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RESEARCH ARTICLE

The Impact of Fintech on Economic Growth: Evidence from Panels of Turkic and Southeast Asian Countries

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Abstract

From the beginning of the 21. century, the whole world has witnessed huge changes because of technological improvements and revolutionary inventions. It can be inferred that technological developments affect mankind in terms of many aspects like cultural, psychological, social etc. and these impacts reflect on our lives much more immediately than in past times. One of these impacts can be observed in economic and financial platforms. Financial technology has recently attracted great interest. The cause of this situation may be said to be Fintech becoming a global phenomenon. Therefore, many researchers have tended to investigate the impact of technological improvements on economic growth. This study attempts to evaluate the impact of financial technological improvements on economic growth between 2000 and 2020 for Turkic and selected Asian countries. In obtaining results, panel data analysis has been used. The results indicate that internet usage rates and fixed broadband subscriptions have positive impacts on economic growth. However, mobile cellular subscriptions do not have any impact on economic growth. According to the findings, information-communication technologies and other macroeconomic factors positively affect economic growth.

Keywords

Turkic countries and selected Asian countries, Panel data analysis, Fintech, Economic growth, Communication technologies

Introduction

From the beginning of the millenium era, dazzling developments have been seen in almost every aspect of human life. It does not seem like wrong to claim that these developments have been observed, especially in communication and information technology fields. Because of technological improvements and revolutionary inventions, the whole world has witnessed huge changes and a paradigm shift. Communication and information technologies simplify information circulation and thus have direct effects on humankind in terms of many aspects like cultural, economical, psychological and social etc. (Kurniawati, 2021; Badwan & Awad, 2022).

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If it is described, it can be stated that "*Fintech*" is a branch of service sector that benefits from mobile-based information technology to increase the efficiency of financial systems. Another definition that might be verbalised is "*internet finance*" or "*digital finance*", which comprises all shapes of financial transactions/operations, markets and intermediaries. When we look at the etymological origins, as a term, "*Fintech*" is a composition of "finance" and "technology" words and corresponds to industrial innovation that emerged from the combination of financial services and information technology (Schueffel, 2016). With respect to the contribution of economic growth and value creation; it may be seen that developments in the field of financial technology and communication-information technology, such as electronic banking, e-commerce, mobile devices, wireless networks, Internet of things, artificial intelligence, cloud computing, and blockchain, have enormous and revolutionary impacts recently (Sassi & Goaied, 2013; Song & Appiah-Otoo, 2022; Awais et al., 2023). It was not thought wrong to claim that; Fintech will give shape business processes/models, subvert conventional financial operations/products, and bring a brand new breath by providing a unique business perspective in the millennium (Bu et al., 2022; Awais et al. 2023).

Fintech and communication-information technologies (CIT) augment the accessibility of information, shape new communication methods, and, as a result, increase the efficiency of many distinct financial and economic activities (Kurniawati, 2021). In terms of innovation perspective, CIT can be seen as a broad innovation type of financial service and technological progress, combining technological-product-resource allocation innovations. Through the Fintech, both information transparency and effective distribution of resources have increased however information asymmetry that causes improper market functioning has been mitigated. Fintech may also facilitate turning savings into investment and effective capital use. Therefore, it may be claimed that economic growth of countries or households has effected in an affirmative direction via these technologies (Bu et al., 2022).

Due to rapid developments in communication and information technologies, the number of Internet users continues to grow worldwide. According to data from the International Telecommunication Union, as of 2022, nearly 5.3 billion people - approximately 66% of the world's population - have been using the Internet. This indicates a 24% increase since 2019 and indicates that 1.1 billion people were predicted to have come online during that period, as well (International Telecommunication Union, 2023). According to data of Brimco; market size of global digital transactions was $5.44 trillion in 2020, and by year 2026, it was predicted to be worth $11.29 trillion. It is also predicted that the Fintech industry will reach $ 11.8 billion (by year of 2018) to approximately $306 billion (by year of 2023). In 2021, more than a hundred million people benefited from the opportunity of "*proximity mobile payment*". According to Getapp, proximity mobile payments can be described as a type of payment method for goods or services, which a customer uses (via Near Field Communication-NFC technology) his/her mobile phone or other smart device. According to the same data of Brimco, in

year of 2020, 90% of smartphone users involved in a mobile payment and mobile payment market ran up to a value of more than $1 trillion all over the world. It is projected that mobile transactions will continue to grow, and 60% of customers look to transact or communicate with their financial institutions via a single platform, for example, a mobile application. Additionally, since 2019, the rate of cash usage at all sales points has decreased by 42%.

Nowadays, in which we stand on the edge of 4th industrial revolution, Fintech makes it easier and cheaper for people to access financial services, via computer/Internet technologies and mobile phone applications, in comparison to traditional financial service types. Thanks to these technologies, more people can enter money and capital markets, and consequently economic-financial growth has increased globally (Shkarlet et al., 2018; Shen et al., 2021).

