence	Panel Data Analysis	There is absolute convergence. There is mixed results for conditional convergence.
Abdioğlu and Uysal (2013)	NUTS-II	2004-2008	Conditional Convergence	Panel Unit Root Test	There is no conditional convergence.
Karaalp and Erdal (2012)	73 provinces and 7 Regions	1993-2001	Conditional Convergence	Panel Data Analysis	There is conditional convergence.
Zeren and Yılancı (2011)	NUTS-II	1991-2000	Absolute Convergence and Conditional Convergence	Panel Data Analysis	There is absolute convergence and conditional convergence.
Yıldırım et al. (2009)	NUTS-II and 67 provinces	1987-2001	Absolute Convergence and Conditional Convergence	The Theil Coefficient Of Concentration Index	There is absolute convergence and conditional convergence
Erk et al. (2000)	67 provinces and 7 regions	1979-1997	Absolute Convergence and Conditional Convergence	Cross Sectional Analysis	There is no absolute convergence and conditional convergence

there is a huge regional disparity in GDP per capita. Moreover, public investment expenditures are far from reducing regional inequalities in the country, as regions with high GDP per capita receive more public investment than regions with low GDP per capita except TR 90 (Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane). Huge disparities in income distribution between regions may be a signal of multiple long run equilibria. Therefore, this study aims to investigate the existence of convergence clubs in Turkey. Despite regional differences in income and accompanying public investment distributions, this study also scrutinizes the existence of conditional convergence.

According to Bernard and Durlauf (1996), when economies have multiple long run equilibrium, cross sectional tests tend to spuriously reject the null hypothesis of no convergence. As before we mentioned in order to avoid spuriously reject the null; we use Phillips and Sul (2009) (PS) procedure to identify convergence clubs in Turkey at regional level. This procedure has four steps to identify the subgroups. In the first step, we order individuals in the panel according to the last observation of the log of rGDPpc. In the second step we select the first "k" highest individuals in the panel from the subgroup and run log(t) regression. After the regression, then we calculate the convergence test statistic for this subgroup. Step three is about adding individuals to the subgroups. Finally, the last step is about stopping the rule. After determining clubs, we also investigate the effect of public capital in these clubs. To test the regional conditional convergence in Turkey, under constant

Table 2: Summary of the Basic Data for Turkish Regions at NUTS II Level.

NUTS II Regions	GDP per capita in 2019 (1000 TL, in 2009 prices)	Real GDP per capita as a proportion of Turkey's Average in 2019	Share of total GDP in 2019	Real public investment in 2019 (1000 TL, in 2009 prices)	Share of total public investment in 2019	Share of total public investment on average
Year	**2019**	**2019**	**2019**	**2019**	**2019**	**2004-2019**
TR10	6236.31	165.86	7.75	75247.64	13.11	17.47
TR21	4460.04	118.62	5.54	5147.39	0.90	1.84
TR22	3384.80	90.02	4.21	20029.42	3.49	2.13
TR31	4350.93	115.72	5.41	34262.30	5.97	3.90
TR32	3337.62	88.77	4.15	22622.92	3.94	2.60
TR33	3173.87	84.41	3.94	11862.40	2.07	2.66
TR41	4180.45	111.18	5.20	46924.26	8.17	4.20
TR42	4703.40	125.09	5.84	33115.75	5.77	4.22
TR51	5114.59	136.03	6.36	46121.17	8.03	9.62
TR52	2978.76	79.22	3.70	14196.56	2.47	3.29
TR61	4049.80	107.71	5.03	18126.54	3.16	3.85
TR62	2855.28	75.94	3.55	25310.34	4.41	3.16
TR63	2319.40	61.69	2.88	40801.68	7.11	3.26
TR71	2627.52	69.88	3.27	8223.98	1.43	4.26
TR72	2811.62	74.78	3.49	15963.35	2.78	2.59
TR81	2608.63	69.38	3.24	8158.34	1.42	1.62
TR82	2631.90	70.00	3.27	5091.07	0.89	1.51
TR83	2340.32	62.24	2.91	13999.56	2.44	3.14
TR90	2519.81	67.02	3.13	44286.17	7.71	6.00
TRA1	2461.56	65.47	3.06	10569.55	1.84	1.93
TRA2	1675.31	44.56	2.08	3783.36	0.66	1.42
TRB1	2259.82	60.10	2.81	12975.93	2.26	2.33
TRB2	1556.72	41.40	1.93	13594.88	2.37	2.16
TRC1	2430.66	64.65	3.02	8944.48	1.56	2.25
TRC2	1466.27	39.00	1.82	28826.32	5.02	4.54
TRC3	1933.82	51.43	2.40	5968.00	1.04	4.06
Turkey's GDP per capita in 2019:		3759.94	**Total public investment in 2019:**		574153.38	

return of scale following Mankiw, Romer, and Weil (1992), and Barro and Sala-i Martin (1992), we start with Cobb Douglas production function as follows:

$$Y = K^{\alpha}_{t}(A_tL_t)^{1-\alpha} \qquad 0<\alpha<1, \qquad (1)$$

where Y denotes output, K stands for capital, L for labor and A for technological progress.

$y = Y_t / L_t$ is the output per unit of labor and $k = K_t / L_t$ is the stock capital per unit of labor. Also, $\tilde{y} = Y_t / A_tL_t$ and $\tilde{k} = K_t / A_tL_t$ are the output per unit of effective labor and the stock of capital per effective labor, respectively. Hence, we can rewrite the production function as follows:

$$\tilde{y} = \tilde{k}^{\alpha} \qquad (2)$$

s_K represents the investment ratio while $s_K Y_t$ stands for the investment portion of income. It is assumed that δ is the depreciation rate, technology and labor grow at exogenously determined rates g and n respectively. As shown in equation (3), the dynamic version of $\tilde{k}$ indicates the convergence to its steady state value. It can be written as:

$$\overset{0}{\tilde{k}} = s_K\tilde{y} - \tilde{k}(g+n+\delta) \qquad (3)$$

Since $\tilde{k}$ represents a constantly rising function, the derivatives of the logarithm of time become zero, equaling the steady-state $\overset{0}{\tilde{k}}$ to zero.

We obtained steady state production function ($\tilde{y}^* = (\tilde{k}^*)^\alpha$) using equation (3). Its logarithmic form can be expressed by:

$$\ln \tilde{y}^* = \alpha \ln \tilde{k}^* \quad (4)$$

Combining equation (3) and (4) under the assumption of steady state $\overset{0}{\tilde{k}}$ equals zero. We acquire the following form:

$$\ln \tilde{k}^* = \frac{1}{1-\alpha} \ln s_K - \frac{1}{1-\alpha} \ln(n+g+\delta) \quad (5)$$

In the above equation, $\tilde{k}^*$ refers to the steady state value of $\tilde{k}$.

Substituting Equation (5) with Equation (4), gives:

$$\ln \tilde{y}^* = \frac{\alpha}{1-\alpha} \ln s_K - \frac{\alpha}{1-\alpha} \ln(n+g+\delta) \quad (6)$$

Furthermore, the derivative of Equation (4) as to time is as thus:

$$\frac{d \ln \tilde{y}}{dt} = \alpha \frac{d \ln \tilde{k}}{dt} k \quad (7)$$

Solving $\frac{d \ln \tilde{y}}{dt}$ with first-order Taylor expansion we reach the following equation:

$$\frac{d \ln \tilde{y}}{dt} = -(1-\alpha)(n+g+\delta)(\ln \tilde{y} / \ln \tilde{y}^*) \quad (8)$$

Defining $(1-\alpha)(n+g+\delta) = \lambda$ in equation (8). With first order linear differential equation we obtain the following form:

$$\ln(\tilde{y}/\tilde{y}_0) = -(1-e^{-\lambda t}) \ln \tilde{y}_0 + (1-e^{-\lambda t}) \ln \tilde{y}^* \quad (9)$$

Using the definition of output per unit of effective labor ($\tilde{y} = Y_t / A_t L_t$) and defining public capital as a technology shifter, equation (10) can be rewritten as:

$$\ln(y / y_{t-1}) = -(1-e^{-\lambda t}) \ln y_{t-1} + (1-e^{-\lambda t})(\ln \tilde{y}^* + g + pc_{t-1}) \quad (10)$$

The parameters are defined as $\beta_1 = -(1-e^{-\lambda t})$, $\beta_2 = (1-e^{-\lambda t})$ and $\beta_0 = (1-e^{-\lambda t}) \ln \tilde{y}$ In equation (10), following Islam (1995), we obtain the panel case of the theoretical model:

$$\ln(y_{it} / y_{it-1}) = \beta_0 + \beta_1 \ln y_{it-1} + \beta_2 pc_{it-1} + u_{it} \quad (11)$$

where u_t implies the error term.

The GMM model developed by Blundell Bond (1998) depends on first differences (14) and level equation (13).

$$\ln(y_{it}/y_{it-1}) = \beta y_{it-1} + \gamma pc_{it-1} + \theta + \eta_i + \nu_{it} \quad (13)$$

$$\Delta \ln(y_{it}/y_{it-1}) = \beta \Delta y_{it-2} + \gamma \Delta pc_{it-1} + \Delta \nu_{it} \quad (14)$$

$$u_{it} = \eta_i + \nu_{it}$$

where fix effects are represented by ηi and idiosyncratic shocks are vi in the model.

EMPIRICAL RESULTS

In this section we report the empirical results of two different convergence frameworks: club convergence and conditional convergence. In the first step of empirical analysis, we investigate the existence and significance of the club convergence. For this purpose, we apply Hodrick-Prescott filter to extract trend and cyclical components for each individual in the panel from real GDP per capita and after that, we apply log(t) test as mentioned as in PS and Du (2017). The second step of the empirical analysis is to identify the clubs after determining that there are multiple equilibria. In the third step of the empirical analysis, PSmerge and LT procedures are used to examine whether there are merging clubs. Finally, the fourth step is to investigate whether there is conditional convergence between regions.

