İNSAN&İNSAN, Yıl/Year 11, Sayı/Issue 37, Kış/Winter 2024, 11-26 Araştırma Makalesi / Research Article
DOI: https://doi.org/10.29224/insanveinsan.1369367 www.insanveinsan.org e-ISSN: 2148-7537

Human Capital, Physical Capital, Economic Complexity, and Economic Growth Nexus in Türkiye: New Evidence from Bootstrap Fourier Granger Causality in Quantiles Approach

Türkiye'de Beşerî Sermaye, Fiziki Sermaye, Ekonomik Karmaşıklık ve Ekonomik Büyüme Bağlantısı: Kantil Bootstrap Fourier Granger Nedensellik Yaklaşımından Yeni Kanıtlar

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Abstract: *Economic development is an important indicator demonstrating the increases in societies' socioeconomic welfare levels. Countries need to advance in economic, social, cultural, and political domains in order to achieve economic development. From this aspect, Türkiye is far from having a developed country profile at this moment. Accordingly, the present study aims to assess Türkiye's development issues. For this purpose, the effects of human capital, physical capital, and economic complexity index on economic growth in Türkiye are analyzed for the period 1970-2017 using the bootstrap Fourier Granger causality in quantiles (BFGC-Q) approach recently recommended by Cheng et al. (2021). The results of the analysis indicate that human capital, physical capital, and economic complexity index have a positive causal effect on economic growth. For sustainable development, Türkiye needs foreign capital investments in a stable economic model. Furthermore, it is recommended that Türkiye should pay importance to education, science, and technology at both theoretical and practical levels, and increase the value-added and technology level in exports by diversifying its high-tech product range.*

Keywords: *Human capital, Physical capital, Economic complexity, Economic development, Causality*

Öz: *İktisadi kalkınma, toplumların sosyo-ekonomik refah seviyelerinin yükseldiğini gösteren önemli bir göstergedir. İktisadi kalkınmanın gerçekleşebilmesi için ülkelerin ekonomik, sosyal, kültürel ve politik alanlarda gelişmiş olması gerekmektedir. Bu bağlamda Türkiye, bugüne gelinen süreçte kalkınmış bir ülke görünümünden uzaktır. Bu doğrultuda bu çalışmanın amacı Türkiye'nin kalkınma sorunlarını değerlendirmektir. Bu amaç kapsamında Türkiye'de beşerî sermaye, fiziki sermaye ve ekonomik karmaşıklık endeksinin ekonomik büyüme üzerindeki etkisi Cheng vd. (2021) tarafından yakın zamanda*

Gönderim 30 Eylül 2023 *Received 30 September 2023*
Düzeltilmiş Gönderim 11 Aralık 2023 *Received in revised form 11 December 2023*
Kabul 28 Aralık 2023 *Accepted 28 December 2023*

Yayıncı / Publisher: Okur Yazar Derneği / Literacy Association, İstanbul, Turkey
Website: https://www.okuryazar.org.tr

önerilen kantil bootstrap Fourier Granger nedensellik (BFGC-Q) yaklaşımı kullanılarak 1970-2017 dönemi için analiz edilmektedir. Analiz sonuçları, beşerî sermaye, fiziki sermaye ve ekonomik karmaşıklık endeksinin ekonomik büyüme üzerinde pozitif nedensel bir etkiye sahip olduğunu göstermektedir. Türkiye, sürdürülebilir kalkınma için istikrarlı bir ekonomik modelde yabancı sermaye yatırımlarına ihtiyaç duymaktadır. Ayrıca, Türkiye'nin teorik ve uygulama düzeyinde eğitim, bilim ve teknolojiye önem vermesi ve yüksek teknolojili ürün yelpazesini çeşitlendirerek ihracattaki katma değer ve teknoloji düzeyini artırması önerilmektedir.

