

## EXPLORING THE EMPIRICAL LINKAGES BETWEEN INNOVATION, ECONOMIC GROWTH AND CONSUMER PRICES: EVIDENCE FROM CPEC COUNTRIES

### İNNOVASYON, EKONOMİK BÜYÜME VE TÜKETİCİ FİYATLARI ARASINDAKİ AMPİRİK BAĞLANTILARI KEŞFETMEK: CPEC ÜLKELERİNDEN KANITLAR

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**Cite As** Balkar, O.E. & Çildir, Ç. (2021). "Exploring The Empirical Linkages Between Innovation, Economic Growth And Consumer Prices: Evidence From Cpec Countries", International Academic Social Resources Journal, (e-ISSN: 2636-7637), Vol:6, Issue:32; pp:1901-1910

#### ABSTRACT

This study was conducted in order to investigate the empirical linkages between innovation, consumer prices and economic growth. China, India, Kazakhstan, Kyrgyzstan and Pakistan, which are in the China-Pakistan Economic Corridor (CPEC), were chosen as sample of the study. Annual Global Innovation Index Score (GIIS), Consumer Price Index Score (CPIS) and GDP per Capita (GDPPC) data of the relevant countries were accessed for the period from 2011 to 2020. Relevant data were evaluated with panel data methods.

The regression analysis of the study showed that GIIS has a positive effect on GDPPC. Similarly, it has been found that GDPPC has a positive effect on GIIS. However, it has been determined that CPIS has a negative effect on GDPPC. The causality analysis results showed that there is unidirectional causality from GDPPC to CPIS in the long and short term. However, a bidirectional causality relationship has been determined between GDPPC and GIIS in the short run.

**Key words:** Innovation, Consumer Prices, Economic Growth.

#### ÖZET

Bu çalışma; inovasyon, tüketici fiyatları ve ekonomik büyüme arasındaki ampirik bağlantıları araştırmak amacıyla yapılmıştır. Çin-Pakistan Ekonomik Koridoru (CPEC)'nda yer alan Çin, Hindistan, Kazakistan, Kırgızistan ve Pakistan ülkeleri, çalışmanın örneklemini olarak seçilmiştir. 2011 ile 2020 yılları arasındaki bir dönem için ilgili ülkelerin yıllık Global İnovasyon Endeksi Skoru (GIIS), Tüketici Fiyat Endeksi Skoru (CPIS) ve Kişi Başına GSYİH (GDPPC) verilerine erişilmiştir. İlgili veriler, panel veri yöntemleriyle değerlendirilmiştir.

Çalışmanın regresyon analizi, GIIS'in GDPPC üzerinde pozitif yönde etkisi olduğunu göstermiştir. Benzer şekilde, GDPPC'nin GIIS üzerinde olumlu yönde etkisi olduğu keşfedilmiştir. Ancak CPIS'in GDPPC üzerinde negatif yönde etkisi olduğu tespit edilmiştir. Nedensellik analizi sonuçları ise uzun ve kısa dönem vadede GDPPC'den CPIS'a tek yönlü nedenselliğin bulunduğunu göstermiştir. Bununla beraber kısa vadede ise GDPPC ile GIIS arasında çift yönlü nedensellik ilişkisi tespit edilmiştir.

**Anahtar Kelimeler:** İnovasyon, Tüketici Fiyatları, Ekonomik Büyüme.

#### 1. INTRODUCTION

Globalization, technological and facilitating trade changes have altered the mechanism and scope of economies all around the world. Due to these changes, economic growth has been considered as one of the most critical objectives to achieve sustainable finance system (Claessens and Laeven, 2005). In this context, the causes and effects of economic growth began to attract the attention of researchers and practitioners (Giménez et al., 2015).

It is known that the dynamics of an economy are closely related to how and in which areas the limited resources are used. For that reason, policy makers pay attention to the functions of financial productivity (Romer, 1986). Consequently, they try to manage the instability of economy by reallocating or restructuring the key factors such as Research and Development (R&D) expenditures and market prices (Ky and Cabral, 2017).

Adapting new technologies, methods or processes increase the superiority of outputs. These actions can improve the level of competition and consumer prices in markets (Aghion and Howitt, 1992). Therefore, researchers recognize innovation as a powerful source to reach desired level of competitiveness (Gackstatter et al., 2014), societal happiness (Ali, 2014) and economic growth (Guloglu and Tekin, 2012).