The coefficient, standard error, and t statistic of log(t) test are reported in Table 3. Due to the fact that t statistic is less than -1.65 (calculated as -18.76), which indicates that the null hypothesis of convergence is rejected at 5 percent significance level, there are multiple equilibria. As a consequence of the log (t) test result, we can use PS algorithm to investigate sub grubs in the panel. The PS algorithm initially identified 6 convergence clubs and one divergence club as stated in Table 4.

Following Sichera and Pizzuto (2019) we use PSmerge and LT club merging algorithms respectively to seek for possible mergers. Our findings revealed that PSmerge and vLT club-merging algorithms have identical results in terms of the number of final clubs and members of the clubs. Since they have the same results, this study reports just PSmerge statistics instead of reporting both of them in Table 5.

Table 5 shows the final members of the clubs after employing club-merging algorithms. According to the club-merging algorithm, Club 4 and Club 5 should merge with each other. The final number of clubs (five) and their members are illustrated in Table 5.

As a result, we concluded that there are five convergence clubs in NUTS II regions in Turkey. Figure 1 illustrates the average of the real GDP per capita in 2019 (mean(lny)) and share of total public investment on average (2005-2019) (meanpcavg) values of each club[1.] It is seen that Club 1 and TR 10, which have a high income, also receives a high share of public investment.

[1] Figure 1 was prepared in Excel. Figure 2, 3 and 4 are drawn in the GEODA program and Figure 5 is created in the R package program.

Table 3: Club Convergence log(t) Test

Variable	Coef (log(t))	sth	t-stat	prob
log(t)	-0.522	0.028	-18.76	0.00

Coef is the coefficient of log (t) test and sth is the standard error of the coefficient. Besides, t-stat is the t statistics of log (t) test.

Table 4: Coefficient of log(t) Test for Initial Clubs

Initial Clubs	Coeff log(t)	Std err.	t value	N	Members
Club 1	0.51	0.15	3.36	2	TR42,TR51
Club 2	2.96	0.31	9.64	2	TR21,TR31
Club 3	-0.05	0.06	-0.87	12	TR22, TR32, TR33, TR41, TR52, TR61, TR62, TR71, TR72, TR81, TRA1, TRC1
Club 4	0.16	0.08	1.94	5	TR63, TR82, TR90, TRB1, TRC3
Club 5	-0.04	0.07	-0.52	2	TR83, TRA2
Club 6	4.85	1.34	3.31	2	TRB2, TRC2
Divergent				1	TR10

Coeff is the coefficient of log (t) test, std err. is the standart deviation of the coefficient. The results are obtained from using R following Sichera and Pizzuto (2019).

Table 5: Club-Merging Algorithm Results

Final Clubs	Coeff log(t)	Std err.	t value	N	Members
mClub 1 (1)	0.51	0.15	3.36	2	Club 1
mClub 2 (2)	2.96	0.31	9.64	2	Club 2
mClub 3 (3)	-0.05	0.06	-0.87	12	Club 3
mClub 4 (4)	0.16	0.08	1.94	7	Club 4 and 5
mClub 5 (5)	-0.04	0.07	-0.52	2	Club 6
mDivergent (0)				1	TR10

Coeff is the coefficient of log (t) test, std err. is the standard deviation of the coefficient. The results are obtained from using R following Sichera and Pizzuto (2019).

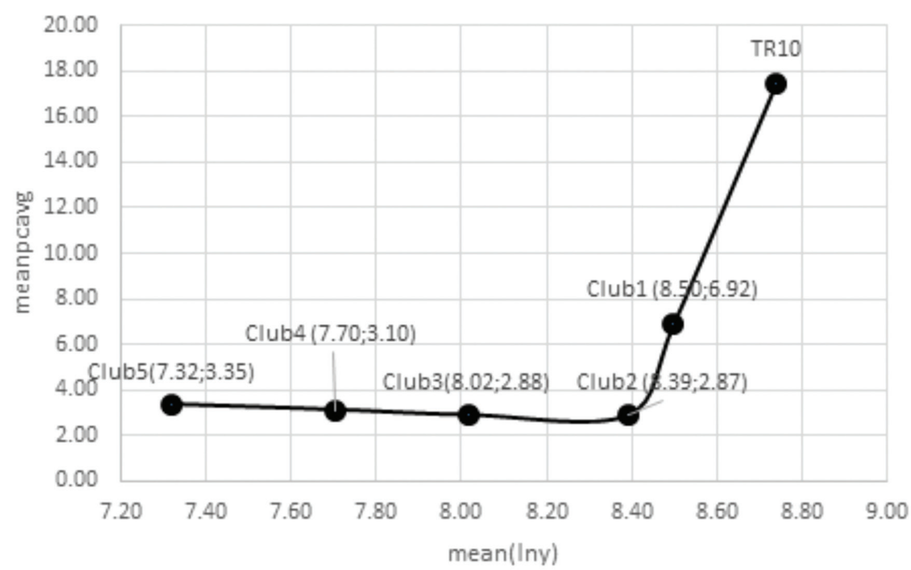

Fig. 1: Basic data of Convergence/Divergent Clubs: Real GDP per capita in 2019 and Share of Total Public Investment on Average (2005-2019)

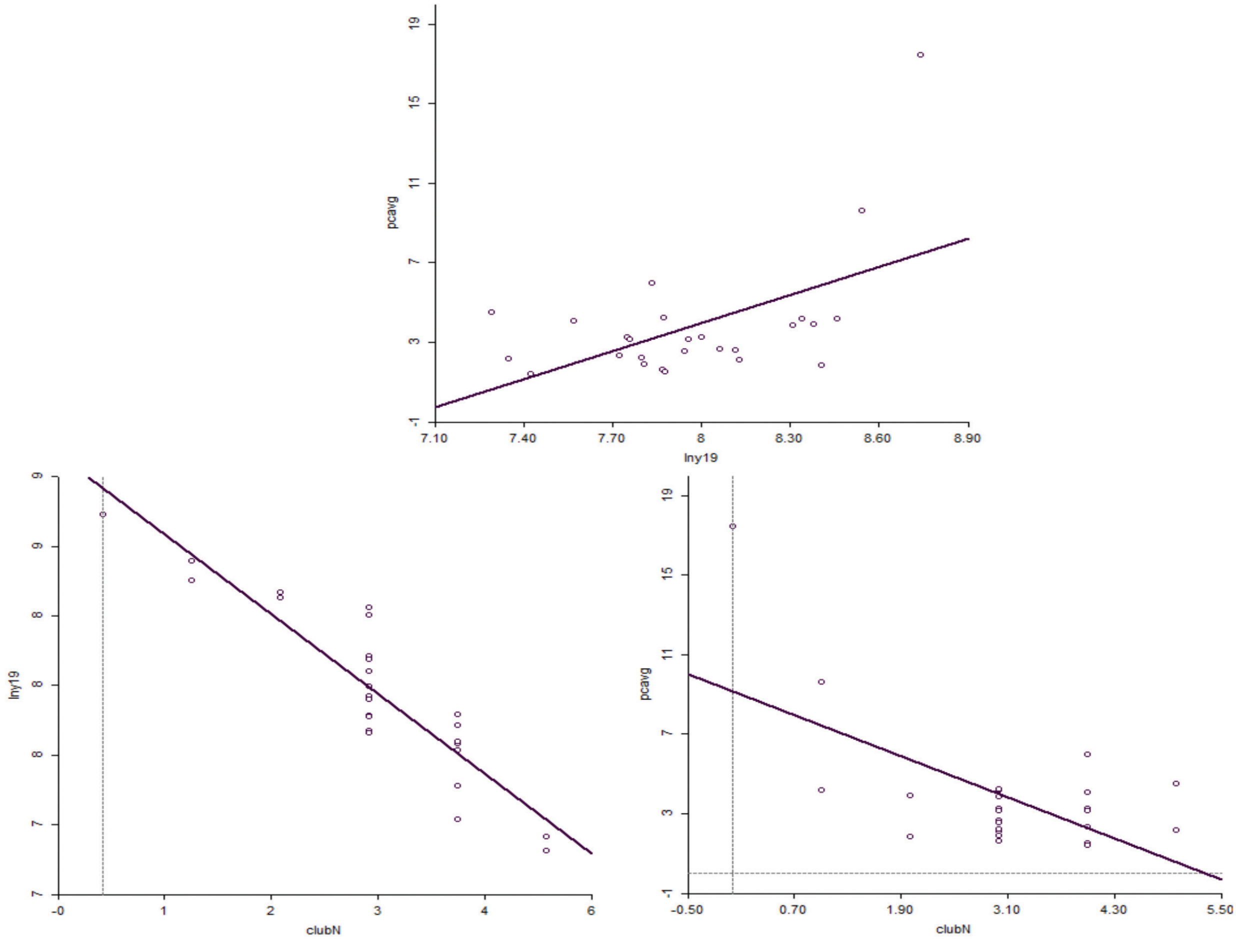

Fig. 2: The Relationship Between Log of Real GDP per capita in 2019 (lny19) and Share of Total Public Investment on Average (2005-2019) (pcavg).

