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Research Article

Examining the Relationship Between Growth, Urbanization and Physical Capital with the Boostrap Causality Test: The Example of E-7 Countries

Mert A. Atamer [a]

Abstract

Introduction: The study investigated the causal relationship between economic growth, physical capital, and urbanization variables in E-7 countries (Brazil, China, India, Indonesia, Mexico, Russia and Türkiye). The purpose of this study is to contribute to the more effective design of economic growth strategies and development policies by revealing the structural characteristics of the relationships between the variables in question in E-7 countries. The limited number of comprehensive empirical analyses in the literature, which address the simultaneous effects of physical capital and urbanization on economic growth in these countries, highlights the originality and importance of the study.

Method: The analysis was carried out with annual data from 1990 to 2022. Boostrap Causality (2006) analysis was used.

Results or Findings: According to the findings obtained from the analysis, the panel results are as follows: bidirectional causality was determined between growth and urbanization, unidirectional causality was observed from growth to physical capital. Similarly, unidirectional causality was found from urbanization to physical capital. It was observed that the results differed at the cross-section level.

Discussion or Conclusion: The results emphasize that the effects of urbanization and physical capital on economic growth vary depending on country characteristics and policy preferences. In addition, policy inferences were made on both panel and country basis.

Keywords: economic growth, physical capital, urbanization, causality analysis

JEL Codes: O44, O47, C23

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Araştırma Makalesi

Büyüme, Kentleşme ve Fiziki Sermaye Arasındaki İlişkinin Boostrap Nedensellik Testi ile İncelenmesi: E-7 Ülkeleri Örneği

Mert A. Atamer[a]

Öz

Giriş: Çalışmada E-7 ülkelerinde (Brezilya, Çin, Hindistan, Endonezya, Meksika, Rusya ve Türkiye) ekonomik büyüme, fiziki sermaye ve kentleşme değişkenleri arasındaki nedensel ilişki incelenmiştir. Bu çalışmanın amacı, E-7 ülkelerinde söz konusu değişkenler arasındaki ilişkilerin yapısal özelliklerini ortaya koyarak ekonomik büyüme stratejilerinin ve kalkınma politikalarının daha etkin bir şekilde tasarlanmasına katkıda bulunmaktır. Bu ülkelerde fiziksel sermaye ve kentleşmenin ekonomik büyüme üzerindeki eş zamanlı etkilerini ele alan literatürdeki kapsamlı ampirik analizlerin sınırlı sayıda olması, çalışmanın özgünlüğünü ve önemini vurgulamaktadır.

Yöntem: Analiz, 1990-2022 yılları arasındaki yıllık verilerle gerçekleştirilmiştir ve Boostrap Nedensellik (2006) analizi kullanılmıştır.

Sonuçlar ya da Bulgular: Analizden elde edilen bulgulara göre panel sonuçları şu şekildedir: büyüme ve kentleşme arasında çift yönlü nedensellik, büyümeden fiziksel sermayeye doğru tek yönlü nedensellik tespit edilmiştir. Benzer şekilde, kentleşmeden fiziksel sermayeye doğru tek yönlü nedensellik bulunmuştur. Sonuçların kesit düzeyinde farklılık gösterdiği görülmüştür.

Tartışma ya da Yapılan Çıkarımlar: Sonuçlar, kentleşmenin ve fiziksel sermayenin ekonomik büyüme üzerindeki etkilerinin ülke özelliklerine ve politika tercihlerine bağlı olarak değiştiğini vurgulamaktadır. Ayrıca hem panel hem de ülke bazında politika çıkarımları yapılmıştır.

Anahtar Kelimeler: **e**konomik büyüme, fizik sermaye, kentleşme, nedensellik analizi

JEL Kodlar: O44, O47, C23

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Introduction

The determinants of economic growth have been at the center of economic literature for many years. In this context, resource endowments, especially physical capital, stand out as a key element in explaining growth differences at regional and national levels (Li et al., 2015). Traditional growth models reveal that investments in physical capital such as infrastructure, machinery, and technology, as well as the availability of natural resources, shape production processes and directly affect economic performance (Widarni & Bawono, 2021). Physical capital is considered one of the main drivers of growth due to its ability to increase production capacity and its potential to strengthen economic infrastructure. This view is supported by both theoretical and empirical studies (Li et al., 2015; Sen, 2013).

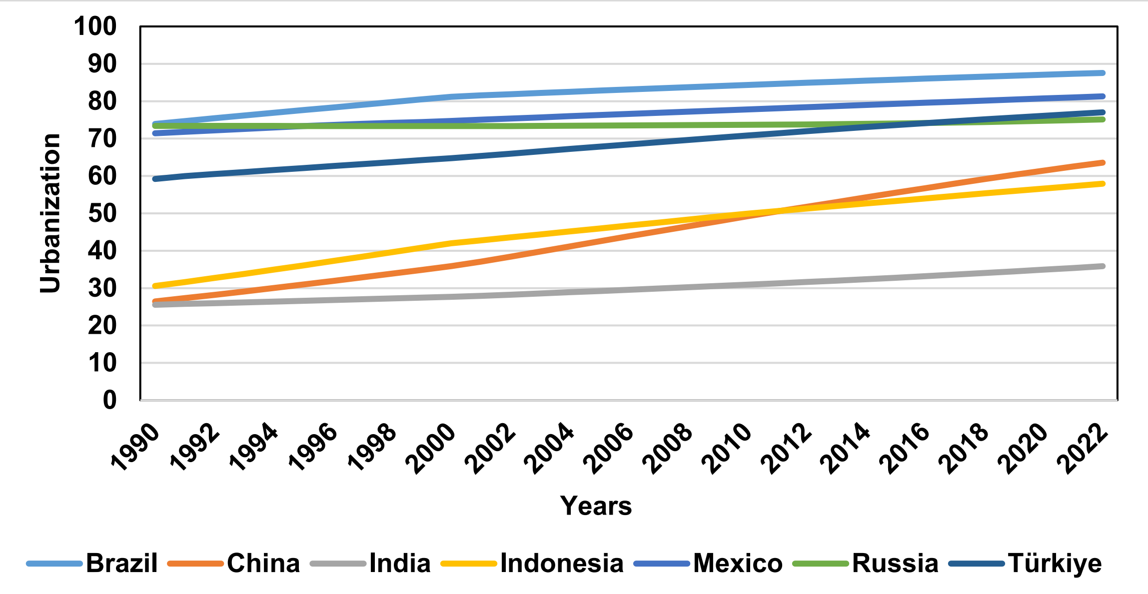
Physical capital accumulation not only encourages more efficient use of existing production factors but also contributes to productivity growth by facilitating the adoption of technological developments. This makes physical capital an indispensable element for the sustainability of long-term development (Uddin et al., 2025). On the other hand, physical capital investments contribute to the creation of an attractive economic environment for both local entrepreneurs and international investors, thus playing a structural role in directing capital flows (Casi & Resmini, 2017).