We believe that the Turkic countries of Turkey, Azerbaijan, Kazakhstan, Kyrgyzstan, Turkmenistan, and Uzbekistan, with their common cultural and historical ties, can form a meaningful group to compare the effects of Fintech on economic growth. These similarities allow for a consistent analysis of Fintech's effects on economic growth. In addition, countries such as China and India, which are among the world's largest economies, and Indonesia, Pakistan, Tajikistan, and Russia, which are emerging markets and have a large geographical and economic impact, provide a suitable basis for assessing the role of Fintech in economic growth on a global scale. China, in particular, a leader in mobile payment systems and digital banking, while in regions such as India and Indonesia, Fintech is seen as a critical tool for bringing financial services to the unbanked population through digital platforms. The impact of Fintech on economic growth can be understood through many factors, such as organisational innovations through the development of Information and Communication Technologies (ICT), productivity growth, efficiency of market transactions, new business opportunities, social and cultural changes, and education and knowledge management innovations. These factors allow us to assess Fintech's contribution to economic growth from a broad perspective. For this reason, we selected the Turkic countries and strategically and economically important countries such as China, India, Indonesia, Pakistan, Tajikistan, and Russia. Moreover, studies by Omer (2021) and Razzag (2024) revealed the importance of Fintech in these regions. In short, Fintech is thought to increase economic prosperity in these countries that are endowed with many resources.

In this context, Fintech's worldwide enourmous progress has strengthened our hands. Therefore, we think that in 2000-2020 period, a nexus between Fintech usage of the Turkic World countries and selected some Asian countries and economic growth worths researching on it for our aforementioned study. The rest of our study has been organised as; in the second part, existing literature, in the third part, variables and data set used in the study, and in the fourth part, findings of the research have been mentioned. In the fifth and last part, the results were evaluated and provided some advices.

Literature Review

Although the impact of the Fintech sector, which is named as communication and information technology, on economic growth has been accepted for many years, this impact has been felt much more seriously on a global scale in recent years. It is stated that the important elements that have made Fintech popular late are; technological progresses, changing customer demands and macroeconomic effects. Solow, (1956), In the study, also recognised as the "Solow Theory", Solow indicates that promoting technological developments will enhance income in the current labour market, and with that, innovations created by the real sector due to technological progress will have a significant impact on economic growth. On the other hand, Romer (1990) stated that technological change in the growth model is endogenous, and technological improvements guide investment decisions. Therefore, he asserted that technological improvements will direct economic growth. Bai and Ding (1998), held the view that technological innovations impact financial development in a positive manner and support economic growth. Pohjola (2001) also found that, given the importance of both human and physical capital and similar economic factors, both developing and developed countries will need information technology to promote economic growth. Jorgenson and Vu (2005), examined the influence of investments in information technology on economic growth in the world's 14 largest economies between 1989 and 2003. From that study, they find that technological investments greatly affect economic growth. Additionally, in their study, they determined that this effect was more prominent in the G7 countries and that developing Asian countries followed the G7 countries.

The vast majority of the studies in the literature show that the impacts of financial technologies (Fintech) on economic growth have a positive direction (Madden & Scott, 2000; Torero et al., 2002; Nasab & Aghaei, 2009; Yapraklı & Sağlam, 2010; Anthony & Patrick, 2013; Ishida, 2015; Salahuddin & Gow, 2016; Khan et al., 2020; Cumming & Schwienbacher, 2021). According to the research conducted by Garces and Daim (2012) in the United States, communication and information technology has an affirmative effect on economic growth. In the study of Yılmaz & Kırışkan (2017), conducted in Türkiye, it's claimed that communication and information technology is a crucial element for economic growth. Sadigov et al., (2020) stated that, advances in Fintech support economic growth by increasing real sector financing. According to Kurniawati (2021), communication and information technologies have a significant effect on economic development in high income level and middle income level Asian countries. Kurniawati also stated that improving CIT infrastructure in middle-income Asian countries is necessary to further expedite economic growth. Song and Appiah-Otoo (2022), clearly indicate that Fintech is a basic determinant of China's economic growth. Badwan and Awad (2022) stated that the growing use of financial technology in Palestine contributes to economic growth. Naeruz et al. (2022), also specified that financial technological advances have an affirmative effect on Indonesia's economic growth. Between 1995 and 2008, Türedi