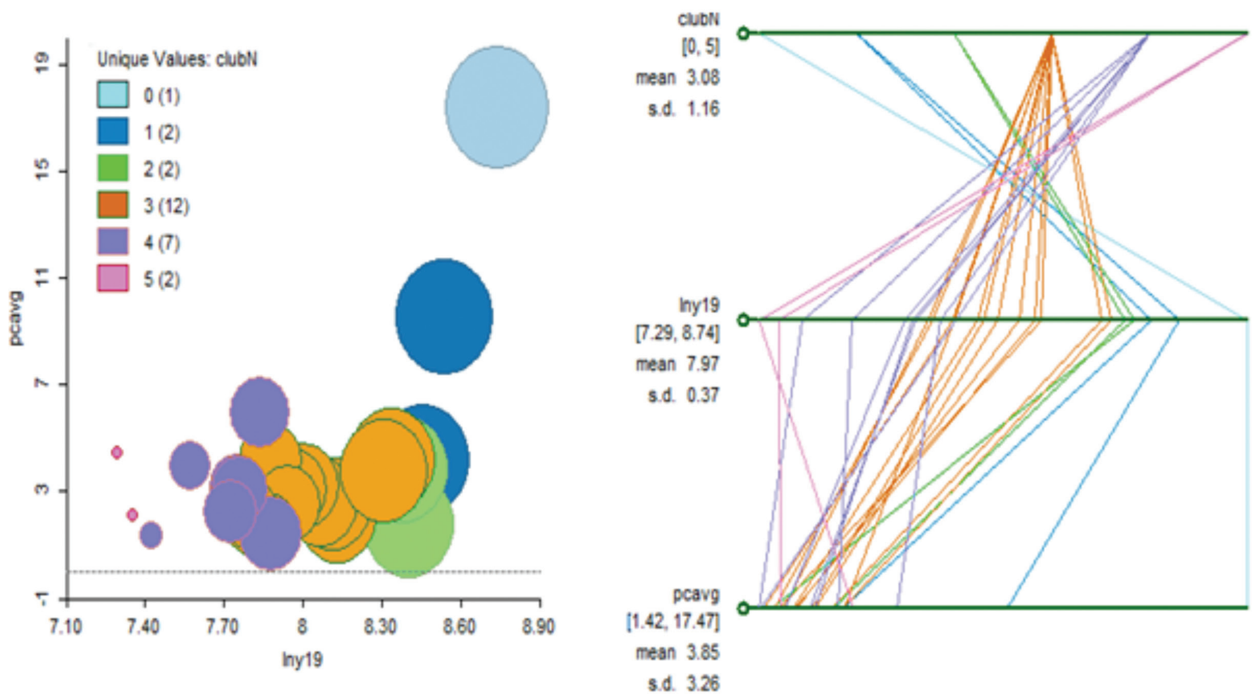

Fig. 3: The Bubble Chart and Parallel Coordinates of lny19 and pcavg.

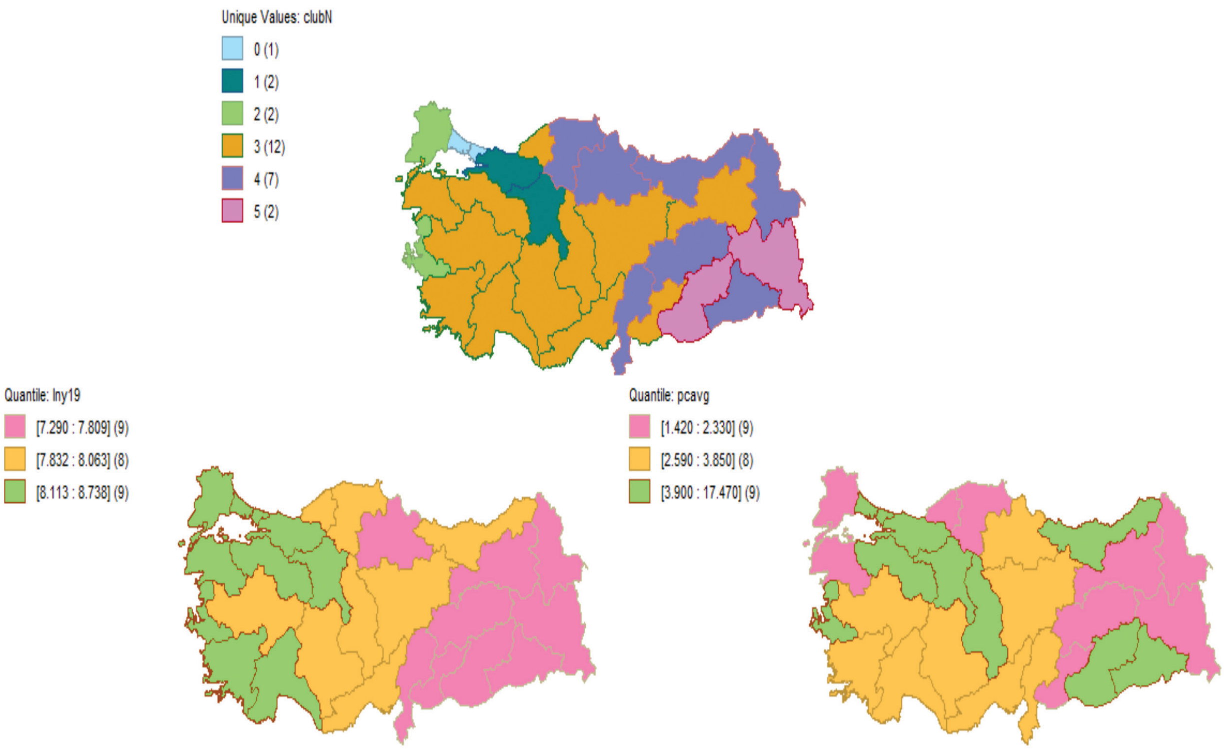

Fig. 4: The Quantile Map of Clubs, Log of Real GDP per capita in 2019 (lny19) and Share of Total Public Investment on Average (2005-2019) (pcavg).

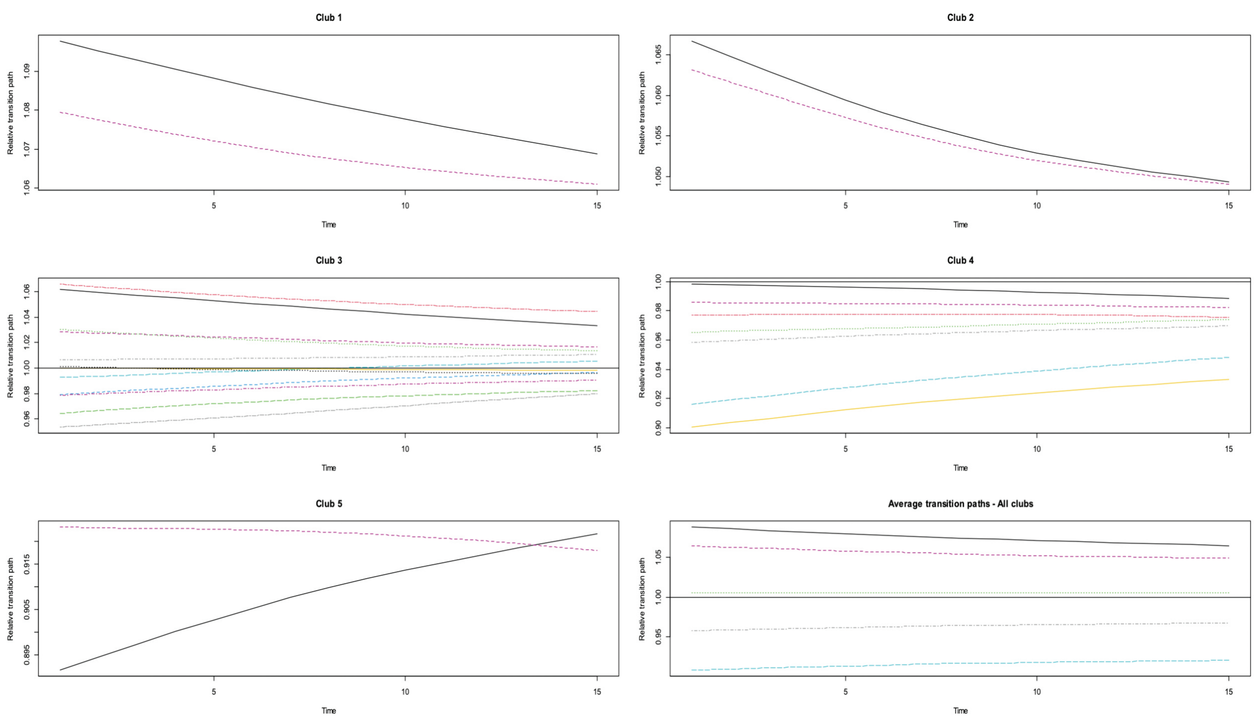

Fig. 5: The Relative and Average Transition Paths of Initial Convergence Clubs

Figure 2, the relationship between log of real GDP per capita in 2019 (lny19) and share of total public investment on average (2005-2019) (pcavg), highlights the positive relationship between income and share of public investments distribution as in Figure 1. Also, Figure 2 shows that convergence clubs and their member's classification in terms of lny19 and pcavc variables.

The bubble chart and parallel coordinates plot of lny19 and pcavg are illustrated in Figure 3. According to Figure 3, as in Figure 1 and Figure 2, clubs with high income level have a relatively high amount of share of public investment. Therefore, the bubble chart shows that public investment expenditures are not aimed to reduce regional inequalities in the country. The parallel coordinates graph shows that the share of public capital is not distributed equally in terms of GDP per capita. Figure also illustrates that clubs 1, 2 and TR10 (only member of divergent club) have a higher proportion of public investment rates on average than others.

The members of convergence and divergent clubs are colored in Turkey's NUTS II level map and quantile map also shown for income and share of public investment data in Figure 4. Although there are neighboring regions within the same clubs, there are cases where non-neighboring regions are also located in the similar clubs. On the other hand, according to Figure 4, most of the regions have high level of public investments with high income levels, but in some cases vice versa. It also supports the unequal distribution of public capital.

Figure 5 illustrates relative transition parameters and paths for club members and average transition parameters and paths of convergence clubs, respectively. These parameters in the figure calculated from log of real GDP per capita for the 26 sub regions over the period 2005 to 2019 after eliminating the business cycle following Phillips and Sul (2009). Figure shows how regions' real GDP per capita approach their steady state of each club.

Figure 5 also indicates that relative transition paths get closer over time which is the signal of convergence. However, average transition paths of clubs in the figure shows that the speed of convergence over time is quite low between clubs which may be a signal of multiple equilibria or invalidity of absolute convergence. Despite the low speed of convergence with respect to average transition paths of clubs in the figure, as stated in the introduction section public capital investment has the capacity to achieve convergence. However, Figure 1-4 and Table 2 illustrate that public investments are not used to reduce regional income differences. Therefore, share of public capital may be a distinguishing structural factor, for conditional convergence. For this purpose, this study also tests the conditional and unconditional convergences.