In addition to physical capital, urbanization is widely accepted as an important factor driving economic growth (Shaban et al., 2024). This process mostly involves the movement of an increasing portion of the national population from rural areas to urban centers and the spread of urban lifestyles (Potts, 2012). Urbanization leads to population growth in cities that already have limited resources (Ülger et al., 2024). In this context, the increase in the level of urbanization creates a supportive effect on economic growth through mechanisms such as the expansion of labor markets, the development of industrial and service sectors, the concentration of infrastructure investments and the increase in innovation capacity.

Figure 1 shows the development of urbanization rates in the E7 countries ("Brazil, China, India, Indonesia, Mexico, Russia and Türkiye") between 1990 and 2022. When the graph is examined, it is understood that Brazil has the highest urbanization rate, while India has the lowest. Urbanization rates have increased steadily over time in all countries except Russia. China, in particular, stands out as the country with the most significant increase in urbanization rates during the period examined.

Figure 1

Urbanization in E7 countries (%)

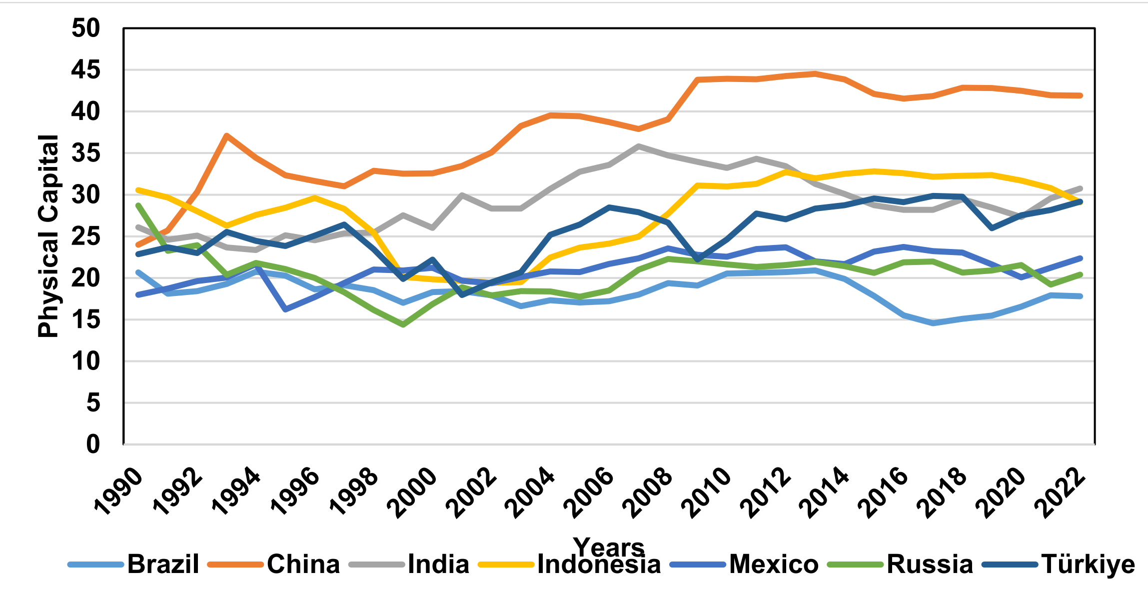


Note. This figure created by the author using Microsoft Excel.

Figure 2, reveals significant disparities in physical capital accumulation among E7 countries. China's high ratios reflect a capital-intensive growth strategy, whereas countries such as Turkey, Brazil, and Mexico exhibit lower and more stagnant trajectories.