Anahtar Kelimeler: *Beşerî sermaye, Fiziki sermaye, Ekonomik karmaşıklık, Ekonomik kalkınma, Nedensellik*

Introduction

In economic theory, the concepts of growth and development are two closely related terms. Growth refers to a quantitative increase in the production of goods and services in comparison to the previous period, whereas development includes qualitative elements besides the growth. Economic growth is necessary for economic development but not sufficient on its own. In addition to economic growth, it is also a necessity to have a general increase in society's economic, social, and cultural aspects to achieve economic development (Peet and Hartwick, 2009: 1). In order for this socioeconomic development to be achieved, policies such as pursuing a more equitable income distribution, reducing regional development disparities, providing education, health, and security services more equally to all segments of society, creating a more democratic society within the scope of economic rights and freedoms, and generating permanent solutions to urbanization, infrastructure, and environmental issues are necessary (Giddens and Sutton, 2016: 121). The most important economic developments in the world's economic history occurred in European countries with the Industrial Revolution. Therefore, concepts such as industrialization, modernization, and westernization were considered equivalent to economic development (Mıhçı, 1996: 66). From this perspective, countries developing high value-added industrial products, which will gain a competitive advantage in industrial markets, in the industrial sector are considered developed and economically advanced countries. Other countries are classified as developing and underdeveloped countries (Doğan, 2011: 52).

The initial stage of economic development is production and economic growth. Particularly after the Industrial Revolution, factors such as division of labor, specialization, physical capital accumulation, human capital, technology, population growth rate, natural resources, income distribution, and public expenditures have been related to production quantity and economic growth (Ehrlich, 1990: 3). One of the simplest and most comprehensive production functions developed specifically for the economic variables to be addressed in the present study is the Cobb-Douglas (1928) production function. In $Q = A\ L^{\alpha}K^{\beta}$, the output quantity (Q) is related to the level of technology (A), labor force (L), and capital quantity (K). The parameter α in the function represents the labor elasticity of production, whereas the parameter β represents the capital elasticity of production (Chiang, 2005: 439). Developing countries require physical capital to

grow economically. However, low saving rates hinder them from achieving the desired level of investment and production. Therefore, many developing countries cannot break free from the "Poverty Trap" and cannot achieve their development goals (Nurkse, 1952: 571). Human capital can support production and economic growth by increasing efficiency in the periods, when the marginal return on physical capital decreases, and through technological development. However, there is a bilateral relationship between economic development and human capital, and the effect of human capital on production and economic growth is extremely limited when development does not occur (Benhabib and Spiegel, 1994: 165). In a Cobb-Douglas-type production function, the Economic Complexity Index (ECI) is an important variable related to economic growth and is the subject of empirical analysis in the present study. ECI, introduced by Hidalgo and Hausmann (2009), is calculated based on the diversity of products exported by a country and the prevalence of the products produced by world countries. If a country efficiently utilizes human capital and produces and sells high-tech products that are not produced in other countries, then it gains a competitive advantage in international trade and achieves stable economic growth (Parkin et al., 2005: 684).

Until the post-WWII years, economic growth and development were perceived as synonymous economic events. It is claimed that the era of development was began by Harry Truman, the president of the USA, with the Truman Doctrine aid to be provided to economically underdeveloped countries (Macekura, 2013: 127). In addition to being a political plan implemented against the Soviet threat, the emphasized economic rationale is to decrease the developmental disparity between countries. In the course of time, the emphasis on economic development differences had a remarkable role in the increasing importance of the concept of economic development (Turhan, 2020: 152). Türkiye, with its strategic location, has played a significant role as a buffer against the spread of socialism to the European continent. In return for this political responsibility, the economic and in-kind physical capital needed for development plans was received within the scope of the Truman Doctrine and Marshall Aid.

In the 20th century, development plans were implemented in Türkiye as in many developed and developing countries around the world. During the first decade of the Republic, the shortage of qualified personnel and physical capital hindered the realization of planned investments. The first planned development period in Türkiye was implemented with the First Five-Year Industrial Plan in 1934. During this development plan period, dirigiste* policies implemented led to Türkiye being perceived as a socialist state even more advanced than interventionist liberal policies. In subsequent periods, although attempts were made to achieve economic development with the Second Five-Year Industrial Plan and the Economic Defense Plan in 1939, as well as the Urgent Industrial Plan in 1946 and the Economic Development Plan in 1947, the goals fell short of expectations (Şahin, 2011).