System GMM (Sys-GMM) test results are indicated in Table 6. We obtained the Sys- GMM results by using the written STATA modules (Roodman, 2009). The Arellano & Bond (AR (#)) test developed by Arellano & Bond (1991) tests the hypothesis of no correlation in the series. Therefore, the high probability value of the AR(2) test statistic is important for the estimator to give reliable results. In this study, if the probability value of the AR(2) test statistic is less than 0.05, the number of lags that can be used for the dependent variable is increased. If the problem persists, the number of lags that can be used for the independent variables has been increased. In this way, the appropriate number of lags was determined. The most important difference of the Sys-GMM estimator, outlined by Blundell & Bond (1998) and Arellano & Bover (1995), from the Arellano & Bond (1991) Difference-GMM estimator is that it relies on estimating a two-equation regression system in levels and first differences in order to increase efficiency (Roodman, 2006).

According to Table 6, public capital is statistically significant at 5 % level with a positive sign. However, it has a low impact on growth because of the low magnitude of coefficient. Meanwhile, as stated in the conditional convergence framework, the results revealed that negative relationship exists and is statistically significant at 5 % level between real income and growth rate. This result is consistent with the literature and theoretical framework for conditional convergence. Therefore, after accepting that the share of public capital is an important structural factor, conditional convergence is valid for NUTS II regions in Turkey during the period 2005-2019. However, the unconditional convergence findings revealed that there is no significant relationship between real income and growth rate. Besides, the coefficient of the real income is positive which indicates the divergence. This result is consistent with Figure 5.

Table 6: Sys-GMM Results

Dependent Variable is Growth	Conditional Convergence Sys-GMM Results				Absolute Convergence Sys-GMM Results			
	Coef	**Std. Err.**	**t- stat**	**prob.**	**Coef**	**Std. Err.**	**t- stat**	**prob.**
c	3.39	1.26	2.68	0.01	0.48	0.44	1.09	0.28
y_{t-1}	-0.35	0.16	-2.1	0.04	0.03	0.06	0.53	0.59
pc_{t-1}	0.014	0.006	2.2	0.03				
	Hansen-J p-value	0.18	Sargan p-value	0.02	Hansen-J p-value	0.20	Sargan p-value	0.22
Second order serial correlation (p-value of AR(2) Test)				0.26	Second order serial correlation (p-value of AR(2) Test)			0.20

All equations include year dummies. GMM is the Blundel-Bond System GMM estimator using lagged growth rates and levels as instruments, also uses levels of independent variables and share of public capital on average as instruments. Robust t-statistics are used.

CONCLUSION

This study examines club convergence at regional level and the impact of share of public investments expenditures on conditional convergence for the period 2005 to 2019. It does so by observing 26 sub-regions (NUTS II level) in Turkey using PS, PSmerge, LT procedures to determine the convergence clubs and also System GMM estimators to test the validity of conditional and unconditional/absolute convergence. Initial empirical results show that there are six convergence clubs in Turkey and one divergent club. However, after utilizing merging algorithms proposed by PSmerge and LT, we reach five convergence clubs and one divergent club.

On the other hand, the results of Sys-GMM developed by Arellano and Bover (1995), and Blundell and Bond (1998), shows that initial GDP is statistically significant for conditional convergence, while it is not for unconditional convergence. Thus, if the club convergence or conditional convergence is not taken into consideration, divergence occurs between NUTS II regions. Additionally, public investment is found significant for the conditional convergence model, while basic data of the regional level reveal that public investment does not target to reduce regional disparities. Therefore, its impact on growth is relatively low according to the Sys-GMM results supporting the claim. This result is also compatible with the summary of the basic data (Table 2 and Figure 1-5) and literature. According to the basic data of the regions, there are some huge regional disparities in real GDP per capita and public investment expenditures distributions. Moreover, public capital investment expenditures are far from reducing regional inequalities in the country since regions with high GDP per capita receive more public investment expenditures than the regions with low GDP per capita except TR 90 (Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane). Club averages from the basic data also highlights the positive relationship between income and share of public investments distribution which is another important signal that the public capital is not aim to reduce regional disparities. Additionally, the parallel coordinates graph of the clubs in the empirical findings also shows that the share of public capital is not distributed equally in terms of GDP per capita. Moreover, Clubs 1, 2 and TR10 (member of the divergent club) have higher proportion of public investment rates on average than others. These findings are compatible with the results of Karadağ, Önder, and Deliktaş (2004, 2007) for Turkey. They argue that public capital has no or low impact on convergence as Turkey invests in less developed regions without considering the rate of return and the effectiveness of public capital.

Overall, the results support that the government does not use public capital as a tool to reduce regional disparities. On the other hand, one of the underlying reasons for the differentiation of structural factors between regions is public investments. Besides, the findings revealed that there is conditional convergence when the share of public investments among regions are taken into consideration. Also, the findings emphasize the existence of convergence clubs, which indicates multiple equilibria while, there is no unconditional convergence at NUTS II level in Turkey. Therefore, public capital should be used much more effectively because of its capability to reduce regional disparities. As a result, policy makers should implement policies that consider the effectiveness of public capital.

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Appendix

NUTS II Level	Province Names
TRA1	Erzurum, Erzincan, Bayburt
TRA2	Ağrı, Kars, Iğdır, Ardahan
TRB1	Malatya, Elazığ, Bingöl, Tunceli
TRB2	Van, Muş, Bitlis, Hakkâri
TRC1	Gaziantep, Adıyaman, Kilis
TRC2	Şanlıurfa, Diyarbakır
TRC3	Mardin, Batman, Şırnak, Siirt
TR10	İstanbul
TR21	Tekirdağ, Edirne, Kırklareli
TR22	Balıkesir, Çanakkale
TR31	İzmir
TR32	Aydın, Denizli, Muğla
TR33	Manisa, Afyonkarahisar, Kütahya, Uşak
TR41	Bursa, Eskişehir, Bilecik
TR42	Kocaeli, Sakarya, Düzce, Bolu, Yalova
TR51	Ankara
TR52	Konya, Karaman
TR61	Antalya, Isparta, Burdur
TR62	Adana, Mersin
TR63	Hatay, Kahramanmaraş, Osmaniye
TR71	Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir
TR72	Kayseri, Sivas, Yozgat
TR81	Zonguldak, Karabük, Bartın
TR82	Kastamonu, Çankırı, Sinop
TR83	Samsun, Tokat, Çorum, Amasya
TR90	Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane

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The Relationship Between Foreign Direct Investment, Economic Growth, Energy Consumption and Co2 Emissions: Evidence from ARDL Model with a Structural Break for Turkey

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ABSTRACT

This paper investigates the impact of foreign direct investments, energy consumption and economic growth on CO2 emissions in Turkey for the period of 1974-2015 by using autoregressive distributed lag (ARDL) model with a structural break. The robustness of the model is tested by using FMOLS, DOLS and CCR estimators. The findings reveal a long-run relationship between the variables, and show that FDI contributes positively to CO2 emissions, validating pollution haven hypothesis. Economic growth (measured by GDP) has a significantly positive relationship with CO2 emissions whereas impact of its squared on CO2 emissions is also significant but negative which confirms Environmental Kuznets Curve (EKC) hypothesis. Energy consumption is also positively associated with CO2 emissions, implying that larger levels of energy consumption lead to a higher environmental degradation. The dummy variable including the structural break is similarly statistically significant and positive. It is concluded that because of FDI inflows engender an increase in carbon emissions, Turkey should adopt cleaner technologies to avoid environmental pollution.

Keywords: CO2 emissions, pollution haven hypothesis, foreign direct investment, energy, economic growth.

JEL Classification Codes: O13, O44, Q56

INTRODUCTION

Environmental issues in economics are typically ignored until the late 1980s, but the topic has secured an increasing interest among economists for a few decades. The environment which we live in is affected by various sorts of economic activity. The industry, households, governments, the institutions and the state of technology altogether construct an economy that operates within the environmental system. The environment provides the aforementioned economic system with inputs of raw materials, energy and natural resources which are eventually transformed by economic system into outputs (Hanley et al., 2013). As a result, the environment is regarded as an economic asset that is crucial to the operation of the economic system. Although the higher economic activity may lead major improvements in human life, it arises through a tradeoff in use of environmental resources, resulting in increased scarcity (Barbier, 2011). The depletion of natural resources is a matter of interest and it is widely acknowledged that economic activity is in some forms are related with this depletion. Natural resources are becoming increasingly scarce over time and thus it is important to consider how to leave a clean and safe environment for future generations. The extensive interest on the awareness on environmental degradation has found an expansion area with the influential paper of Grossman and Krueger (1991) which assumes an inverted-U shaped relationship between income and environmental pollution. However, the ongoing debate on the nexus between income and environmental pollution is still contentious (Panayotou, 1997; Stern, 2004; Apergis and Payne, 2009). Obviously, income is not the sole factor in influencing environmental quality. Several other factors such as exponential energy consumption (Menyah and Wolde-Rufael, 2010; Zakari et al., 2021), foreign direct investment inflows (He, 2006; Tang, 2015; Solarin et al., 2017), trade openness (Shahbaz et al., 2013b; Zhang et al., 2017), urbanization (Hossain, 2011; Lv and Xu, 2019), corruption (Cole, 2007; Sinha et al., 2019; Go et al., 2021) and financial development (Sadorsky, 2011; Omri et al., 2015; Bekhet et al., 2017) are also directly related with the environmental quality of a country.