(2013) attempted to determine the effect of information and communication technology on economic progress in 53 countries, 23 developed and 30 developing. The study in which the sample was quite wide, Türedi benefited from the panel data analysis. The result of the empirical analysis indicates that the use of CIT in both developed and developing countries has a positive impact on economic growth. Erumban and Das (2016) targeted to reveal the role of CIT in routing economic growth in India between 1986 and2011. In their studies, they divided the usage areas of CIT into manufacturing and service sectors. According to the results, it can be seen that the use of CIT in India enhances economic efficiency. Another important finding in the aforementioned study is that the weight of CIT used in the service sector is higher than that used in other sectors. Toader et al. (2018) discovered, that the prevalence of CIT in European Union countries between 2000 and 2017 is an important factor in economic growth. Romdhane et al. (2020), between 2001 and 2017, examined the relationship between Fintech usage and economic boost for 21 African countries. Findings demonstrate that financial and technological developments stimulate growth in African countries. Nair et al. (2020) examined the impact of CIT infrastructure on economic growth in OECD countries. According to the empirical findings, the progress of CIT makes a long-term contribution to economic growth. Kirayeva et al. (2021) evaluated the impact of financial technologies on economic growth in the period of 2004-2019. The country groups in their research comprise selected countries from the EU, CIS (Commonwealth of Independent States) and economies in transition. As a consequence of their research, they documented a significantly increased usage of Fintech in the countries examined. In the examined period, additionally, with the transformation in financial technology, researchers determined that there was downsizing in physical (numbers of bank branches) fields by transferring the financial transactions of the countries to the digital environment. As a result, they verified that a strong link exists between financial technologies and economic progress.

Bu et al. (2022) evaluated the effect of Fintech improvements in China on real economic progress using panel data analysis. Due to this study, it has been demonstrated that Fintech usage has crucial and encouraging dimensions to economic growth. Utami (2022) analysed Fintech's impact on economic growth in Indonesia between the years 2020-2022. The empirical results indicate that Fintech has a significant affirmative impact on economic development. In the research carried out by Gomes et al. (2022), the impact of Fintech on economic growth in OECD countries tried to be determined. In this research, 36 OECD countries were divided into groups according to their level of development between 2000 and 2019, and the GMM panel method was applied. The result of that study shows that Fintech usage has a significant effect on economic growth in OECD countries. In this respect, the cruciality of Fintech usage was emphasised to policy makers in terms of economic revival.

Even though it has been confirmed in the literature that the connection between Fintech and economic growth is affirmative, there are some studies that also stated the opposite or that

there is no relationship between them. For example, Li et al. (2009) examined the nexus between fintech and economic growth in the Chinese economy. But, according to the results of their study, they could not identify any connection between Fintech and economic growth. Nabi et al. (2022) aimed to reveal the impact of CIT usage on economic growth for N11 (Next Eleven) countries in the 2000-2018 period. It has been identified that there is a negative correlation between the increasing use of CIT in N11 countries and economic growth in the examined period.

Although our study focuses on the nexus between Fintech and economic growth, we think that the impact of control variables, as well, in the model on economic growth need not be neglected. Studies in the literature claim that economic growth is positively affected by gross fixed capital formation (GFCF) (Ali, 2017; Boamah et al. 2018; Pasara & Garidzirai, 2020), general government final consumption expenditure (GOV) (Gomes et al. 2022; Poku et al. 2022), financial development (FG) (Salahuddin et al. 2016; Gow, Kurniawati, 2022).

This study focuses on the nexus between Fintech usage and economic growth in the Turkic and selected Asian countries. In the literature, it is seen that in most studies examining the linkage between Fintech and economic growth, a single criterion is used as the Fintech indicator. On the other hand, limited number of studies have focused on mobile cellular subscriptions, fixed broadband subscriptions and internet usage rate measurements as Fintech indicators. In addition, existing studies in the literature neglect the causal relationship between Fintech and economic progress. Finally, almost no studies have evaluated the impact of Fintech usage on economic growth from a wide perspective in countries in the Turkic world. Thus, our study not only enrichs the existing literature but also contributes to the literature by investigating the impacts of various Fintech indicators on economic growth for countries in the Turkic world and selected Asian countries.

In his neoclassical growth theory, Solow (1956) argued that information and communication technologies (ICTs) promote economic growth through technological advances and improved labour quality. However, Solow considered these technological developments as exogenous factors. Recent empirical studies, on the other hand, have examined the effects of the internalisation of technological innovations on economic growth, and these findings have been associated with endogenous growth theory (Ehrlich, 1990:9). In this context, the impact of Fintech, which is an important part of ICT, on economic growth can also be explained by endogenous growth theory. Therefore, researchers generally emphasised that ICT has a significant impact on the economic growth of countries (Choi and Yi, 2009; Andrianaivo and Kpodar, 2011; Farhadi, et al. 2012).