* The term "dirigiste policy" refers to the controlled intervention of the state in the economic system, particularly in markets, prices, the monetary system, credit volume, production volume, and consumption issues. The statement "*The dirigiste policies implemented during the First Five-Year Development Plan period are not doctrinal but pragmatic*" is clear evidence that Türkiye did not embrace a socialist ideology during that period (Şahin, 2011: 56).

During the First Five-Year Industrial Plan period, Türkiye prioritized industrial production for development, but in exchange for signing the Marshall Aid Agreement, it took on the role of an agricultural country and the task of becoming the agricultural depot of European countries.

After World War II, countries around the world experienced rapid economic growth (The Golden Age of Growth) until the impact of the Oil Crisis and stagflation in the 1970s (Yeldan, 2009: 13). In Türkiye, however, after an unplanned period of ten years following 1950, planned development periods began in 1963, and the Harrod-Domar growth model was adopted for economic growth. The development plans implemented were "*imperative for the public sector, directive and incentive for the private sector*," whereas macro-level plans set goals for each sector and prioritized regional development (Alpay and Alkin, 2017: 125). Although policies similar to the industrialization policies of Germany and the USA were implemented by adopting the theoretical foundations of the Infant Industry Thesis, import substitution industrialization failed for capital and intermediate goods production stages in many periods. With the decisions of 24 January 1980, the foreign exchange-saving import substitution industrialization approach was replaced by a foreign exchange-generating export promotion policy in the open economy model (Kepenek and Yentürk, 2004: 193). The free-market model, first implemented in the goods market, was also introduced in financial markets with Law No. 32 enacted in 1989 (Boratav, 2018: 192). Nevertheless, after experiencing the 1994 crisis, the financially fragile market also restrained economic growth during the 2000 and 2001 crises in Türkiye's development journey. Following the crisis periods, it is argued that hot money, public expenditures, and investments in the construction sector are the determinants of economic growth for the Turkish economy (Gürkaynak and Sayek-Böke, 2013: 69). As of 2017, Türkiye's economic problems are quite similar to those of 1929. Türkiye requires physical and human capital for economic growth and development. To achieve this goal, foreign capital investments should be encouraged, and science and technology should be focused more on by reforming education (Eğilmez, 2022: 156).

Türkiye is implementing growth and development models adopted by developed countries and following the development plans of industrial countries. However, it is highly noticeable that Türkiye has not been able to reach the desired level of economic development and prosperity during this process. In this context, Türkiye's problem of not being able to develop forms the main motivation for this study. In this context, unlike most other studies, the present study analyzes the impact of ECI, a variable relatively less addressed in the literature, in addition to human and physical capital, on economic growth in Türkiye. Furthermore, this study is the first research to investigate the relationship between human capital, physical capital, and ECI and economic growth in Türkiye using the newly created bootstrap Fourier Granger causality in quantiles approach by Cheng et al. (2021).

The remaining sections of the study are organized as follows: Following this introduction section, the second section continues with a summary of the empirical literature. The third section presents the introduction of the data set and the model. The fourth section reports empirical findings. The study is concluded with the conclusions and policy recommendations section.

Literature Summary

In the present study, the literature is summarized under two subheadings: the relationship between human-physical capital and economic development, and the relationship between economic complexity and economic development.

Relationship between Human-Physical Capital and Economic Development

Although economic growth is an important precondition for economic development, it is not a sufficient condition. For societies to achieve economic development, economic growth must be accompanied by social, cultural, and political development, and income must be distributed more equally among the members of the society. Even though economic growth and economic development were considered equivalent phenomena until the post-WWII years, the socioeconomic welfare disparities between societies revealed that these two phenomena were not the same. Policies aiming to educate the population for economic development began to lead to the improvement in human capital after the 1960s. Over time, studies analyzing the impact of human capital on economic growth and economic development began in the literature.