Turkey has experienced a significant increase in energy consumption, CO2 emissions and foreign direct investments during the last few decades. CO2 emissions (metric tons per capita) have been almost quadrupled in the last five decades. CO2 emissions were measured as 1.22 metric tons per capita in 1970, and the employed quantity was 5.01 metric tons per capita in 2018. Greenhouse gas emissions of Turkey increased significantly during the period of 1990-2010, primarily

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due to CO_2 emissions, and according to Carbon Dioxide Information Analysis Center (CDIAC) of the United Nation (UN)'s data of 2008, Turkey was among the top 25 CO_2 emitting countries in the world (Seker et al., 2015; Mutafoglu, 2012). The noticeable increase in CO_2 emissions is mostly induced by increased rate of energy consumption. In 1970, the energy consumption has measured as 522.2 kg of oil equivalent per capita and it was estimated as 1651.3 kg of oil equivalent per capita in 2015 (World Bank, 2022). According to the International Energy Agency, the industry in Turkey is highly energy-intensive and is admitted as one of the most energy-intensive among OECD countries (Isiksal et al., 2019). Although, it has had some fluctuating performances, particularly during periods of crisis, foreign direct investment inflows have followed a similar path, with FDI (foreign direct investment) inflows accounting for 34 percent of GDP in 1970 and 105 percent of GDP in 2020. A brief glance to Turkish economy reveals that it has encountered several structural changes during the last half-century. In the early 1980s, Turkey has started to implement liberalization policies which resulted in significant economic growth emanated by considerable increase in international trade, financial sector inflows and foreign direct investments. This makes Turkey as an important case involving the relevant variables.

As a major tool on transferring technology, financial capital and other skills, foreign direct investments (FDIs) have three types of impacts on host country that they are economic political and social. The political effects focus mostly on the insecurity of national independence and the social effects are primarily concerned with the possibility of cultural transformation of society and creation of foreign elite in host country. Economic effects, on the other hand, imply a variety of outcomes in terms of output, the balance of payments and market structure (Moosa, 2002). The majority of the studies agree that FDI contributes to economic growth via providing capital, increasing productivity, creating new job probabilities and boosting competitiveness (De Mello, 1999; Mallampally and Sauvant, 1999; Hermes and Lensink, 2003; Batten and Vo, 2009; Faras and Ghali, 2009; Alfaro et al., 2010; Chee and Nair, 2010; Choong et al., 2010; Lee, 2013; Iamsiraroj, 2016). However, some studies have explained that there is no direct impact of FDI on growth (Carkovic and Levine, 2002; Durham, 2004) or the occurrence of positive effects of FDI on welfare and growth requires the presence of other factors or preconditions, such as a specific level of human capital stock or adequate level of investment in the absorption of foreign technologies and skills (Borensztein et al., 1998; Blomström and Kokko, 2003; Mencinger, 2003; Akinlo, 2004). Although the nexus between foreign direct investment and growth is highly debated, the economic effects of FDI mainly neglect to consider environmental issues (Pazienza, 2014). However, there is a direct impact of FDI on environmental degradation and the contributions on this area have extended during the last decades.

We investigate the impact of foreign direct investments, energy consumption and economic growth on CO_2 emissions by using autoregressive distributed lag (ARDL) modeling approach to cointegration with a structural break. The study assumes that there is at least one structural break in certain specific periods for each variable because the investigation spans a reasonably long-period. The main aim of the study is to explore the relationship between environment, foreign direct investments, economic growth and energy consumption by including a structural break to the analysis. The study also aims to explain whether pollution haven hypothesis is valid by investigating the impact of FDI on CO_2 emissions. Although there are several studies using ARDL methodology, this study differs from the literature by including a structural break to ARDL model as an exogenous variable. The following chapter includes a literature review on the nexus of related variables. The third chapter presents the basic methodologies used in the analysis and continues with the findings. The study is finalized with conclusion chapter.

LITERATURE REVIEW

Environmental degradation related issues such as energy consumption, economic growth, foreign direct investment, financial development or trade openness are highly popular among economists and there are increasing number of studies attempting to explore new aspects of this area. Several new theories have emerged as a result of the contribution of these studies. The investigation of the relationship between income and environment has caused Environmental Kuznets Curve (EKC) to be discovered which suggests an inverted-U shaped association between economic growth and environmental degradation (Grossman and Krueger, 1991). Some studies have validated EKC hypothesis (Acaravci and Ozturk, 2010; Ren et al., 2014; Boluk and Mert, 2015; Shahbaz et al., 2018), whereas others have found no support for it (Chandran and Tang, 2013; Al-Mulali et al., 2015; Dogan and Turkekul, 2016). The relevant literature on Turkey has also yielded conflicting results. Gurluk and Karaer (2004)'s study is among the first which investigates the relationship between economic growth and CO_2 emissions, and they find an inverted-U type relationship over the period 1975-2000. Basar and Temurlenk (2007), on the other hand, discover an N-shaped relationship and find no evidence for the validity of EKC hypothesis in Turkey between 1950 and 2005. By using the Johansen cointegration methodology, Akbostanci et al. (2009) find a unique long-run relationship between economic growth and CO_2 emissions, but reject the validity of EKC hypothesis and suggest a monotonically increasing relationship for the period of 1968-2003. Katircioglu and Katircioglu (2018) support the increasing relationship for Turkey in the period of 1960-2013, demonstrating that the association between economic growth and CO_2 emissions is not inverted-U shaped. By using an ARDL approach, Halicioglu (2009) proposes a long-run relationship between economic growth and CO_2

Table 1. Studies on the relationship between GDP, EC, FDI and CO2 emissions for Turkey

Author(s)	Period	Variables	Methodology	Results
Halicioglu (2009)	1960-2005	GDP, CO_2, EC, TRA	ARDL bound test	No support on EKC hypothesis.
Ozturk and Acaravci (2010)	1968-2005	GDP, CO_2, EC, EMP	ARDL bound test	No evidence on supporting EKC hypothesis.
Mutafoglu (2012)	1987-2019	GDP, CO2, FDI	Johansen cointegration, Granger causality	No evidence of FDI-led growth and supporting evidence on PHH.
Kocak (2014)	1960-2010	GDP, CO2	ARDL bound test	EKC hypothesis is not supported in the long-run.
Balibey (2015)	1974-2011	GDP, CO2, FDI	Johansen cointegration test, Granger causality	A long term relationship exists between variables and an increase in FDI causes an increase in CO2 emissions.
Seker et al. (2015)	1974-2010	GDP, CO_2, EC, FDI	ARDL, ECM, Granger causality	Although it is relatively small, FDI has positive impacts on CO2.
Gokmenoglu and Taspinar (2016)	1974-2010	GDP, CO_2, EC, FDI	ARDL bound test, Toda-Yamamoto causality	Economic growth, energy consumption and foreign direct investments are long-run determinants of environmental degradation.
Kaya et al. (2017)	1974-2010	GDP, CO2, FDI, TRA	ARDL, Granger causality	FDI has a negative impact on CO2 in short run, but affects positively in long run.
Kilicarslan and Dumrul (2017)	1974-2013	CO2, FDI	Johansen cointegration test, VECM model	PHH is valid.
Kizilkaya (2017)	1970-2014	GDP, CO_2, EC, FDI	ARDL bound test.	No significant relationship between FDI and CO2 emissions.
Ozturk and Oz (2017)	1974-2011	GDP, CO_2, EC, FDI	Maki cointegration test, Granger causality	EKC hypothesis is valid. FDI has positive effects on environment, validating pollution halo hypothesis both in long- and short-run.
Kocak and Sarkgunesi (2018)	1974-2013	GDP, CO2, FDI, EC	Maki cointegration test, DOLS, Hacker and Hatemi-J test	Long-run relationship between the variables and pollution haven hypothesis is valid in Turkey.
Haug and Ucal (2019)	1974-2014	GDP, CO2, FDI, TRA, POP, FD	Linear and non-linear ARDL	Increases in FDI have no significant impacts on CO_2 emissions in long-run. Increases in imports cause an increase in CO2.
Isiksal et al. (2019)	1980-2014	GDP, CO_2, EC, FDI, TRA, RIN	ARDL bound test, Hatemi-J cointegration test	The EKC hypothesis and PHH are valid.
Mert and Caglar (2020)	1974-2018	FDI, CO2	Hidden cointegration tests	Increases in FDI cause a decrease in CO2 both in long and short-run. Supports the validity of asymmetric pollution halo hypothesis.
Bildirici (2021)*	1975-2017	GDP, CO_2, EC, FDI, TER	Pedroni, Kao and Westerlund cointegration tests	FDI contributes to GDP and increases environmental pollution.
Agboola et al. (2022)	1970-2020	GDP, CO_2, EC, FDI, URB	Dynamic ARDL	Supports the validity of PHH in short run and the pollution halo in long run.

*This paper investigates not only Turkey, also three other countries (China, India and Israel). Explanations for variables are GDP= economic growth, EC= energy consumption, CO2= Carbon dioxide emissions, FDI= foreign direct investment, TR= trade openness, EMP= employment, CF= capital formation, POP= population density, RIN= real interest rates, URB= urbanization, TER= terrorism, FD= financial development.

emissions. However, the findings of the study do not support EKC hypothesis. Omay (2013) and Tirgil et al. (2021) find an N-shaped relationship for Turkey which contradicts EKC hypothesis. Ozcan et al. (2018) also find no evidence on supporting EKC for the period of 1961-2013 for Turkey. Balibey (2015) finds an inverted-U shaped relationship, but after a turning point, when increased income causes an increase in pollution, the association becomes an N-shaped in long-run. Pata (2018, 2019), on the other hand, confirms EKC hypothesis for Turkey by using both ARDL and bootstrap ARDL cointegration tests. There are also several more studies for Turkey that employ a variety of other variables for environment such as SO2 (Elgin and Oztunali, 2014; Karahasan and Pinar, 2021; Tirgil et al., 2021) or ecological footprint (Dogan et al., 2020; Sharif et al., 2020; Bulut, 2021) and the findings of these studies are also contradictory. The findings of Elgin and Oztunali (2014), Sharif et al., (2020) and Bulut (2021) support EKC hypothesis, whereas Dogan et al. (2020) find no evidence for it. Finally, Karahasan and Pinar (2021) find a U-shaped relationship between economic growth and environment, while Tirgil et al. (2021) assume an inverted N-shaped relationship.