Figure 2

Physical Capital in E7 countries

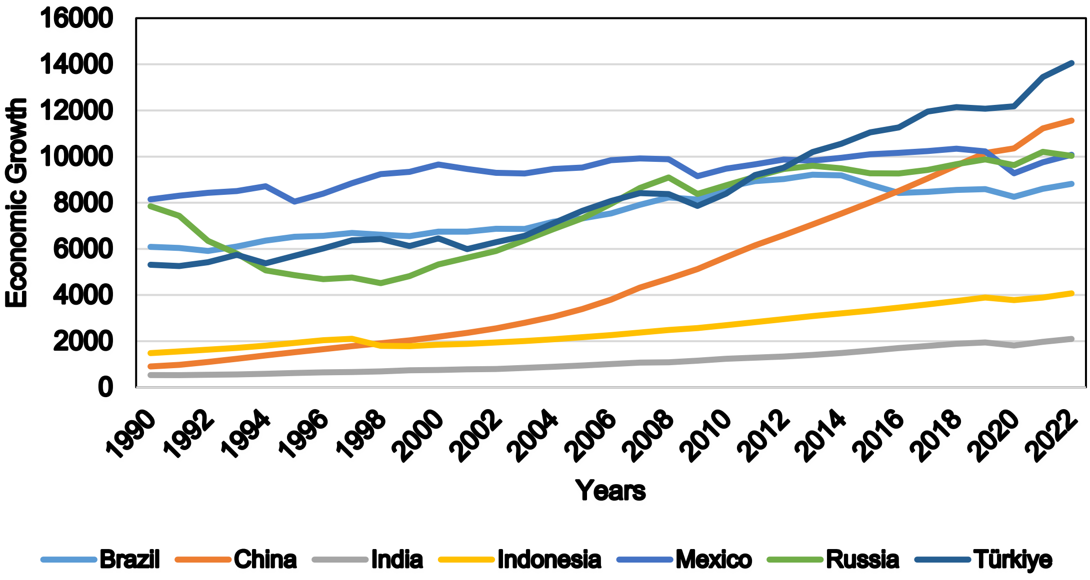


Note. This figure created by the author using Microsoft Excel.

Figure 3, demonstrates that, among the E7 countries, China and India have emerged as global economic power centers, while Indonesia has distinguished itself as a rising regional actor. In contrast, the growth performances of Brazil, Mexico, Russia, and Turkey have remained more limited, and these countries have faced difficulties in enhancing their relative weight within the E7 on a global scale.

Figure 3

Economic Growth in E7 countries



Note. This figure created by the author using Microsoft Excel.

In recent years, the relationships between physical capital, urbanization, and economic growth have been investigated with increasing interest, especially in developing economies. E-7 countries attract attention with their rapid economic growth, demographic transformations, and acceleration of urbanization processes, and therefore, their weight in the global economy increases daily. The E-7 countries comprise a group of developing countries, with many similarities but also significant differences. While some variables may be observed significantly across the panel, they may differ significantly at the country level. In this context, this sample group is worth examining in terms of its socio-economic activities and will contribute to the literature with its results. Therefore, in order to ensure the sustainability of growth processes in these countries, it has become a critical need to better understand the interaction of physical capital, urbanization, and economic growth dynamics.

The motivation of this study is to contribute to the more effective design of economic growth strategies and development policies by revealing the structural characteristics of the relationships between the variables in question in E-7 countries. The limited number of comprehensive empirical analyses in the literature, which address the simultaneous effects of physical capital and urbanization on economic growth in these countries, highlights the originality and importance of the study. In this direction, the main objective of the study is to empirically investigate the causal relationship between physical capital, urbanization, and economic growth variables in E-7 countries using annual data for the period 1990-2022. The findings to be obtained in the study are aimed at contributing to a better understanding of the drivers of growth in these countries and to guide sustainable development policies.

In the continuation of this study, the second section includes the relevant literature and in the third section, the definition of the data set and model, the method and findings are presented in detail. In the last section, a general evaluation was made in line with the results obtained and policy recommendations were included.

Literature Review

The empirical literature investigating the determinants of economic growth is quite extensive. In recent years, the impact of the energy factor on economic growth has been a wide field of study. The fact that physical capital is the determining factor of economic growth is one of the cornerstones of the classical model. This study investigates the causal relationships between the variables of physical capital, urbanization, and economic growth. In this section, a summary of the studies investigating the relationship between physical capital, urbanization, and economic growth, especially those investigating the causal relationship, is included.

Table 1
Literature Review

Author	Country/Country Group	Years	Method	Variables	Findings
Liddle (2013)	Four country groups (high-income, upper-middle-income, lower-middle-income, and low-income countries)	1970-2007	AMG	UR, EC, and EG	The impact of UR on EG varies significantly from negative to neutral to positive as countries develop.
Liddle and Messinis (2015)	100 countries	1960-2009	Dumitrescu-Hurlin causality analysis	UR change and EG	There is no causal relationship between the variables in middle-income countries and Latin American countries. For African countries, however, there is a two-way causal relationship between UR and EG.
Du (2017)	35 cities in China	2003-2012	Granger causality analysis	Land UR quality and EG	There is a long-term causality between UR and EG. Furthermore, EG has a positive effect on the quality of UR.
Pablo-Romero and Sánchez-Braza (2015)	38 countries	1995-2007	Panel data analysis	Energy use and EG	Energy use productivity flexibilities have been calculated positively for all country groups.
Nguyen and Nguyen (2018)	7 ASEAN countries	1993-2014	Granger causality analysis, FE, RE, Driscoll ve Kraay, D-GMM ve PMG	UR and EG	There is a causal relationship between UR and EG and UR has a positive effect on EG.