Schultz (1961) carried out one of the first studies examining the impact of human capital on economic development. In this study, it was argued that investments in human capital led to an increase in the real income of workers at the micro level and to an increase in production at the macro level. During the same period, Denison (1962) argued that growth and development in the USA economy could not be explained solely by physical capital and investigated the possible effect of human capital. Denison, who examined the impact of human capital on the USA economy for the period of 1929-1957, found that a 2% increase in the education level of workers resulted in a 23% increase in real national income. Barro (1989), who analyzed the effect of human capital on economic growth for 98 countries in the period of 1960-1985, claimed that underdeveloped countries could reduce the economic disparity with developed countries if they had high levels of human capital. Numerous studies have been carried out empirically on the impact of human and physical capital on economic development and economic growth during this process. Among these studies, Brempong and Wilson (2004) for the period of 1975-1994 in sub-Saharan African countries and 23 OECD countries, Park (2006) for the period of 1960-1995 in 94 developed and developing countries, Cohen and Soto (2007) for the period of 1960-2000 in 38 countries, Matousek and Tzeremes (2021) for the period of 1970-2014 in 100 countries reported that human capital, as well as physical capital, is an important determinant of economic development. Even though there are studies suggesting that human and physical capital have no effect on economic development or that the effect is negative for different countries and periods (Hartwig, 2012), the number of empirical studies reaching this conclusion in the literature is extremely limited.

In literature, there are also numerous studies empirically examining the impact of human and physical capital on economic development for Türkiye. Çakmak and Gümüş (2005) carried out a study for the period of 1960-2002 on the impact of physical and human capital on economic growth. The model used in their study, the real GDP value representing economic growth, the real fixed capital

investments representing physical capital, and the number of students graduating from elementary school, middle school, and higher education representing human capital were used to calculate the human capital index. The analysis results suggested that physical and human capital had a positive effect on economic growth, whereas the labor variable had a negative effect. However, the impact of physical capital was found to be higher than that of human capital on economic growth.

Karataş and Çankaya (2011) investigated the effect of human and physical capital investments on economic growth in Türkiye for the period of 1980-2006 using three different models. In the estimation model, the dependent variable represents the per capita real GDP growth rate, and the ratio of fixed capital investments to GDP represents physical capital, whereas the ratio of total education expenditures, total health expenditures, and higher education enrollment rate represent human capital. The estimation results indicated that higher education enrollment rate had a more positive impact on economic growth compared to fixed capital investments, and fixed capital investments had a more positive impact on economic growth compared to education and health expenditures.

Manga et al. (2015) analyzed the impact of human and physical capital on economic growth in BRICS-T (Brazil, Russia, India, China, South Korea, and Türkiye) countries for the period of 1995-2011. In their study, the schooling rate and the return on education represent human capital, the value of fixed capital investment represents physical capital, and the real GDP value represents economic growth. Panel Fully Modified Ordinary Least Squares (FMOLS) estimator was used as the empirical method. The FMOLS estimation results showed that both human and physical capital had a positive effect on economic growth. A 1% increase in human capital leads to a 2.81% increase in economic growth for the overall panel, whereas a 1% increase in physical capital leads to a 0.62% increase in economic growth. These results demonstrated that, in their study sample, human capital was more effective in promoting economic growth in comparison to physical capital.

Çeştepe and Gençel (2019) analyzed the causality relationship between human capital and economic growth in Türkiye for the period of 1986:Q1-2016:Q2. They used educational expenditures and expenditures on vocational, scientific, and technical activities to represent human capital, while GDP variable for economic growth. The results of the causality test indicated a bidirectional causality relationship between GDP and expenditures on vocational, scientific, and technical activities and a unidirectional causality relationship from educational expenditures to GDP.