There have also been numerous studies on the relationship between environmental degradation and energy consumption, with income being one of the key variables in these analyses. The interrelated relation between these variables has caused the expansion of the literature. Kraft and Kraft (1978)'s influential paper on economic growth and energy consumption is one of the early papers and it resulted in a considerable increase in studies on environmental degradation. Soytas (2007) for the U.S., Menyah and Wolde-Rufael (2010) for South Africa, Zhang and Chang (2009) for China, Pao and Tsai (2010) for BRIC countries, Alam et al. (2012) for Bangladesh, Chandran and Tang (2013) for ASEAN-5 economies, Shahbaz et al. (2013a) for Indonesia, Boutabba (2014) for India, Al-Mulali et al. (2015) for Vietnam, Alshehry and Belloumi (2015) for Saudi Arabia, Omri et al. (2015) for MENA countries, Gokmenoglu and Taspinar (2016) and Balli et al. (2020) for Turkey, Ssali et al. (2019) for 6 Sub-Saharan African countries, Bekun et al. (2019) for South Africa, Adebayo and Akinsola (2021) for Thailand, Abbas et al. (2021) for Pakistan and Ahmed et al. (2022) for 22 OECD countries are some examples of these studies. Most basically, higher energy demand is linked to higher environmental pollution in these studies and they found a causal relationship between energy consumption and environmental pollution.

The studies concerning the relationship between foreign direct investment and carbon emissions are abundant. A large number of these studies support the idea that increased foreign direct investment leads to an increasing rate of environmental degradation, especially if the environmental regulations are inadequate or non-existent (Pazienza, 2014). This concept is known as *pollution haven hypothesis* and scientific studies have been unable to provide systematic evidence of its presence and have produced controversial results. Several studies confirm the validity of pollution haven hypothesis (Bukhari et al., 2014; Shahbaz et al., 2015; Solarin et al., 2017; Mert et al., 2019; Essandoh et al., 2020; Mike, 2020; Balli et al., 2021). However, some other studies (Tamazian and Rao, 2010; Al-Mulali and Tang, 2013; Tang and Tan, 2015; Zhu et al., 2016; Jugurnath and Emrith, 2018; Salehnia et al., 2020) suggest that FDI reduces CO2 emissions, rejecting pollution haven hypothesis and arguing that FDI has positive impacts on economies of host countries. This view is mostly based on pollution halo hypothesis which contends that FDI helps developing countries to find the opportunity to improve cleaner technologies with investments on high-level research and development (Jalil and Feridun, 2011; Kocak and Sarkgunesi, 2018; Huynh and Hoang, 2019). The literature on pollution halo hypothesis is also contentious and presents a diverse nature (Balsalobre-Lorente et al., 2019; Mert and Caglar, 2020; Duan and Jiang, 2021; Kisswani and Zaitouni, 2021; Xu et al., 2021; Shinwari et al., 2022). According to He (2008), the relationship between FDI inflows and environmental pollution is significantly more complicated than a simple one-way relationship. FDI can enhance the production scale, transform the industrial structure, provide technical requirements and support host country to embrace advanced technology to control environmental degradation by increasing the income level. Therefore, FDI's impact on environment can be divided into three categories which are *scale, structure (composition) and technique effects* (Grossman and Krueger 1991; Copeland and Taylor 1994; Grossman, 1995; He, 2008; Pazienza 2014; Bakhsh et al. 2017). The scale effect implies the change in the scale of production which leads to a shift in pollution. The technique effect, on the other hand, depicts the change in pollution as a result of the use of environment-friendly technologies in production (Liang, 2014). The increment in the scale of the production will cause higher pollution levels, indicating that the scale effect is predicted to be hazardous to the environment. The technique effect refers to the utilization of cleaner technologies which are beneficial for environment (Pazienza, 2019). A growing number of studies investigate these effects. Bakhsh et al. (2017), for Pakistan during the period of 1980-2014, find that an increase in economic growth leads to an increase in pollutant emissions due to the results of technique and composition effects, using the 3SLS model. Pazienza (2019), for OECD countries, highlights the beneficial role of FDI on environment, mentioning that the scale of inflows increases, the impact of FDI decreases. He (2008), for China, concludes that scale and technique effects are the key operators of FDI's effects on environmental pollution. Pao and Tsai (2011), for BRIC countries, support the scale effect. Bin and Yue (2012), for Chinese industries, find that technological effect reduces emissions, while scale and composition effects increase emissions; however the impact of technological effect is greater than other two effects, indicating that pollution haven hypothesis is also not valid for China. Jun et al. (2018) apply the wavelet approach for China for the period of 1980-2016 and suggest that FDI causes CO2 both in short and long term and emphasize that China's participation to the World Trade Organization (WTO) in 2001 has accelerated the inflows of dirty industries, resulting in both scale and composition effects. *Table 1* denotes a literature review on economic growth, energy consumption, foreign direct investment and CO2 emissions for Turkey. As can be seen, ARDL is a common methodology among these studies. However, the results may differ. Although the majority of studies have discovered a long-term relationship between the relevant variables, the findings on both EKC and pollution haven hypotheses are controversial for Turkey.

DATA AND METHODOLOGY

The study includes the data of Turkey in the period of 1974-2015. The following model is defined to examine the relationship between CO2 emissions and foreign direct investment, economic growth and energy consumption:

$$lnCO2E_t = \alpha_0 + \alpha_1 lnFDI_t + \alpha_2 lnGDP_t + \alpha_3 lnGDP\hat{}2_t + \alpha_4 lnEnUse_t + \alpha_5 DU_t + \varepsilon_t \quad (1)$$

The data is obtained from World Bank database and the natural logarithms of the variables are taken to minimize skewness and make the relationship between economic variables more convenient to interpret. The dependent variable in the model is CO2 emissions (measured by CO2 emissions per capita) and we have four independent variables that they are foreign direct investment (measured by FDI inflows), economic growth (measured by GDP per capita), economic growth squared and energy consumption (measured by energy use per capita). DU_t is the dummy variable, denoting the break year and will be included in the model based on the results of the relevant unit root test. STATA 14.0 and EViews 12.0 software[1] are used to employ econometric analyses.

The simplest way to test unit root begins with AR(1) model which is $y_t = \rho + \alpha y_{t-1} + e_t,\ t = 1, 2 \ldots$ and if ρ is left as unspecified, the null hypothesis of y_t has a unit root, H_0:α=1 and the alternative hypothesis is that H_1:α<1. When |α|<1, then y_t is a stable AR(1) process (Wooldridge, 2002, p. 578). Two of the most common unit root tests are the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests (Dickey and Fuller, 1979; Phillips and Perron, 1988). ADF is primarily concerned with the estimation of α. The null hypothesis is defined as α=0 and the alternative hypothesis is α<0. Δ denotes the first difference and t is the time trend (Glynn et al., 2007):

$$\Delta y_t = \rho + \beta_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-1} + e_t$$

We chose the optimal lag length according to the Schwert (1989)'s rule of thumb for determining the upper bound for k (k_{max}). Then, $k_{max} = 12\left(\frac{T}{100}\right)^{1/4}$.

Zivot-Andrews unit root test with one structural break is then used. Although Dickey and Fuller (1979, 1981)'s unit root testing procedure is one of the most common methodology in economics, as Nelson and Plosser (1982) pointed out, current shocks will have a permanent effect on long-run level of most macroeconomic variables. Zivot and Andrews (1992) have developed Perron (1989)'s methodology and Perron (1989)'s unit root test allows a structural break for three alternative models. The crash model (A) allows for a shift in the intercept; the changing growth model (B) undertakes the change in the trend. The third model (C), on the other hand, considers the change both in the intercept and the trend. The null hypothesis of Perron test investigates whether the variable contains a unit root with drift by allowing an exogenous structural break at a time $1<T_B<T$. The alternative hypothesis is that the series is trend-stationary which denotes a one-time break in trend variable at time T_B. Zivot and Andrews (1992, p. 28) treat the structural break (T_B) as an endogenous occurrence and construct their regression equations to test unit root as;

$$y_t = \hat{\mu}^A + \hat{\theta}^A DU_t(\hat{\lambda}) + \hat{\beta}^A t + \hat{\alpha}^A y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^A \Delta y_{t-j} + \hat{e}_t(A)$$

$$y_t = \hat{\mu}^B + \hat{\gamma}^B DT_t^*(\hat{\lambda}) + \hat{\beta}^B t + \hat{\alpha}^B y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^B \Delta y_{t-j} + \hat{e}_t(B)$$

$$y_t = \hat{\mu}^C + \hat{\theta}^C DU_t(\hat{\lambda}) + \hat{\beta}^C t + \hat{\gamma}^C DT_t^*(\hat{\lambda}) + \hat{\alpha}^C y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^C \Delta y_{t-j} + \hat{e}_t(C)$$

DU_t is the dummy variable which implies a shift in intercept and DT^*_t defines a shift in the trend occurring in time T_B. $DU_t(\lambda)=1$ if $t>T_B$ and 0 otherwise. $DT^*_t(\lambda)=t-T_B$ if $t>T_B$, 0 otherwise. Similar to Perron (1989)'s approach, Model A includes a one-time shift in the intercept. Model B is concerned with the change in a broken trend. Finally, model C checks the stationarity of the series by taking into account the change of both intercept and broken trend (Rahman and Saadi, 2008).