Malumfash and Gambo (2018)	1980-2016	Nigeria	ARDL	UR and EG	UR has a positive impact on EG in the short term, but no significant impact in the long term.
Long (2020)	1980-2016	6 ASEAN countries	Frequentist and Bayesian inferences	UR and EG	UR has a significant and positive impact on EG.
Odugbesan and Rjoub (2020)	1993-2017	MINT countries	ARDL	EG, CO2 emissions, UR, and EC	There is a long-term relationship between EG, EC, CO2 emissions, and UR.
Osiobe (2020)	14 Latin American countries	1950-2014	Granger causality analysis	Physical capital and EG	No causal relationship has been identified.
Pomi et al.. (2021)	Bangladesh	2000-2018	VAR model	Physical capital and EG	Physical capital can contribute to EG in different time dimensions.
Mehmood et al.. (2021)	Pakistan	1979-2019	Granger causality analysis	UR, institutional development, human capital, and EG	UR is the cause of growth and plays an important role in the accumulation of human capital through structural changes.
Haryanto et al.. (2021)	Indonesia	1990-2018	VECM model	UR, education, and EG	EG and education have a strong causal effect on UR.
Jacobs et al.. (2022)	South Africa	1997-2020	Granger causality analysis	Population, UR, and EG	There is no causal relationship between population and EG.
Duran et al.. (2023),	D-8 conutries	1981-2016	Dumitrescu-Hurlin causality analysis	Capital, energy use, and per capita income	A unidirectional causal relationship has been identified from capital to GDP per capita and from GDP per capita to EC.
Hacıimamoğlu and Sungur (2024),	1970-2017	Turkey	BFGC-Q (Fourier Granger causality in canticles)	Human capital, physical capital, economic complexity index, and EG	Human capital, physical capital, and economic complexity index have been found to have a positive effect on EG.
Jemuliyi and Jeke (2024),	1991-2022	Nigeria	ARDL-EMC model	UR and EG	UR does not support EG.

UR=Urbanization, EG=Economic growth, EC=Energy consumption
Note. This table was created by autor

In the summary of the literature reviewed, it was observed that the effect of urbanization and physical capital on economic growth was generally positive. In addition, it was observed that physical capital, urbanization, and economic growth were in a causal relationship. The difference between this study and the existing literature is the causality estimator used. The method used is a second-generation causality test. That is, it is sensitive to cross-sectional dependence. It also allows variables to be stationary at mixed levels (I(0)-I(1)). Its most significant feature is that it produces results at the panel level while also producing results at the country level. This distinguishes it from other causality tests. In this context, since the results differ across panel and cross-section units, it is possible to observe the specific countries responsible for the differences. The findings allow us to evaluate the results for both the panel and the countries, and to make policy recommendations. Therefore, this method has many advantages and offers a different perspective than other studies.

Data and Model Definition, Method and Findings

Explanations on Data and Model

This study investigates the causal relationship between economic growth, physical capital and urbanization variables in E-7 ("Brazil, China, India, Indonesia, Mexico, Russia and Türkiye") countries. The analysis was carried out with annual data for 1990-2022. The variables used are obtained from the "World Bank" database. The definitions of the variables are as follows; Physical capital; Gross fixed capital formation (% of GDP), urbanization; urban population (% of total population), economic growth; GDP per capita (constant 2015 US$). The models estimated in the study are as follows;

$$logeb_{i,t} = \beta_0 + \beta_1 logk_{i,t} + u_{i,t} \quad (1)$$

$$logk_{i,t} = \beta_0 + \beta_1 logeb_{i,t} + u_{i,t} \quad (2)$$

$$logeb_{i,t} = \beta_0 + \beta_1 logfs_{i,t} + u_{i,t} \quad (3)$$

$$logfs_{i,t} = \beta_0 + \beta_1 logeb_{i,t} + u_{i,t} \quad (4)$$

$$logk_{i,t} = \beta_0 + \beta_1 logfs_{i,t} + u_{i,t} \quad (5)$$

$$logfs_{i,t} = \beta_0 + \beta_1 logk_{i,t} + u_{i,t} \quad (6)$$

Methods and Findings

The study used the variables economic growth, physical capital, and urbanization. Table 2 contains the summary statistics for these variables.

Table 2
Summary Statistics and Correlation Matrix

Variables	Obs	Mean	St.Dev.	Min	Max
Logeb	231	3.653	0.371	2.723	4.147
Logk	231	1.751	0.164	1.407	1.942
Logfs	231	1.394	0.114	1.157	1.648

Note. Created by autor using Stata 10 for Windows

In the summary statistics table, the maximum value is observed for the economic growth variable. The minimum value is for the physical capital variable. The number of observations is 231. This number is sufficient for panel data analysis.

In this study, the Breusch and Pagan (1980) LM test was used to examine the existence of cross-sectional dependence. This test was developed to determine whether the units in panel data sets are independent of each other. It acts on the assumption that events that occur in one country can affect other countries, especially in cases where economic integration is high at the global level. This situation is evaluated as an indicator of the interactions of countries in economic and other sectors. In this direction, the test used to analyze the level of dependency among the cross-sectional units in the panel with each other is expressed as follows.

$$y_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it} \tag{7}$$

In the equation, y_{it} is the dependent variable for the *i* unit and *t* time period and x_{it} is the independent variables. α_i is used to represent the fixed effects specific to the units and ε_{it} is used to represent the error term. The test statistic is as follows;

$$LM = T\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{p}_{ij}^2 \tag{8}$$

T is the time, N is the cross-sectional units, and $\hat{p}_{ij}$ is the correlation coefficient between the estimated error terms. The estimated correlation coefficient of the error terms, $\hat{p}_{ij}$ is calculated as follows;

$$\hat{p}_{ij} = \frac{\sum_{t=1}^{T}\hat{\varepsilon}_{it}\hat{\varepsilon}_{jt}}{\sqrt{\sum_{t=1}^{T}\hat{\varepsilon}_{it}^2\sum_{t=1}^{T}\hat{\varepsilon}_{jt}^2}} \tag{9}$$

The null hypothesis of the test is "H0: There is cross-sectional independence between error terms".

Delta test is a method used to evaluate the homogeneity of coefficients in panel data models. This test is applied to test the validity of the homogeneity assumption of the coefficients, especially in cases where differences between individuals (cross-sectional units) may be found in panel data analysis. The mathematical expression used to test the homogeneity assumption is illustrated by the following equation.

$$y_{it} = \beta_i x_{it} + \varepsilon_{it} \tag{10}$$

The test investigates whether all units have the same coefficient (β). The hypotheses of this test are as follows;

Null Hypothesis: The coefficients are homogeneous among all units ($\beta_i \neq \beta \; for \; all \; i$).