Relationship Between Economic Complexity and Economic Development

Economic Complexity Index (ECI), closely related to human capital, is a new economic indicator introduced by Hidalgo and Hausmann (2009). Therefore, the number of empirical studies in the literature in this field is limited. In general, for developed and developing countries in different periods, it was determined that ECI had a positive impact on economic growth. Some of these studies are as follows. Hausmann et al. (2014) identified the positive impact of economic complexity on economic growth over a 30-year period covering 1978-88, 1988-98,

and 1998-08 in 128 countries. Hausmann et al. (2016) reconfirmed the positive impact of economic complexity on economic growth in Panama in their study for the period of 2013-2014. Britto et al. (2016) comparatively examined the relationship between ECI and different development paths for Brazil and South Korea for the period of 1960-2000. Their study concluded that, after 1992, South Korea had an increase in the export of medium and high-tech products, while Brazil did not achieve this structural transformation.

Zhu and Li (2017) found in their research covering the period of 1995-2010 in a sample of 210 countries that ECI had a more positive impact on economic growth in high-income country groups in comparison to other countries. Udeogu et al. (2021) revealed that ECI was a significant determinant of economic growth for 31 OECD countries for the period of 1982-2017.

In contrast to studies empirically proving the positive effect of economic complexity on economic growth, there also are studies in the literature that show no significant effect between these two variables in different periods. Ferrarini and Scaramozzino (2016) did not find any effect of economic complexity level on production in 89 countries with low-middle and high-income levels for the period of 1990-2009. Stojkoski and Kocarev (2017) could not find any significant relationship between economic complexity and economic growth in the short term for 16 Southeastern and Central European countries for the period of 1995-2013. However, in the same period and for the same group of countries, ECI positively affected growth in the long term. Soyyiğit (2018) examined the relationship between ECI and per capita GDP for OECD countries for the period of 1990-2016. Given the results of cointegration tests, no long-term relationship was determined between the two variables. However, individual results revealed a positive and significant relationship between the level of economic complexity and growth for Austria, Canada, Greece, Ireland, and the USA, whereas a negative and significant relationship was found for Norway.

Soyyiğit et al. (2019) estimated the effect of economic complexity, exports, and fixed capital investments on per capita income in 18 countries within the G20, excluding the EU and Russia, for the period of 1970-2016 by using a random coefficient model. The results indicated that economic complexity positively affected per capita income in Brazil, China, Germany, Indonesia, Japan, Mexico, South Korea, Türkiye, and the USA, whereas it negatively affected in Argentina, Australia, Canada, Saudi Arabia, and the United Kingdom. Examining the share of sophisticated manufactured goods in the export products of the countries, where a negative relationship was found, it was determined that the share of sophisticated products in exports decreased or remained constant. Therefore, these countries should increase the share of high-value sophisticated products in their exports for sustainable development.

Yıldız and Akbulut Yıldız (2019) investigated the causality relationship between ECI and real GDP for the period of 1970-2016 in 10 newly industrialized countries (China, India, Thailand, Malaysia, the Philippines, Türkiye, South Africa, Brazil, Mexico, and Indonesia). Their study using the causality test proposed by Konya (2006) revealed a unidirectional causal relationship from the variable of economic

complexity to the variable of economic growth for the overall panel. However, no significant causal relationship could be found between these two variables in Türkiye.

Çoban (2020) analyzed the relationship between economic complexity level and economic development in the E7 countries (Brazil, China, Indonesia, India, Mexico, Türkiye, and Russia) for the period of 1993-2017. The Human Development Index published by the United Nations Development Program (UNDP) was used to represent economic development. Given the Dumitrescu-Hurlin panel causality test results, a unidirectional causal relationship from the human development variable to the economic complexity variable was identified.

Bayar (2022) predicted the relationship between economic complexity level and economic growth in CIVETS countries (Colombia, Indonesia, Vietnam, Egypt, Türkiye, and South Korea) for the period of 1995-2019 by using the Augmented Mean Group estimator. The findings suggested a positive effect of economic complexity level on economic growth. However, as shown causality test results, there was a unidirectional causal relationship from economic growth to economic complexity level.

The literature summary indicates that economic growth is frequently preferred in studies to represent economic development. Numerous studies in the literature have reported that human capital, physical capital, and ECI have a positive effect on economic growth. Furthermore, the effect of human capital and ECI on economic growth varies depending on the development level of countries and the research period. Moreover, the testing of the research model by using the bootstrap Fourier Granger causality in quantile causality test developed by Cheng et al. (2021) is the most distinctive feature of this study. This is because the literature summary presented in this study also indicates that this research topic has not been tested through this test technique in any empirical study.