In this direction, we aim to test the impact of Fintech on the economies of the Turkic countries and some selected Asian countries in our study, based on the following hypotheses that we have developed inspired by various studies in the literature (Bahrini and Qaffas, 2019; Mayer, et al. 2020) that examined the effects of Fintech on economic growth:

H_1: Mobile cellular subscriptions have an affirmative impact on the economic growth of Turkic and selected Asian countries.

H_2: Fixed broadband subscriptions have an affirmative impact on the economic growth of Turkic and selected Asian countries.

H_3: Internet usage rates have an affirmative impact on the economic growth of Turkic and selected Asian countries.

Data Explanation

Information and communication technologies are expressed using monetary and non-monetary indicators. While monetary indicators comprise information and communication technology investments, non-monetary indicators are measured using numerical information such as mobile cellular subscriptions and fixed broadband subscriptions (Hu et al. 2021; Iqbal et al. 2022).

The aim of this research is to evaluate the effect of Fintech, which refers to information and communication technology, on the economic growth of countries in the Turkic world and some Asian countries between 2000 and 2020. Within the scope of the study, country data from Azerbaijan, China, Indonesia, India, Kazakhstan, Kyrgyzstan, Uzbekistan, Pakistan, Russia, Türkiye and Tajikistan were collected. Because Fintech data of Turkmenistan, a Turkic country, could not be accessed, this country was excluded from the sample. In addition, the reason why the study ended in 2020 is that, Fintech data of the countries within the scope of the study were published until this year. In the context of non-monetary indicators of CIT as a Fintech criterion; mobile cellular subscription (per 100 people) (LMOB), Internet use (% of Population) (LINDI), and fixed broadband subscriptions (per 100 people) (LFBROAD) were used. The dependent variable of the research was the gross domestic product per capita (Fixed 2015 US$) (LGDP). The financial development index (LFG), gross fixed capital formation GDP (LGFCF) and general government final consumption expenditures (% of GDP) (LGOV) are also involved in the model as control variables. Among the data used in this study, the financial development index is provided by the International Monetary Fund's (IMF) database at www.data.imf.org, while other data are provided by the World Bank's database Data Bank's official website www.data.worldbank.org.

Model Specifications

For examining the impact of fintech on economic growth; the below defined econometric model was developed by benefiting the studies of Hafru, 2019; Adeleye & Eboagu, 2019; Kurniawati, 2022; Iqbal et al. 2022; and Gomes et al. 2022:

$$LGDP_{it} = \beta_0 + \beta_1 * LMOB_{it} + \beta_2 * LINDI_{it} + \beta_3 * LFBROAD_{it} + \beta_4 * LGFCF_{it} + \beta_5 * LGOV_{it} + \beta_6 * LFG_{it} + u_{it} \quad (1)$$

In this model, i denotes the country, t denotes the time, β denotes the coefficient, and u_it denotes the error term. Additionally, the symbol L in the model indicates that the variables are logarithmic series.

Methodology

Panel data regression and panel causality analyses were used to examine the connection between information and communication technologies (Fintech) and economic development in the Turkic world and selected Asian countries between 2000 and 2020. In order to perform panel data regression analysis and causality analysis, we first checked whether the series contained cross-sectional dependence and whether they were stationary. Cross-sectional dependence analysis of the series (Pesaran, 2004) was examined using the CD test. Whether there is cross sectional dependance in the CD (*Pesaran, General Diagnostic*) test, is tested with "*H0: There is no cross-sectional dependence (H_0:ρ_ij=0)*" (Tatoğlu, 2018). If the series include cross-sectional dependence, the stationarity of the variables is analysed using the second-generation panel unit root test and the cross-sectionally augmented LM, Pesaran and Shin (CIPS). The CIPS test designed by Pesaran is a simple alternative method expanded by standard augmented Dickey-Fuller (ADF) regressions with cross-sectional means of lagged levels and first differences of individual series (Pesaran, 2007). The CIPS stationarity test is applied as "*H0: Series is not stationary (Contains unit root).*" The cross sectional dependence and panel unit root test results are presented in Tables 3 and 4.

In static panel data regression analysis, pooled ECT, fixed effect and random effect models are frequently used. To select among these estimators; F Test which was developed by Moulton and Randolph, Breush-Pagan Lagrange Multiplier (LM) Test and Hausman Test were performed. The null hypothesis of this test is "*H_0: All unit and time effects are equal to zero (H_0:μ_i=λ_t=0)*." (Tatoğlu, 2020). Using the F Test, a decision is made between the pooled least squares and fixed effects models. The Breush-Pagan LM test is estimated with the hypothesis applied as parametric constraints. Using the LM Test, the regression is calculated by using the residuals of the model estimated by using the least squares test (Breush and Pagan, 1980).