Alternative Hypothesis: The coefficients are different for at least one unit ($\beta_i \neq \beta \; for \; all \; i$).

The delta test was first developed by Swamy (1970) and later expanded by Pesaran and Yamagata (2008). The equation used in calculating the test is as follows:

$$\Delta = \frac{1}{N}\sum_{i=1}^{N}(\hat{\beta}_i - \bar{\beta})^2 \qquad (11)$$

$\hat{\beta}_i$ represents the estimated coefficient for section unit i, and β represents the weighted average of the coefficients for all section units.

Table 3 shows the cross-sectional dependence and homogeneity test results.

Table 3
Cross-Section Dependency and Homogeneity Test Findings

	Panel Cross Section Results	
Test	**Statistics**	**p-value**
LM	79.73	0.000***
LMadj	27.33	0.000***
LM_{CD}	0.7	0.483
	Homogenity Test	
	Delta	**p-value**
	22.495	0.000***
adj.	23.997	0.000***

** and *** are used to represent significance at 5% and 1% significance levels.

Note. Created by autor using Stata 10 for Windows

According to the results in the first part of the table, the null hypothesis was rejected and the existence of cross-sectional dependence was accepted. According to the delta test results, it was concluded that the slope coefficients were heterogeneous.

Unit root tests are used to determine the stationarity properties and stationarity degrees of the variables in the model. In this study, since the estimated model has cross-sectional dependence, the "CADF (Cross-sectional Augmented Dickey-Fuller) test", which is one of the second generation unit root tests and is considered to be effective for heterogeneous and homogeneous series, was preferred. The test in question was developed by Pesaran (2006) and first calculates the CADF test statistics for each series in the panel. Then, the arithmetic average of these statistics is taken to obtain the CIPS statistic representing the entire panel. The CADF test is calculated based on the following model proposed by Pesaran (2006).

$$t_i \text{ (N,T)} = \frac{\Delta y_i' \bar{M}_w y_{i-t}}{\sigma_i (y_{i-1}' \bar{M}_w y_i)^{1/2}} \qquad (12)$$

Table 4 shows the stationarity levels of the variables.

Table 4

CADF Test Findings

Variables	Constant		Trendli	
	t-bar/ Z[t-bar]	**p-val**	**t-bar/ Z[t-bar]**	**p-val**
Logeb	-2.667/-2.497	0.006***	-2.438/-0.295	0.384
Logk	-3.144/-3.839	0.000***	-4.288/-5.856	0.000***
Logfs	-2.518/-2.077	0.019**	-3.206/-2.603	0.005***

*, **, and *** indicate significance at 10%, 5%, and 1% significance levels. 1 is used as the lag length.

Note. Created by autor using Stata 10 for Windows

Both fixed and trended options were used in the CADF unit root test. When the probability values were examined, it was observed that all variables became stationary at level.

In the study, the causality test developed by Konya (2006) was used to analyze the causal relationships between the variables. The test in question differs from other causality tests because it can reveal the causality relationships at the unit level, as well as panel-level causality results. In addition, this method stands out with its sensitivity to cross-sectional dependency and its applicability in the presence of both homogeneous and heterogeneous slope coefficients. The equations used in the calculation of this test are as follows: Konya (2006);

$$y_{1,t} = \alpha_{1,1} + \sum_{I=1}^{mly_1} \beta_{1,1I} y_{1,t-1} \sum_{I=1}^{mlx_1} \gamma_{1,1I} x_{1,t-1} + \varepsilon_{1,1,t} \quad (13)$$
$$y_{2,t} = \alpha_{1,2} + \sum_{I=1}^{mly_1} \beta_{1,2I} y_{2,t-1} \sum_{I=1}^{mlx_1} \gamma_{1,2I} x_{2,t-1} + \varepsilon_{1,2,t} \quad (14)$$
$$y_{Nt} = \alpha_{1,N} + \sum_{I=1}^{mly_1} \beta_{1,NI} y_{N,t-1} \sum_{I=1}^{mlx_1} \gamma_{1,NI} x_{N,t-1} + \varepsilon_{1,N,t} \quad (15)$$

and

$$x_{1,t} = \alpha_{2,1} + \sum_{I=1}^{mly_2} \beta_{2,1,I} y_{1,t-1} \sum_{I=1}^{mlx_2} \gamma_{2,1I} x_{1,t-1} + \varepsilon_{2,1,t} \quad (16)$$
$$x_{2,t} = \alpha_{2,2} + \sum_{I=1}^{mly_2} \beta_{2,2,I} y_{2,t-1} \sum_{I=1}^{mlx_2} \gamma_{2,2I} x_{2,t-1} + \varepsilon_{2,2,t} \quad (17)$$
$$x_{N,t} = \alpha_{2,N} + \sum_{I=1}^{mly_2} \beta_{2,N,I} y_{N,t-1} \sum_{I=1}^{mlx_2} \gamma_{2,NI} x_{N,t-1} + \varepsilon_{2,N,t} \quad (18)$$

In the equations used in the test, the variables y and x represent those for which the causality relationship is investigated. N is the cross-section unit of the panel (i = 1,2,...,N); t denotes time (t = 1,2,...,T). The lag length is indicated by the symbol '1', while 'mly' and 'mlx' indicate the lag lengths of the variables 'y' and 'x', respectively. With this method, not only the causality relationship is determined, but also the direction of causality. The analysis is carried out by comparing the bootstrap critical values specific to each cross-section unit with the Wald statistics. In cases where the Wald statistics are greater than the bootstrap critical values, the null hypothesis of no causality is rejected and it is concluded that there is a causal relationship between the relevant variables.