Data and Model

This study investigates the effect of human capital (HCI), physical capital (CAP), and the economic complexity index (ECI) on economic growth (GDP) in the context of Türkiye's development issues. In this regard, this study utilizes quarterly data covering the period from 1970Q1 to 2017Q4. The time frame of this study starts from 1970, which corresponds to the availability of ECI data for Türkiye and ends with the year 2017 since data beyond 2017 is not accessible. To avoid small sample issues, annual data was transformed into quarterly data following the approach of Shahbaz et al. (2018). To obtain more reliable findings, the quadratic match-sum approach was used for converting annual frequency data to quarterly frequency data. The quadratic match-sum approach is a useful method because it allows for the conversion of data from low frequency to high frequency. Furthermore, this approach is superior to interpolation methods because it restricts data changes during the transition from low frequency to high frequency and is seasonally adjusted. GDP data was obtained from the World Bank's (WB) World Development Indicator Database (WB, 2023). HCI and CAP data were collected from Penn World Table version 10.01 (PWT 10.01), whereas ECI data was extracted from MIT's Observatory of Economic Complexity (OEC, 2023). In the analysis, logarithmic versions of all data were used, except for ECI, which includes negative values. Variable definitions are provided in Table 1.

Table 1. Variables Definition

Variable	Definition	Source
GDP	Real gross domestic product (Constant 2015 US$)	WB (2023)
HCI	Human capital index (Based on years of schooling and returns to education)	PWT 10.01
CAP	Capital stock (Constant 2017 US$)	PWT 10.01
ECI	Economic complexity index (The index is calculated based on the diversity, prevalence, and number of countries capable of producing the activities that a country produces or exports)	OEC (2023)

A synopsis of descriptive statistics is presented in Table 2. GDP has the highest mean, median, maximum, and minimum values. The variables with the highest standard deviation (SD) are CAP and GDP, respectively. In general, for a variable to show normal distribution or symmetry, the ideal skewness value should be 0. However, as seen in Table 2, GDP and CAP show positive skewness, whereas HCI and ECI exhibit negative skewness. Considering the kurtosis values, it can be seen that all indicators, except for ECI which demonstrates leptokurtic distribution, exhibit platykurtic distribution. Finally, according to the Jarque-Bera (JB) test statistic, GDP, HCI, CAP, and ECI do not follow a normal distribution. Therefore, it would be more appropriate to use quantile causality tests instead of traditional or standard Granger causality tests. Because traditional or standard regression techniques such as OLS estimate the average relationships between dependent and independent variables, they only demonstrate a partial dimension of the relationship. On the other hand, the techniques based on the quantile approach provide a more comprehensive analysis since they estimate the effects of independent variables on different points or locations of the dependent variable. Furthermore, the quantile approach offers more robust estimation results even in the presence of outliers.

Table 2. Synopsis of Descriptive Statistics

	GDP	HCI	CAP	ECI
Mean	6.625	0.148	3.631	0.025
Median	6.623	0.152	3.580	0.034
Maximum	6.906	0.224	4.013	0.117
Minimum	6.365	0.067	3.338	−0.138
SD	0.147	0.046	0.172	0.061
Skewness	0.093	−0.269	0.791	−0.897
Kurtosis	1.933	1.899	2.902	3.618
JB	9.385***	12.025***	20.108***	28.826***
Probability	0.009	0.002	0.000	0.000
Obs.	192	192	192	192

Note: At 1%, the significance level is indicated by ***.

Following the studies of Denison (1962), Barro (1989), and Hausmann et al. (2014) that are the prominent studies on this subject, the estimation model of the present study is presented in Equation (1) under the assumption that human capital,

physical capital, and economic complexity are functions of economic growth.