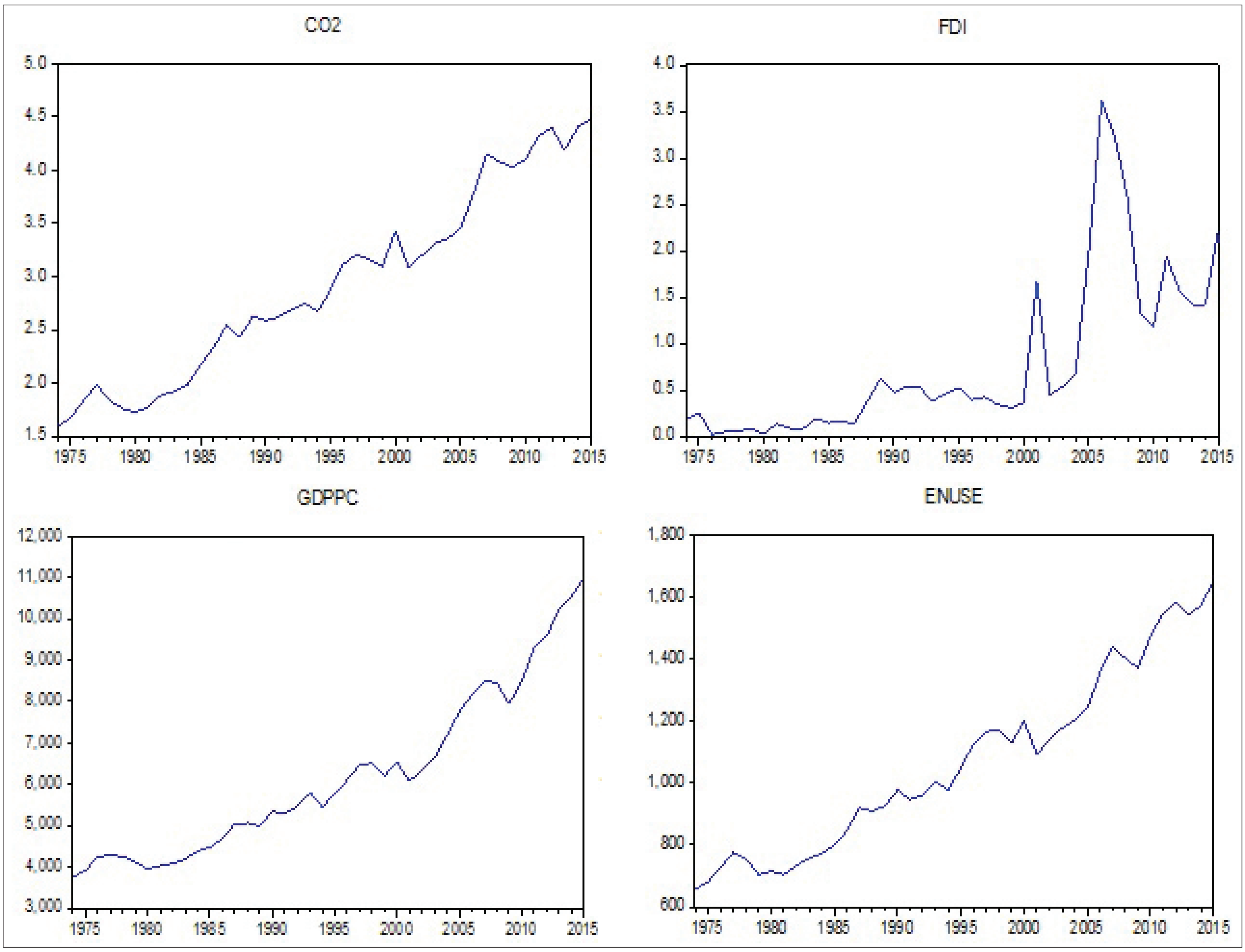
After employing the unit root tests, we used Pesaran & Shin (1998) and Pesaran et al. (2001)'s autoregressive distributed lag (ARDL) model to investigate long- and short-run cointegration between variables. Since ARDL model is more indifferent whether the variables are stationary at I(0) or I(1), it is more effective than the previous approaches. Thus, we rewrite the equation (1) in ARDL model form is shown below:

$$\Delta lnCo2E_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1,i} \Delta lnCo2E_{t-i} + \sum_{i=0}^{q} \alpha_{2,i} \Delta lnFDI_{t-i} + \sum_{i=0}^{v} \alpha_{3,i} \Delta lnGDPpC_{t-i} + \sum_{i=0}^{y} \alpha_{4,i} \Delta lnGDPpC\hat{}2_{t-i} + \sum_{i=0}^{w} \alpha_{5,i} \Delta lnEnUSE_{t-i} + \alpha_6 DU_j + \alpha_7 lnFDI_{t-1} + \alpha_8 lnGDP_{t-1} + \alpha_9 lnGDP\hat{}2_{t-1} + \alpha_{10} lnEnUse_{t-1} + \nu_t$$

According to the test, the null hypothesis which implies no cointegration, $H_0:\alpha_6=\alpha_7=\alpha_8=\alpha_9=\alpha_{10}=0$ and the alternative hypothesis is $H1: \alpha_6 \neq \alpha_7 \neq \alpha_8 \neq \alpha_9 \neq \alpha_{10} \neq 0$.

Finally, we employed Phillips and Hansen (1990)'s Fully Modified OLS (FMOLS) and Stock and Watson (1993)'s Dynamic OLS (DOLS) regressions to obtain efficient results for cointegrated variables. Both regressions are useful long-run estimators as they do not include endogeneity, small sample bias and serial correlation (Ahmad and Du, 2017). The robustness of the coefficients is assessed by using Park (1992)'s Canonical Cointegrating Regression

[1] ADF and PP unit root tests and FMOLS, DOLS regressions and CCR are estimated with EViews, Zivot-Andrews unit root tests and ARDL model are ran with Stata, and ARDL model is estimated by using Kripfganz & Schneider (2018)'s ARDL command. The optimal lag is chosen automatically due to the Akaika Information Criteria. For detailed information on the step of the analysis, see Kripfganz & Schneider (2018).



(CCR) which permits asymptotic Chi-square testing together with normal mixture distribution and deals with the problem of nonscalar nuisance parameters (Khan et al., 2020).

FINDINGS

The graphs depict the performances of time-series variables. As can be seen, CO2 variable has tended to decline, especially prior to the 1980 liberalization policies and following the 2001 economic crisis. FDI, on the other hand, has increased dramatically since the early 2000s. However, the performance of FDI is more volatile than the performance of other variables in the study. GDP and energy consumption variables also denote an increasing pattern and show a similar performance like CO2 emissions.

The findings of the traditional unit root tests (ADF and PP) revealed that the variables are stationary at their first difference, with the exception of FDI. FDI is stationary at I(0) at 1% level of significance. The findings indicate that CO2 emissions, GDP, GDP^2 and energy consumption variables are stationary at their first difference at the 1% level of significance. The assumption of null hypothesis of these tests assumes that the variable is non-stationary, while the alternative hypothesis implies the stationarity of the variable. We performed the unit root tests with a model including both trend and intercept, and the findings are summarized in *table 2*. The results confirm the applicability of ARDL model which is indifferent to the stationarity of the variables at I(0) or I(1).

Then, we employed Zivot-Andrews unit root test with a structural break and the findings are shown in *table 3*. Zivot-Andrews unit root test results demonstrate that all series are stationary in their first difference at least at 1% significance level both in model A and in model C. The results reveal that FDI is stationary at I(0) at 5% level of significance in model A and model C and I(0) at 1% level of significance in model B. According to model C, which includes both the change in time trend and intercept, the statistically significant time break for CO2 emissions is 1981, which is also the same time break for GDP variables. Turkey implemented considerable trade liberalization policies in 1980, which will have an impact on crucial variables in the following years.

After employing the unit root tests, we estimated whether some series are bound together to understand the long-run relationship between the series. ARDL bound test procedure is appropriate whether the variables are integrated of I(0) or I(1) (Pesaran et al., 2001). According to ARDL bound test, the null hypothesis is $H_0^F:(\alpha = 0) \cap \sum_{j=0}^{q} \beta_j = 0$ and the alternative hypothesis is $H_1^F:(\alpha \neq 0) \cap \sum_{j=0}^{q} \beta_j \neq 0$.

Table 2. The findings of ADF and PPP unit root tests

Test-stat	***Level***		***1st Difference***	
Variables	*ADF*	*PP*	*ADF*	*PP*
lnCO2E	-2.988 (0.147)	-3.111 (0.117)	-6.785* (0.000)	-8.170* (0.000)
lnFDI	-4.622* (0.003)	-4.580* (0.004)	-	-
lnGDPpC	-1.868 (0.652)	-1.868 (0.653)	-6.279* (0.000)	-6.276* (0.000)
lnGDPpC^2	-1.678 (0.743)	-1.678 (0.743)	-6.282* (0.000)	-6.279* (0.000)
lnEnUSE	-3.136 (0.111)	-3.252*** (0.089)	-6.586* (0.000)	-7.157* (0.000)

Note: *, ** and *** shows 1%, 5%, 10% level of significance, respectively. Schwarz Information criterion is used and prob-values are shown in parenthesis. Test critical values are -4.192, -3.521 and -3.191 for 1%, 5% and 10% level of significance respectively.

Table 3. The findings of Zivot-Andrews unit root test

Model A	***Level***		***1st difference***	
	t-stat	*Time break*	*t-stat*	*Time break*
lnCO2	-3.965(0)	1985	-6.655(0)*	1982
lnFDI	-5.169(0)**	1988	-9.493(0)*	1981
lnGDPpC	-2.777(0)	2004	-6.334(0)*	2003
lnGDPpC^2	-2.670(0)	2004	-6.352(0)*	2003
lnEnUse	-3.348(0)	2001	-6.391(0)	1998
Model B	***Level***		***1st difference***	
	t-stat	*Time break*	*t-stat*	*Time break*
lnCO2	-3.147(0)	1990	-6.429(0)*	1987
lnFDI	-4.939(0)*	2008	-10.146(0)*	1981
lnGDPpC	-3.155(0)	2002	-6.227(0)*	1981
lnGDPpC^2	-3.182(0)	2002	-6.227(0)*	1981
lnEnUse	-3.634(0)	1981	-6.242(0)*	1981
Model C	***Level***		***1st difference***	
	t-stat	*Time break*	*t-stat*	*Time break*
lnCO2	-4.446(0)	1985	-7.601(0)*	1981
lnFDI	-5.323(0)**	2005	-10.032(0)*	1983
lnGDPpC	-3.321(0)	2001	-6.910(0)*	1981
lnGDPpC^2	-3.352(0)	2001	-6.815(0)*	1981
lnEnUse	-3.891(0)	1985	-6.789(0)*	1982

Note: The values in parenthesis are lag orders. *, ** and *** shows 1%, 5%, 10% level of significance, respectively.