Table 5 shows the Konya Causality test findings for Model 1.

Table 5
Bootstrap Panel Causality Results Model 1

H_0: Growth is not the cause of urbanization					
Countries	**Wald Statistics**	**Bootstrap Probability Value**	**Critical Value**		
			%1	**%5**	**%10**
Brazil	0.082	1.000	59.148	44.245	37.636
China	17.370**	0.044	23.368	16.755	14.237
India	4.375	0.336	14.365	10.068	8.155
Indonesia	10.926**	0.038	15.151	9.930	7.992
Mexico	11.448**	0.036	15.201	10.672	8.328
Russia	3.520	0.609	25.817	16.951	13.597
Türkiye	8.457	0.514	23.567	18.530	15.699
Panel Fisher	**Statistics: 23.940**		**Probability Value: 0.047****		

***, **, * represent critical levels of 1%, 5% and 10%. Bootstrap was run for critical values as 10,000. Lag length is 1.

Note. Created by autor using Stata 10 for Windows

This test shows both panel results and cross-section results. According to the null hypothesis, when the panel is examined in general, the probability value of the hypothesis is rejected. In this context, a causal relationship from growth to urbanization is observed. At the cross-section level, the null hypothesis is rejected in China, Indonesia and Mexico, and causality from growth to urbanization is detected in these countries.

The estimation results for Model 2 are shown in Table 6.

Table 6
Bootstrap Panel Causality Results Model 2

H_0: Urbanization is not the cause of growth					
Countries	**Wald Statistics**	**Bootstrap Probability Value**	**Critical Value**		
			%1	**%5**	**%10**
Brazil	18.061	0.650	56.397	42.181	37.304
China	4.760	0.569	25.087	16.297	13.074
India	9.891**	0.037	13.077	8.794	6.687
Indonesia	3.491	0.327	21.733	12.195	8.193
Mexico	15.736**	0.038	19.603	14.239	11.887
Russia	3.696	0.269	16.995	10.244	7.765
Türkiye	10.807	0.408	29.234	21.857	17.985
Panel Fisher	**Statistics: 21.778**		**Probability Value: 0.083***		

***, **, * represent critical levels of 1%, 5% and 10%. Bootstrap was run for critical values as 10,000. Lag length is 1.

Note. Created by autor using Stata 10 for Windows

Firstly, when the panel results are evaluated, the hypothesis that urbanization is not the cause of growth is rejected. In this context, causality from urbanization to growth has been determined. When the panel results for Model 1 are compared, bidirectional causality between urbanization and growth has been found. In the unit level results, the results are significant in India and Mexico. Accordingly, causality from urbanization to growth has been found in these countries. In line with these results, bidirectional causality relationship between urbanization and growth has been found in Mexico.

Table 7

Bootstrap Panel Causality Results Model 3

H₀: Growth is Not the Cause of Physical Capital					
Countries	**Wald Statistics**	**Boostrap Probaility Value**	**Critical Value**		
			%1	**%5**	**%10**
Brazil	2.942	0.708	23.892	16.719	13.187
China	14.412**	0.030	18.082	12.092	9.856
India	2.000	0.956	33.062	23.989	19.098
Indonesia	14.787***	0.001	9.890	6.465	4.954
Mexico	7.001	0.582	25.753	18.229	15.771
Russia	12.159*	0.051	18.155	12.197	9.650
Türkiye	15.978	0.566	40.213	30.139	26.645
Panel Fisher	**Statistics: 29.782**		**Probability Value: 0.008*****		

***, **, * represent critical levels of 1%, 5% and 10%. Bootstrap was run for critical values as 10,000. Lag length is 1.

Note. Created by autor using Stata 10 for Windows

According to the results in the table; the panel probability value led to the rejection of the hypothesis that growth is not the cause of physical capital. This result showed that there is a one-way causality from growth to physical capital. In the unit-level results, the null hypothesis was rejected in China, Indonesia and Russia, while it was accepted in other countries. Therefore, causality from growth to physical capital was found in these countries.

Table 8

Bootstrap Panel Causality Results Model 4

H₀: Physical Capital Is Not the Cause of Growth					
Countries	**Wald Statistics**	**Bootstrap Probability Value**	**Critical Value**		
			%1	**%5**	**%10**
Brazil	12.514	0.104	25.307	16.407	12.983
China	5.236	0.209	16.009	9.991	7.805
India	2.954	0.933	35.988	25.336	21.129
Indonesia	2.821	0.210	13.333	7.168	5.245
Mexico	12.758	0.163	28.066	19.394	15.637
Russia	5.343	0.239	14.063	10.087	8.146
Türkiye	7.386	0.883	44.178	32.286	28.820
Panel Fisher	**Statistics: 17.657**			**Probability Value: 0.223**	

***, **, * represent critical levels of 1%, 5% and 10%. Bootstrap was run for critical values as 10,000. Lag length is 1.

Note. Created by autor using Stata 10 for Windows

When the results for Model 4 were evaluated, it was observed that the panel result was not significant. This result shows that there is no causality from physical capital to growth. Similarly, in the results at the cross-section level, no causality from physical capital to growth was detected in any country.

Table 9 shows the estimation results for Model 5.

Table 9

Boostrap Panel Causality Results Model 5

H_0: Urbanization is not the cause of physical capital					
Countries	**Wald Statistics**	**Bootstrap Probability Value**	**Critical Value**		
			%1	**%5**	**%10**
Brazil	10.983*	0.088	18.226	12.859	10.681
China	5.892	0.746	30.031	21.983	18.298
India	7.526	0.277	20.117	14.093	11.247
Indonesia	8.677	0.251	23.306	15.423	12.722
Mexico	9.252	0.110	15.890	12.320	9.750
Russia	15.068***	0.007	13.094	8.062	6.243
Türkiye	10.741	0.503	31.946	24.572	20.510
Panel Fisher	**Statistics: 26.492**		**Probability Value: 0.022****		

***, **, * represent critical levels of 1%, 5% and 10%. Bootstrap was run for critical values as 10,000. Lag length is 1.