In the Breush-Pagan LM test, hypothesis testing is performed in the form of "*H_0: The variance of unit effects is zero (H_0:σ_μ^2=0).*" (Tatoğlu, 2020). Breush-Pagan LM test is made for deciding between the pooled least squares and random effects models. The Hausman test

is designed under the null hypothesis of misidentification and is developed for model specification. This test is performed to test the instrument variable, time section model and simultaneous equation model (Hausman 1978: 1251). The null hypothesis of this test is "H_0*: Difference between parameters is not systematical.*" (Tatoğlu, 2020). The Hausman test was used to select the appropriate model from the fixed-effects and random-effects models. These three estimator tests are presented in Table 5. After deciding on the regression model according to the results of the Hausman test, F test and Breush-Pagan test, assumption tests are run to determine whether there is a heteroscedasticity, autocorrelation and cross-sectional dependence problem in the model.

The main assumption tests in panel data models are the Levene, Brown and Forsythe Multiplier Test, Durbin-Watson and Baltagi-Wu local best invariant (LBI) tests and the Frees Test. The Levene, Brown and Forsythe tests are derived to test the inequality of variances. In other words, it tests the presence of heteroscedasticity. The null hypothesis of this test is established as "H_0*: The variances of the units are equal.*". The tests applied to the auto-correlation problem are Durbin-Watson and Baltagi-Wu LBI tests. In these tests, a critical value close to 2 indicates that there is no auto-correlation problem. The test hypothesis is established as "H_0*: There is no auto-correlation*." (Tatoğlu, 2020). Frees developed the test that examines the existence of a cross-sectional dependence. The model tests the hypothesis that there is no cross-sectional dependence (Frees,1995). The results of the assumption tests are presented in Table 6.

According to the results of the panel data assumption tests, we found that the model exhibits heteroskedasticity, autocorrelation and cross-sectional dependence problems. Taking these three problems into account, a model estimation was made using the Driscoll-Kraay Robust Estimator. Driscoll-Kraay Test, which is a simple extension of the common non-parametric covariance matrix estimation technique, yields standard error estimates that are robust to all general forms of spatial and temporal dependence as the time dimension grows (Driscoll-Kraay 1998). In this study, the regression created by robust estimation is described in Model (1) and the results are displayed in Table 7.

After determining the impact of Fintech indicators on economic growth, the relation between the dependent variable and independent variables is evaluated with Dumitrescu-Hurlin Panel Causality Test. Dumitrescu-Hurlin's hypothesis testing is established as "H_0*: X is not the cause of Y.*" (Dumitrescu & Hurlin, 2012). The panel causality test results are summarised in Table 8.

Findings

The descriptive statistical analysis of the series used for the sample to determine the impact of Fintech on economic growth in the Turkic and selected Asian countries is displayed in Table 1. The results of the correlation analysis exhibiting the multicollinearity between dependent and independent variables are presented in Table 2.

Table 1
Descriptive Statistics

Variables	Observation	Mean	Standart Deviation	Minimum	Maximum
LGDP	231	7.9219	0.9334	6.0645	9.3986
LMOB	231	3.5620	1.7393	-3.9904	5.1749
LINDI	231	2.5101	1.5589	-3.0241	4.4536
LBROAD	231	0.6851	2.9959	-8.8057	3.5244
LGFCF	231	3.2770	0.3159	2.2123	4.0602
LGOV	231	2.5348	0.2611	1.8767	3.0343
LFD	231	1.3716	0.6429	-2.8739	-0.3977

In this study, there are 231 observations between 2000 and 2020. The variable with the highest average is LGDP at a rate of 7.92%, while the lowest is LBROAD at a rate of 0.68%. On the other hand, LBROAD had the highest standard deviation 2.99%, while LGOV had the lowest standard deviation 0.26%. The variable with the lowest minimum value is LBROAD and the variable with the highest minimum value is LGDP. While LGDP has the highest maximum value, LFD has the lowest maximum value. In addition, when having looked at the Fintech sub-metrics, LMOB variable has the highest average (3.56%) and LBROAD variable has the lowest average (0.68%). After explaining the descriptive statistics of the variables used in the model, the relationships between the variables were tested using Spearman's rank correlation test. Spearman's rank correlation test examines the relationship between two non-uniform heterogeneous series (Spearman, 1904). The results of this test are summarised in Table 2.