Table 4. ARDL bound test results

	Coef. (p-value)	10% I(0), I(1)	5% I(0), I(1)	1% I(0), I(1)
F-Stat	26.250 (0.000)	2.632, 3.863	3.185, 4.571	4.489, 6.228
t-stat	-10.619 (0.000)	-2.538, -3.648	-2.887, -4.054	-3.597, -4.870

Note: The critical values are belong Kripfganz & Schneider (2018).

If H_0^F is rejected, testing the null hypothesis of t-stat as $H_0^t{:}\alpha = 0$ versus $H_1^t{:}\alpha \neq 0$. The definitions of the test decisions are specified as follows: we do not reject H0F or H0t, respectively, if the test statistic is closer to zero than the lower bound of the critical values; and we reject the H0F or H0t, respectively, if the test statistic is more extreme than the upper bound of the critical values (Kripfganz and Schneider, 2018). The findings of ARDL bound test shown at *table 4* depict that the null hypothesis of no cointegration between the variables is rejected, as the F-stat and t-stat go over the upper bounds in all levels, implying the statistical evidence of the presence of long-run relationship between the variables.

Since we achieved a cointegration relationship between the variables, we then estimated the long- and short-run coefficients of foreign direct investment, economic growth, and energy consumption variables. After determining the optimal lag according to Akaike information criteria, the ARDL (1, 0, 1, 1, 0) regression model is estimated. The results of the ARDL cointegration test is given at *table 5*.

As it can be seen, all of the short-run and long-run coefficients are statistically significant. The positive value of GDP per capita and the negative value of GDP per capita squared confirm the validity of EKC hypothesis for Turkey, implying that income has a positive impact on CO2 emissions until a certain income level, after which the impact reverses. In the long run, a 1% increase in energy consumption leads to a 1.01% increase in CO2 emissions. FDI variable is also statistically significant at 10% level, implying a positive contribution to CO2 emissions which supports pollution haven hypothesis in the long-run for Turkey. On the other hand, the dummy variable is also statistically significant at the 5% level, indicating that the structural break in 1981 produced an increase in CO2 emissions. It stands to reason that the implementation of liberalization

Table 5. Short and long-run coefficients of ARDL (1, 0, 1, 1, 0) model

	Coefficient	t-stat	Prob.
Long-run coefficients			
lnFDI	0,008 (0,005)	1.71	0.097***
lnGDPpC	3,257 (1.156)	2,82	0.008*
lnGDPpC^2	-0,182 (0.061)	-2,99	0.005*
lnEnUSE	1,012 (0.127)	7,98	0.000*
Short-run coefficients			
ΔlnFDI	0,009 (0,005)	1,71	0.097***
ΔlnGDPpC	9,535 (2,859)	3,33	0.002*
ΔlnGDPpC^2	-0,553 (0.163)	-3,40	0.002*
ΔlnEnUSE	1,165 (0.148)	7,85	0.000*
Dum81	0,037 (0.013)	2,76	0.010**
C	-23,685 (6,568)	-3,61	0.001*
R^2	0.875	Log likelihood	107.503
ECMt(-1)	-1,151 (0.108)	-10,62*	0.000
Diagnostic Tests			
Normality: Skewness/Kurtosis test, chi^2=1.34 (prob:0.5120)			
Serial correlation: Breusch-Godfrey LM test, chi^2=0.672(prob:0.4123)			
Heteroscedasticity: Breusch-Pagan / Cook-Weisberg test, chi^2=1.13 (prob: 0.2870)			
Functional form: Ramsey RESET test, F (3, 34)=2.21 (prob: 0.1050)			
CUSUM and CUSUMSQ: Stable			

Note: *, **, *** show 1%, 5%, 10% significance levels, respectively. The values in parentheses on coefficient column are standard errors.

Table 6. FMOLS, DOLS and CCR results[2]

	FMOLS		*DOLS*		*CCR*	
	Coef. (Std. Err.)	*t-stat (prob.)*	*Coef. (Std. Err.)*	*t-stat (prob)*	*Coef. (Std. Err.)*	*t-stat (prob)*
lnFDI	0,014 (0,006)	2,280** (0.029)	0,012 (0,006)	1,868*** (0.069)	0,014 (0,006)	2,144** (0.039)
lnGDPpC	3,269 (1,413)	2,314** (0.026)	4,019 (1,450)	2,772* (0.008)	3,027 (1,555)	1,947*** (0.059)
lnGDPpC^2	-0,191 (0,074)	-2,571** (0.014)	-0,232 (0,076)	-3,058* (0.004)	-0,176 (0,081)	-2,176** (0.036)
lnEnUSE	1,160 (0,154)	7,497* (0.000)	1,132 (0,166)	6,810* (0.000)	1,160 (0,181)	6,395* (0.000)
C	-21,021 (5,820)	-3,611* (0.000)	-24,206 (5,936)	-4,078* (0.000)	-19,965 (6,345)	-3,146* (0.003)

Note: *, ** and *** shows 1%, 5%, 10% level of significance, respectively.

policies after the early 1980s would be accompanied by an increment in energy consumption, trade and foreign direct investment, all of which could eventually influence CO2 emissions. The statistically significant and negative lagged error correction term (ECT) coefficient represents that the deviations in the short run will be ameliorated by 151% per year in the long-run which indicates that the equilibrium will be ensured in less than a year. The final lines show the diagnostic test results, and there are no heteroscedasticity and serial correlation problems in the residuals and the normality results show that the residuals follow a normal distribution. Ramsey-Reset test confirms the reliability of the functional form of the model. Finally, the CUSUM and CUSUMSQ tests confirm the stability of the coefficients. The findings of the study are consistent with the results of Mutafoglu (2012), Balibey (2015), Gokmenoglu and Taspinar (2016), Kocak and Sarkgunesi (2018), Isiksal et al. (2019) and Bildirici (2021), while the study does not support the results of Halicioglu (2009), Acaravci and Ozturk (2010), Kizilkaya (2017) and Mert and Caglar (2020) for Turkey.

The cointegrated long-run coefficients can also be denoted by several regression tests and the study utilized fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) regressions, as well as canonical cointegrating regression (CCR). Despite there are few differences in significance levels of some variables, the regression results show that all variables are statistically significant, confirming the robustness of the coefficients and bolstering the long-run results of ARDL model in terms of sign and significance for all variables. The findings of the regressions also demonstrate that all variables have significantly positive impacts on CO2 emissions, with the exception of the GDP per capita squared which is also identical in ARDL model.

CONCLUDING REMARKS

The discussion on the relationship between economic growth, energy consumption, foreign direct investment and CO2 emissions has been popular, but contentious among economists for a long time. In the most fundamental sense, it is widely accepted that increased energy consumption leads to increased economic activity, which results in a reduction in environmental quality. The impact of foreign direct investments on CO2 emissions is similarly unclear, but growing numbers of studies suggest that an increase in foreign direct investments causes environmental degradation in economies with no strict environmental policies. By using an ARDL model with a structural break, the findings of the study reveal that there is a statistically significant long-run relationship between CO2 emissions and foreign direct investment, economic growth and energy consumption. The cointegrated long-run coefficients are also investigated and the robustness of the model is checked by FMOLS, DOLS and CCR estimators. The findings confirm EKC hypothesis and validate pollution haven hypothesis for the period of 1974-2015 in Turkey. EKC hypothesis argues that the environmental degradation will diminish after a threshold of a certain income level. The pollution haven hypothesis, on the other hand, implies that an increase in foreign direct investments may reinforce environmental pollution if there are weak or non-existent environmental regulations. Finally, because the considered period is marked by series of structural changes in the Turkish economy, a structural dummy variable has been included in the analysis. The aforementioned structural break is also statistically significant and it has an increasing effect on CO2 emissions after the break year. According to the findings, policymakers in Turkey should strengthen environmental regulations and invest more on environment-friendly technologies to ensure a sustainable future.

[2] The results of FMOLS, DOLS and CCR including the dummy variable is presented at the appendix 1. According to those findings, although FDI is statistically significant in both FMOLS and CCR, it is statistically insignificant in DOLS regression.

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Appendix

Appendix 1. FMOLS, DOLS and CCR results with dummy variable

(with dummy)	***FMOLS***		***DOLS***		***CCR***	
	Coef. (Std. Err.)	*t-stat (prob.)*	*Coef. (Std. Err.)*	*t-stat (prob)*	*Coef. (Std. Err.)*	*t-stat (prob)*
lnFDI	0,010 (0,005)	1,934*** (0.061)	0,007 (0,005)	1,455 (0.154)	0,010 (0,006)	1,724*** (0.094)
lnGDPpC	2,630 (1,161)	2,266** (0.029)	3,375 (1,229)	2,745* (0.009)	2,568 (1,300)	1,975*** (0.056)
lnGDPpC^2	-0,152 (0,061)	-2,483** (0.018)	-0,193 (0,065)	-2,989* (0.005)	-0,147 (0,068)	-2,167** (0.037)
lnEnUSE	1,097 (0,127)	8,594* (0.000)	1,089 (0,139)	7,842* (0.000)	1,089 (0,152)	7,142* (0.000)
Dum81	0,034 (0,012)	2,795* (0.008)	0,033 (0,013)	2,548** (0.015)	0,034 (0,012)	2,887* (0.007)
C	-17,996 (4,794)	-3,754* (0.000)	-21,258 (5,060)	-4,201* (0.000)	-17,720 (5,311)	-3,336* (0.002)

Note: *, ** and *** shows 1%, 5%, 10% level of significance, respectively.