Note. Created by autor using Stata 10 for Windows

In model number 5, the panel results revealed that there is causality from urbanization to physical capital. In the unit-level results, the probability values in Brazil and Russia are significant, and the null hypothesis is rejected. Accordingly, one-way causality from urbanization to physical capital is identified in these countries.

Finally, Table 10 shows the statistical findings of Model 6.

Tablo 10

Bootstrap Panel Causality Results Model 6

H_0: Physical Capital Is Not the Cause of Urbanization					
Countries	**Wald Statistics**	**Bootstrap Probability Value**	**Critical Value**		
			%1	**%5**	**%10**
Brazil	8.339*	0.098	17.160	10.398	8.287
China	13.190*	0.075	21.101	15.199	11.631
India	12.319	0.119	22.190	16.128	13.105
Indonesia	4.602	0.716	20.468	16.079	13.502
Mexico	9.432	0.111	18.352	11.466	9.605
Russia	3.102	0.626	15.304	11.861	10142
Türkiye	4.223	0.897	41.176	29.016	24.711
Panel Fisher	**Statistics: 20.302**			**Probability Value: 0.121**	

***, **, * represent critical levels of 1%, 5% and 10%. Bootstrap was run for critical values as 10,000. Lag length is 1.

Note. Created by autor using Stata 10 for Windows

Panel results show that there is no causality from physical capital to urbanization. At the unit level, the null hypothesis was rejected in Brazil and China. In this context, causality from physical capital to urbanization was found in these countries. This result showed that there is a bidirectional causality between urbanization and physical capital in Brazil.

Conclusion and Policy Recommendations

The findings obtained for Model 1 are as follows: the causal relationship from growth to urbanization was determined for the whole panel. At the cross-sectional level, causality from growth to urbanization was also observed in China, Indonesia and Mexico. This finding obtained for both the whole panel and for some countries is in the expected direction. Economic growth affects many areas. In this context, growth provides an increase in infrastructure investments, and this encourages migration from rural areas to urban areas. This situation can be especially evident in fast-growing economies such as China, Indonesia and Mexico. Job opportunities created by the effect of growth increase the attractiveness of urban areas, and this accelerates the urbanization process. Physical capital investments support urbanization by developing transportation, health, education, and industrial infrastructure in cities. In countries such as China and Indonesia, the increase in urban population has been supported by planned policies to make economic growth sustainable. The fact that growth triggers urbanization in these countries may be due to these strategies. In countries such as Mexico, urbanization may have occurred due to the effect of internal migration and urban industrialization encouraged by economic growth. The lack of causality from growth to urbanization in some E-7 countries (e.g. Brazil, India, Russia, and Türkiye) may indicate that urbanization processes in these countries are more dependent on demographic and political factors. The impact of physical capital investments on growth and urbanization may vary due to differences in the economic structures of the countries. Since economic growth triggers urbanization, planned urbanization policies should be adopted in fast-growing countries. This may include developing infrastructure in urban areas, improving transportation systems, and providing affordable housing. Urban transformation projects and sustainable urbanization strategies should be prioritized, especially in countries where growth directly affects urbanization, such as China, Indonesia and Mexico. In this way, negative situations that will arise from urbanization driven by growth can be prevented.

Causality from urbanization to growth was observed in Model 2. When this finding was evaluated with the panel results for Model 1, bidirectional causality between urbanization and growth was found. This result is parallel to the study conducted by Liddle and Messinis (2015). In the unit-level results, causality from urbanization to growth was found in India and Mexico. In line with these results, a bidirectional causality relationship was found between urbanization and growth in Mexico. Urbanization supports economic growth by increasing productivity. Urbanization may encourage the concentration of industrial and service sectors by concentrating and using a more efficient workforce. In places where urbanization accelerates, infrastructure such as education, health and transportation develop more rapidly, which triggers economic growth. Rapid urbanization may increase the impact of growth-oriented sectors concentrated in urban areas. In addition, India's demographic structure may cause the urban workforce to contribute more to growth. Industrialization and export-oriented production in cities may lead to urbanization, which triggers growth. In addition, the observation of bidirectional causality highlights the influence of urban infrastructure development and the ability of economic growth to support urbanization. The fact that no direct effect of urbanization on growth is observed in other countries suggests that different economic dynamics such as rural development or natural resource-oriented growth may be dominant in these countries. Infrastructure investments should be prioritized in rapidly urbanizing countries. In countries where urbanization triggers growth, such as India and Mexico, more investment in transportation, education, health, and energy infrastructure may have a positive effect on growth. Planned urbanization policies should be adopted to reduce the environmental and social costs of urbanization. For example, green city policies can be implemented in Mexico to reduce environmental impacts. Urban-rural linkages should be strengthened to extend the causal effect from urbanization and growth to rural areas. This can increase the growth potential in countries with large rural populations, such as India. In countries such as Mexico, where there is a bidirectional causality between urbanization and growth, policies that support economic growth along with urban development should be prioritized. For example, innovative and high value-added production should be encouraged in industrial zones.