Table 2
The Results of the Spearman's Rank Correlation Analysis

	LGDP	LMOB	LINDI	LBROAD	LGFC	LGOV	LFD
LGDP	1.0000						
LMOB	0.7029*	1.0000					
LINDI	0.7502*	0.8873*	1.0000				
LBROAD	0.6832*	0.3431*	0.3933*	1.0000			
LGFCF	0.1724*	0.32483*	0.2259*	0.1231	1.0000		
LGOV	0.1304**	0.1700*	0.2522*	0.4365*	0.0936	1.0000	
LFD	0.6469*	0.2506*	0.3185*	0.3824*	0.2980*	0.1062	1.0000

Note: * and ** indicate significance levels of 1% and 5%, respectively

To the result of the correlation analysis, there was a high correlation between LGDP and LMOB (0.7027 for a p<1%). There was a high correlation between LGDP and LINDI (0.7502 for a p<1%) and between LGDP and LBROAD (0.6832 for a p<1%). There are statistically significant but weak correlations between LGDP, LGFCF and LGOV. There is also a high correlation between LGDP and LFD at 0.6469. There was a very high correlation between LMOB and LINDI (0.8873 for a p<1%). There is a weak correlation between LMOB and LBROAD, LGFCF and LFD, whereas the correlation between LMOB and LGOV is very weak. The correlation coefficients between LINDI and LBROAD, LGFCF, LGOV and

LFD indicate a weak relationship. There was a moderate correlation between LBROAD and LGOV (0.4365 for a p<1%). There was a weak correlation between LBROAD and LGFCF with LFD.

Following the correlation and descriptive statistics analyses, a cross-sectional dependence analysis and panel unit root tests used in series are performed. Pesaran CD cross-sectional dependance test results are summarized in Table 3.

Table 3
Results of Cross-Sectional Dependence Test

	CD-Test	**Prob.**
LGDP	32.41*	0.000
LMOB	33.23*	0.000
LINDI	32.19*	0.000
LBROAD	30.53*	0.000
LGFCF	7.19*	0.000
LGOV	3.77*	0.000
LFD	12.55*	0.000

Note: * indicates significance at 1%

According to the result of the Pesaran CD test, it was detected that both dependent and independent variables consist of cross-sectional dependence. In other words, the null hypothesis was rejected and it was concluded that a cross-sectional dependence exists. In order to determine whether the series with cross-sectional dependence are stationary, the cross-sectional augmented panel unit root IPS (CIPS) test developed by Pesaran (2007), taking into account cross-sectional dependence, is used as the second generation panel unit root test.

Table 4
Results of the CIPS (Intercept) Unit Root Test

Variables	**Level**	**Δ**
LGDP	-2.178***	-2.350**
LMOB	-3.175*	-3.484*
LINDI	-2.300**	-3.921*
LBROAD	-3.094*	-2.707*
LGFCF	-2.766*	-3.013*
LGOV	-2.386*	-3.231*
LFD	-2.171***	-3.112*

Note: *, **, and *** indicate significance levels of 1%, 5%, and 10%, respectively.
Critical values at 1%, 5%, 10% significance are as follows: 2.45, 2.25, 2.14 (Pesaran, 2007).

To the results of the CIPS panel unit test, we determined that all of the series were stationary at different levels of significance. That is, it was concluded that all variables used in the study were I(0).

Since the series are stationary a level, it was decided to perform panel regression analysis in the study. The estimator tests are used to decide which panel regression analyses from the

Pooled LS, Fixed-Effect Model and Random-Effect Model tests will be applied. The results of the panel data regression estimator tests are exhibited in Table 5.

Table 5
Results of Panel Regression Estimator Tests

	F Test		Breush-Pagan LM Test		Hausman Test	
	F. Statistical Value	**Probability Value**	**Chibar2**	**Probability Value**	**Chi2**	**Probability Value**
Model	818.35*	0.000	1971.74*	0.000	2.83	0.830

Note: * indicates significance level of 1%

According to the results of the F test, the null hypothesis was rejected and it was determined that all unit and time effects were not equal to zero. This result shows that using the Pooled LS model is not suitable for the established model. According to the results of Breush-Pagan LM test, the hypothesis that the variance of unit effects is equal to zero is rejected. To the result of hypothesis testing using the LM test, it was decided that the Random-Effect Model must be preferred. According to the results of the Hausman test to decide between the Fixed-Effect Model and Random-Effect Model, the null hypothesis was accepted and it was inferred that the difference between the parameters was not equal. Additionally, it was decided that the most suitable test among the regression analyses was the Random-Effect Model estimator. In order to determine whether there is heteroskedasticity, autocorrelation and cross-sectional dependence in the Random-Effect Model assumption tests were performed.

Table 6
Results of Panel Regression Assumption Tests

Heteroskedasticity Test		
	Test Statistics	**Prob. Value**
W0	12.968*	0.000
W50	10.250*	0.000
W10	12.750*	0.000
Cross-Sectional Dependance Test		
Frees	2.442**	
Results of Autocorrelation Test		
Modified from Bhargava et al. Durbin-Watson	0.228	
Baltagi-Wu LBI	0.373	

Note: * indicates significance level of 1%. ** Frees critical value alpha = 0.10:0.1231, 0.05:0.1611, 0.01: 0.2338

According to the consequences of the assumption tests, the null hypothesis for heteroscedasticity and cross-sectional dependence in the model was rejected. Based on the results obtained, it was decided that the variance of the units was not equal to zero and a correlation was observed between the units. Additionally, since Durbin-Watson and Baltagi-Wu LBI test values were far below 2, it was concluded that there was an autocorrelation problem in the model. From the results of the assumption test, we conclude that the model established comprises all three problems. In order to eliminate these problems, the model must be estimated using robust methods. The most suitable estimator, considering the heteroskedasticity,

autocorrelation and cross-sectional dependance problems, is the Driscoll-Kraay Robust Estimator method. The coefficient results of the model established by considering the estimation method are explained in Table 7.