GDP= *f*(HCI, CAP, ECI)

$$GDP_t = \beta_0 + \beta_1 HCI_t + \beta_2 CAP_t + \beta_3 ECI_t + \varepsilon_t \quad (1)$$

In Equation (1), the dependent variable is GDP, whereas HCI, CAP, and ECI are the independent variables. After taking partial derivatives, the sign assumed for each variable is as follows.

$$\frac{\partial GDP}{\partial HCI} > 0, \frac{\partial GDP}{\partial CAP} > 0, \text{and } \frac{\partial GDP}{\partial ECI} > 0$$

Empirical Findings

In the first stage, the non-linear property of the variables is examined by using the BDS test proposed by Broock et al. (1996). BDS test outcomes are portrayed in Table 3.

Table 3. BDS Test Outcomes

Dimension	GDP	HCI	CAP	ECI
2	0.202***	0.207***	0.199***	0.193***
3	0.344***	0.351***	0.335***	0.324***
4	0.443***	0.453***	0.430***	0.412***
5	0.514***	0.526***	0.496***	0.470***
6	0.565***	0.577***	0.543***	0.506***

Note: At 1%, the significance level is indicated by ***.

Given the BDS test outcomes in Table 3, the null hypothesis of "linear distribution" is rejected for each variable. Therefore, it is determined that all variables exhibit a non-linear property, which means the use of linear analysis methods can lead to misleading conclusions and erroneous policy recommendations.

Before conducting the Fourier causality test, it is crucial to determine the maximum integration degree of the variables in the second stage. Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) unit root tests are used for this purpose. The unit root test outcomes are presented in Table 4.

Table 4. Outcomes of Unit Root Test

	Level			First difference		
	ADF	PP	KPSS	ADF	PP	KPSS
GDP	0.611	0.332	1.696***	−3.628***	−6.482***	0.081
HCI	−1.051	−0.674	1.668***	−3.173**	−3.161**	0.164
CAP	−0.382	0.377	1.438***	−2.761*	−5.269***	0.222
ECI	−2.990	−2.736	1.087***	−3.981***	−6.849***	0.280

Note: At 1%, 5%, and 10%, the significance levels are indicated by ***, **, and *, respectively.

In Table 4, the ADF and PP unit root test outcomes indicate that all variables have unit root at the level but are stationary at the first difference. On the other hand, considering the KPSS unit root test results, all variables are rejected at the level, implying they have unit roots, but not rejected at the first difference, indicating they

are stationary. The unit root test outcomes suggest a maximum integration degree of "1" (d_{max}=1) for all variables.

In the third stage, to assess the necessity of the Fourier approach, the significance of Fourier terms is tested by using an F-test. Table 5 shows the F-test outcomes along with optimal frequencies and optimal lag lengths.

Table 5. F-test Outcomes

Country	Frequency (k*)	Lags (p*)	F-test	CV 10%	CV 5%	CV 1%
Türkiye	0.1	10	7.614***	4.117	4.381	4.692

Notes: At 1%, the significance level is indicated by ***. The optimal Frequency (k*) and optimal lag lengths (p*) are determined based on Akaike Information Criteria (AIC).

In Table 5, the F-test statistic value (7.614) exceeds the bootstrap critical values (CV) at the significance levels of 1% (4.692), 5% (4.381), and 10% (4.117). Thus, the null hypothesis assuming the absence of Fourier components is rejected at the significance level of 1%. This result suggests that Fourier functions are necessary for causality analysis. In other words, the F-test results demonstrate the need to utilize the Fourier approach to examine the causal relationships between economic growth, human capital, physical capital, and ECI.

Using the Fourier term has some advantages. First, the Fourier term regards structural changes by allowing smooth structural breaks. Second, it eliminates the necessity for prior information about the form, date, and number of breaks. Thus, it provides more reliable and robust results (Nazlıoğlu et al., 2016; Bostancı and Koç, 2022).

In the final stage of the analysis, the causal effects of human capital, physical capital, and ECI on economic growth are analyzed using the BFGC-Q test. The BFGC-Q test outcomes are presented in Table 6.