In Model 3, one-way causality from growth to physical capital was found. Osiobe (2020) could not detect any causality between these two variables in her study, so the results obtained differ from this study. In unit-level results, causality from growth to physical capital was observed in China, Indonesia and Russia. Economic growth leads to an increase in financial resources for more capital investment. GDP growth can create market confidence that encourages investments. Growth accelerates infrastructure investments and the expansion of the private sector, which in turn increases physical capital. In China, high growth rates and strong orientation towards public-private sector investments support capital accumulation. In Indonesia, this result may be due to the fact that incomes obtained from natural resources allow growth to be channeled into physical capital. This finding may be because growth obtained from energy and raw material exports in Russia is channeled into infrastructure and other capital investments. In other countries (India, Türkiye, etc.), this relationship may be weak due to the limited depth of financial markets or the failure to transform growth into capital investments. Therefore, the results may have emerged in this way. In line with these findings, public-private partnerships should be encouraged, and the effect of growth on physical capital should be increased by directing the income from growth to capital investments. In India and Türkiye, financial instruments should be diversified to facilitate the transformation of growth into capital accumulation; and it would be a good practice to develop credit markets. In Russia and Indonesia, the income from growth should be directed not only to certain sectors but also to capital investments on a large scale. In addition, appropriate legal and economic environments should be provided to attract foreign direct investments and support local capital formation. Applications in this direction can increase the positive effect of growth on physical capital.

Model 4 shows that there is no causality from physical capital to growth. The results are also similar at the cross-sectional level, and no causality from physical capital to growth was detected in any country. . In this respect, the results differ from the study conducted by Pmi et al. (2021), which found that physical capital contributes to economic growth, and from the study conducted by Duran et al. (2023), which found a one-way causality relationship from capital to economic growth. These findings can be evaluated as follows: investments in physical capital may not have been used efficiently enough to trigger economic growth. Growth dynamics in E-7 countries may be more dependent on factors such as human capital, technology, and innovation. Investments may have been directed to low-impact areas rather than high value-added sectors that will support long-term growth. In this context, investments in areas such as technology, green energy, and digital transformation should be increased to enhance the impact of physical capital on economic growth. In addition, effective management, accountability, and monitoring mechanisms should be strengthened in infrastructure projects to increase the impact of physical capital on growth. The quality of physical capital investments can be increased by creating an attractive economic and legal environment for foreign investors. Policies that support different growth dynamics in rural and urban regions of E-7 countries should be developed. These policy recommendations are critical for E-7 countries to increase the impact of physical capital on growth.

Model number 5 investigates the causal relationship between urbanization and physical capital. The panel results show that there is a causality from urbanization to physical capital. In a similar study, Mehmood et al (2021) found that urbanization plays an important role in capital accumulation. In the unit-level results, one-way causality from urbanization to physical capital was detected in Brazil and Russia. Urbanization encourages physical capital investments by increasing the demand for infrastructure projects (housing, transportation, energy). Urbanization triggers capital investments by causing economic activities and production processes to concentrate in cities. Brazil undergoes the intensive urbanization process that requires large-scale infrastructure projects and industrial investments. In Russia, the parallel progress of urbanization and the development of industrial zones based on natural resources may have increased capital investments. Policy recommendations based on these findings can be as follows: long-term strategic planning should be made for infrastructure projects to evaluate the investment opportunities brought by urbanization. Urbanization processes should be planned effectively and efficiently, and efficient use of investments should be ensured; balanced development should be encouraged in the industry, trade, and housing sectors. In countries such as Brazil and Russia, the economic opportunities created by urbanization should be distributed equally for regional development. Incentive mechanisms should be established to direct physical capital investments to sustainable infrastructure (green buildings, renewable energy projects, public transportation). To strengthen the link between urbanization and physical capital investments, incentives for the expansion of industrial and service sectors in urban centers should be increased.

The last model investigates whether there is causality from physical capital to urbanization. Panel results show that there is no causality from physical capital to urbanization. At the unit level, causality from physical capital to urbanization was found in Brazil and China. This result shows that there is a bidirectional causality between urbanization and physical capital in Brazil. These observations suggest that physical capital investments may have been directed to industrial and export-oriented sectors rather than housing, infrastructure, and transportation projects that encourage urbanization. Heterogeneous demographic and economic structures at the panel level may make it difficult to generalize the relationship between physical capital and urbanization. Physical capital investments were directed to urban infrastructure projects, which encouraged urbanization. In addition, bidirectional causality shows that urban demand increases investment. Rapid economic growth and large-scale infrastructure projects may have increased physical capital investments supporting urbanization. In light of these possible reasons, priority should be given to infrastructure investments that encourage urbanization (public transportation, housing, water and energy infrastructure). Instead of concentrating physical capital investments only in certain cities, physical capital investments should be distributed more evenly to facilitate the transition from rural to urban areas. According to the results conducted in Brazil, it would be appropriate to increase investments in urban planning and infrastructure projects to optimize the two-way relationship between urbanization and capital. In China, investments in green infrastructure projects and environmentally friendly urban planning are crucial for the sustainability of rapid urbanization and economic growth processes. Diversification and increase in physical capital investments should be encouraged to meet the economic demand arising from urbanization. Physical capital investments should be integrated into strategic plans to ensure sustainable urban growth.

The study analyzes the causal relationships between economic growth, urbanization, and physical capital in E-7 countries, and it presents important findings. The Konya Causality test conducted at the panel level and on a country basis revealed the heterogeneous structure of the interactions between growth, urbanization, and physical capital. The panel results show that there is a bidirectional causality relationship from growth to urbanization and from urbanization to growth. However, no unidirectional causality from physical capital to urbanization or growth is found. At the country level, countries such as "China, India, Brazil and Russia" exhibit different dynamics in terms of causality between urbanization and physical capital investments. The emergence of different causality patterns among countries is due to differences in the economic structure, urbanization dynamics and historical development process of each country. These results emphasize that the effects of urbanization and physical capital on economic growth vary depending on country characteristics and policy preferences.

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