Table 7
Results of the Random Effect Driscoll-Kraay Robust Estimator Test

	Coefficient	Driscoll-Kraay Standard Error	Probability Value
LMOB	-0.0092	0.0179	0.613
LINDI	0.1266*	0.0152	0.000
LBROAD	0.0402*	0.0081	0.000
LGFCF	-0.2925*	0.0493	0.000
LGOV	-0.0579	0.0964	0.555
LFD	0.2679*	0.0899	0.007
CONSTANT	9.1379*	0.2752	0.000
Wald Chi2	5857.77*		
Probability	0.0000		
R2	0.1259		

Note: *indicates significance level of 1%

Obtained Driscoll-Kraay robust estimator results demonstrate that the model is statistically significant. On the other hand, if we examine the impact of Fintech indicators on GDP we found that the impact of the LINDI variable on LGDP is positive and statistically significant at the 1% level. While this result shows that a 1% increase in internet usage rates increases the economic growth of the Turkic and selected Asian countries by 12%, it also confirms the hypothesis H_2 established in the hypothesis development section. Similarly, the effect of LBROAD on LGDP is positive and statistically significant at the 1% level. This result means that fixed broadband subscriptions have an increasing effect on the economic growth of the Turkic and selected Asian countries by approximately 4%, whereas the H_3 hypothesis established in the hypothesis development section will be accepted. On the other hand, unlike the existing studies, we reject the H_1 hypothesis established in the hypothesis development section and observe that mobile cellular subscriptions have no impact on the economic progress of the Turkic and selected Asian countries. Nevertheless, we think that it is not wrong to state that this situation does not undermine the economic consistency of our analysis.

In the model, after examining the nexus between Fintech indicators and economic growth, if we look at the impact of control variables on GDP, it has been revealed that the effect of gross fixed capital formation (LGFCF) on LGDP is negative and statistically significant, and financial development (LFD) has a positive effect on LGDP. Finally, we conclude that general government final consumption expenditures (LGOV) have no effect on LGDP. The discussion of the findings obtained within the scope of the study is presented in the conclusion section.

After examining the impact of Fintech indicators and control variables on economic growth in our study, we applied the Dumitrescu and Hurlin Panel causality test to examine

the causal relationship between the variables. Table 8 presents the Dumitrescu and Hurlin Panel causal relationship results.

Table 8
Results of the Dumitrescu and Hurlin Panel Causality Test

	W-Stat	Zbar-Stat	Olasılık
LMOB <=> LGDP	5.0827	3.3029	0.0010*
	3.9289	1.9168	0.0553**
LINDI <=> LGDP	4.7497	2.9028	0.0037*
	9.9395	9.1374	0.0000*
LGDP => LBROAD	2.8505	0.6213	0.5344
	14.8341	15.0174	0.0000*
LGDP => LGFCF	3.0137	0.8174	0.4137
	6.7756	5.3366	0.0000*
LGDP => LGOV	3.0676	0.8821	0.3777
	7.0112	5.6196	0.0000*
LGDP => LFD	1.2354	1.3189	0.1872
	6.0050	4.4108	0.0000*

Note: *and ** indicate significance levels of 1% and 5% respectively

According to the causality findings, a bidirectional causal relationship between mobile cellular subscriptions (LMOB) and economic growth (LGDP) occurs. Likewise, there exists a bidirectional causal relationship between Internet usage rates (LINDI) and economic progress (LGDP). There is also a one-way causal relationship from economic progress (LGDP) to fixed broadband subscriptions (LBROAD). These results prove that a causal relation between Fintech and economic growth exists. On the other hand, our results show that, there's one-way causality from LGDP to LGFCF, LGDP to LGOV and LGDP to LFD.