Table 6. Outcomes of Bootstrap Fourier Granger Causality in Quantiles (BFGC-Q)

H_o: HCI↛GDP				
Quantile	Wald test.	CV 10%.	CV 5%.	CV 1%.
0.2	4.200691	7.219283	8.626009	12.45618
0.4	3.283818	4.591909	5.154739	5.990061
0.6	**4.648963**** (+)	**3.43129**	**4.357971**	**6.228379**
0.8	**2.871825*** (+)	**2.556034**	**3.762611**	**7.800247**
H_o: CAP↛GDP				
0.2	12.92652	53.49262	59.71159	77.83579
0.4	17.46374	28.38332	35.9418	49.23423
0.6	**30.7434**** (+)	**24.5058**	**28.01255**	**42.81566**
0.8	25.17311	33.76121	38.77488	47.16263
H_o: ECI↛GDP				
0.2	**27.33643*** (+)	**27.28251**	**30.22742**	**37.64036**
0.4	**19.35031**** (+)	**16.69726**	**18.79605**	**22.16439**
0.6	**20.94222**** (+)	**14.52014**	**16.39126**	**21.84014**
0.8	10.67401	20.58379	24.30703	30.14726

Notes: At 5%, and 10%, the significance levels are indicated by **, and *, respectively. CV illustrates the critical values. (+) denotes positive effect. Bold values show the presence of causality.

As seen in Table 6, the BFGC-Q test outcomes indicate unidirectional causality from human capital to GDP in the 0.6 and 0.8 quantiles. The coefficient symbol suggests a positive causal relationship between human capital and GDP. The findings verify the increasing impact of human capital on GDP. These findings are consistent with the results of Karataş and Çankaya (2011), Manga et al. (2015), and Çeştepe and Gençel (2019).

Moreover, BFGC-Q test outcomes show that there is a unidirectional causality from physical capital to GDP only in the 0.6 quantile. Considering the coefficient sign of the independent variable, it is found that physical capital has a positive effect on GDP. The obtained results are compatible with the results of Çakmak and Gümüş (2005) and Manga et al. (2015).

Similarly, BFGC-Q test outcomes indicate a unidirectional causality from ECI to GDP in the 0.2, 0.4, and 0.6 quantiles. The positive sign of the coefficients symbolizes that economic complexity index has a positive (increasing) effect on GDP. These results support the findings of Soyyiğit et al. (2019) but contradict the findings of Yıldız and Akbulut Yıldız (2019), Çoban (2020), and Bayar (2022).

Conclusions and Policy Recommendations

This study scrutinizes Türkiye's development issues in the context of the relationship between human capital, physical capital, and economic complexity index on economic growth. Unlike other studies, this research investigates the effect of human capital, physical capital, and economic complexity on economic growth during the period of 1970Q1-2017Q4 by using the BFGC-Q test for the first time in Türkiye. The results of the BFGC-Q test reveal a unidirectional positive causal relationship from human capital, physical capital, and economic complexity index to economic growth. Given these results, some policy recommendations are made for addressing Türkiye's development issues.

- As a developing country, Türkiye needs foreign capital investments. Given its low labor costs in the global context, attracting foreign direct investments in Türkiye can be achieved through incentives offered to foreign capital under conditions of macroeconomic stability.
- Türkiye has one of the largest youth populations in the world. Enhancing the quality of this population through effective education processes will amplify the positive effect of human capital on development. Prioritizing education, science, and technology at both theoretical and practical levels is crucial for economic development in Türkiye.
- With the effect of globalization and free trade, global trade volume and international competition continue to increase every year. In this sense, the production and export of more complex and high-tech domestic products that provide a competitive advantage in international trade are of crucial importance for Türkiye. This can accelerate the growth and development of the Turkish economy.

The present study also has some limitations. First, the research period starts from 1970 and is limited to 2017 because of the availability of economic complexity index

data for Türkiye. Secondly, the development issue is a multidimensional concept and is based on various dynamics. However, this study evaluates Türkiye's development issue only within the scope of the relationship between human capital, physical capital, and economic complexity index with economic growth. Future studies can explore Türkiye's development issue within the context of various economic, socioeconomic, and political variables.

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