Conclusions

This study is conducted in order to reveal the impacts of Fintech indicators, called information and communication technology, on the economic development of the Turkic countries and some selected Asian countries. In this direction, within the scope of the study, first of all the descriptive statistics of the series were evaluated and correlation analysis was performed. Then, the Pesaran CD test was applied to test the cross-sectional dependence of the series, and as a result of the test, it was specified that the series included cross-sectional dependence. The CIPS panel unit root test was then applied to determine the stationarity of the series in the model. To the results of the CIPS unit root test, it was determined that all series were stationary at level. In order to determine the appropriate panel data regression analysis for the stationary series, some estimator and assumption tests were performed. To the result of the estimator tests, it was determined that the most suitable model for the study was the Random Effect model. Due to the heteroskedasticity, autocorrelation and cross-sectional dependance problems arise in the Random Effects Regression Model, our model was tested using the Dris-

coll-Kraay Robust Estimator. According to the robust estimation results, internet usage rates and fixed broadband subscriptions have positive effects on the economies of the Turkic world and certain Asian countries. These findings in line with the results of recent studies indicating that increasing internet usage rates can positively affect economic growth. Salahuddin and Gow (2016) for South African countries, Gomes et al. (2022) for OECD countries Kurniawati (2022) for Asian countries found similar findings. In addition, there are studies suggesting that high levels of fixed broadband subscriptions positively impact economic growth. Toader et al. (2018) for European countries, Nair et al. (2020) for OECD countries, and Badwan and Awad (2022) for Palestine produced parallel results in this regard. In this context, according to the findings of both our study and other studies in the literature, improving the ICT skills of internet users, especially in developing countries, is critical in terms of supporting economic growth and development (Haftu, 2019). On the other hand, it is concluded that financial development, one of the control variables included in the model, has a positive effect on economic growth. This result is consistent with Pasara and Garidzirai (2020) and Nchake and Shuaibu (2022). However, it is observed that the effect of gross fixed capital investments, one of the control variables, on economic growth is negative. There may be several reasons for the negative impact of gross fixed capital investments on economic growth: Low capital formation resulting from slow growth in some countries in the sample of the study, differences in the amount of investment expenditures, inefficient use of investments or low productivity, overcapacity creation, high debt burden, global economic shocks and problems in investment quality may lead to these negative effects. Moreover, Collier and Gunning (1999) argued that one of the main reasons for poor growth performance is low investment.

In this study, causality connections between the variables were also examined with the Dumitrescu and Hurlin Test, and the results of the test showed that there was a bidirectional causality between internet usage rates and economic development. In addition, it was concluded that there's a bidirectional causality between mobile cellular subscriptions and economic development. These results indicate that internet usage rates and mobile cellular subscriptions will affect economic growth, which will affect internet usage rates and mobile cellular subscriptions. Finally, it's been determined that there's a one-way causal relationship from economic growth to fixed broadband subscriptions, financial development indicators, gross fixed capital investments and general government final consumption expenditures.

Recently, both the government and the real sector and scholars have shown great interest in information and communication technologies (Fintech). We believe that we have obtained some important findings by focusing on the Fintech sector in this study. According to these findings, information and communication technologies and other macroeconomic factors positively affect the economic growth of Turkic and selected Asian countries. In this respect, we think that new investments to be made in Fintech infrastructure and improvements to existing investments will be essential factors in guiding the economic development of the Turkic and

selected Asian countries. On the other hand, Internet usage rates, which is one of the CIT indicators, make the biggest contribution to the economies of the Turkic and selected Asian countries, fixed broadband subscriptions make the lowest contribution. Therefore, these results allow policy makers to make important inferences. For example, it seems beneficial for countries to expand their CIT infrastructures and facilitate access to technology for the entire society, especially rural areas. The findings of this study confirm the interpretation that internet usage rates and fixed broadband subscriptions increase economic growth. From this perspective, we believe that improving the CIT infrastructure is of critical importance. Improvement of the CIT infrastructure will also contribute to the progress of the digital economy. Therefore, we believe that it will be beneficial for policymakers, the private sector and academics to act together and accelerate their studies in this field. From this point of view, incentives and projects should be developed by the Turkic and selected Asian countries to facilitate access to technology in rural areas through ICT investment incentive policies, and public awareness should be raised by organising training programmes on the use and benefits of ICT. In addition, cooperation between the public and private sectors should be established, joint projects and funds should be established for Fintech and ICT investments, and tax incentives should be provided to companies investing in these areas. Legal arrangements should be made for the rapid and secure growth of the Fintech sector and innovative projects should be encouraged by increasing R&D support. Finally, high-speed internet access can be expanded through policies to increase fixed broadband subscriptions.

This study examines the impact of CIT on economic growth in the Turkic and selected Asian countries. Given Fintech's global relevance, future research could explore the Fintech-growth nexus among different country groups, especially between developed and developing nations. Sector-specific and city-based analyses, such as Fintech's effects on financial services, retail, health, and education, could reveal differences between metropolitan and rural areas and help to develop regional policies. Additionally, examining the impact of policies and regulations on the Fintech ecosystem can help governments to craft effective strategies. These research directions will provide a more comprehensive understanding of Fintech's impact on economic growth and will contribute significantly to the literature.

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