Within this context, countries choose trading steps that may involve economic cooperation, strategic collaboration and free trade zones to achieve higher innovativeness (Naz et al., 2018). It is thought that these collaborations affect the inflation and economic power of the countries (Das et al., 2020).

Therefore, this study aims to find empirical linkages and causal relationships between economic growth, innovation and consumer prices. In order to do that, China-Pakistan Economic Corridor (CPEC) countries are chosen as research universe. Within this context, Gross Domestic Product per Capita (GDPPC), Consumer Price Index Score (CPIS) and Global Innovation Index Score (GIIS) data of 5 CPEC countries are extracted from different databases for the period between 2011 and 2020.

Due to the availability of statistical data, multi-steps methodology is followed. Principal component analysis (PCA), correlation, panel unit root, cointegration and causality tests are used. After these analyzes, the findings were evaluated and interpreted.

The rest of the paper is organized as follows; Section 2 provides a related literature review; Section 3 describes the methodology of this study. Section 4 contains the empirical results from econometric panel analyzes and Section 5 concludes with policy implications and summary of the main findings.

### 1.1. About CPEC

Over two centuries ago, the Silk Road has made an impact on trade and cultural activities of Asian, European and African countries. There were several logistics routes that affected peace, development and cooperation situations of these countries (Mehtar, 2017). However, the collaboration in the region was losing its power at the beginning of 21st century. In April 2015, CPEC agreement was signed between Pakistan and China to revive collaboration with economic and infrastructure projects (Boni, 2016).

CPEC is considered as a system of regional links that are thought to have positive socio-economic impacts on China and Pakistan as well as Iran, Afghanistan, India, Central Asian Republic countries (CARs) and other actors in the region. This economic corridor project's investments enhanced bilateral trade between CPEC countries and closely followed by other nations (CPEC, 2015; Irshad et al., 2015).

The projects of CPEC aim to increase economic, commercial cooperation and improve geographic connections by developing rail, sea, land and airway transportation systems, focus on strategic locations such as "Gwadar Port" and restore the relationships about energy crises, human trafficking, infrastructure insufficiency and piracy problems as a Modern Silk Road's south corridor (Abid and Ashfaq, 2015; Chang and Khan, 2019).

Under this economic corridor portfolio, these projects are considered as critical points that geographically and strategically connect China to Africa, Europe and Middle East. Especially Gwadar Port projects are evaluated as gateway to provide new route from China to CARs and International North South Transport Corridor (INSTC) and create a new linkage to eleven new members (Kazakhstan, Armenia, Kyrgyzstan, Tajikistan, Ukraine, Belarus, Bulgaria, Syria, Azerbaijan, Oman and Turkey) of INSTC. That is also utilized as a valuable factor on giving China an advantage about modern world's problems such as labor efficiency, industrial cooperation, shipment of goods and sources (Ahmar, 2015; Riaz et al., 2019).

Consequently, CPEC is considered as an important strategic collaboration. This geo-economic partnership between Pakistan and China, attracted the attention of researchers and policy makers (Ahmar, 2015).

## 2. LITERATURE REVIEW

There have been numerous approaches on innovation over the years. As one of the leading researchers in the field, Schumpeter (2004) pointed out that innovation and economic growth are the related and inseparable concepts which affects each other constantly. If economic growth takes place at expected level, investment to innovation increases in specific sectors to boost global competitiveness.

Across civilizations and history, there are various examples that the countries and businesses interact with enhance their agility to financial environment's changes. With innovative approaches in organizational processes and marketable goods, they were able to make critical developments and strengthen their roles in related markets. As a result of that, they expanded economic capabilities and market shares significantly (Ali, 2014).

In this context, consumer prices are evaluated as key drivers of economic transactions. The consumption and demand behaviors of consumers are affected constantly by consumer prices. Therefore consumer prices of an economy, shortly inflation is considered as strategic indicator for selling rate of companies (Yong, 2014).

However, the related field's researchers found direct, indirect or no relationships between innovation, economic growth and consumer prices (Kurniawati, 2020; Rajput et al., 2012). In this direction, the variables in the research accessed from the literature were determined. The methods, results and sample in these studies were evaluated. Relevant literature review about Innovation (IN), Consumer Prices (CP) and Economic Growth (EG) is given in Table 1.

Table 1. Literature Review

Author	Sample	Methods	Variables	Findings
Rajput et al. (2012)	BRICS Countries (2007-2012)	Panel Data Analysis	Global Innovation Index, GDP	IN ↔ EG (C)
Galindo and Méndez-Picazo (2013)	10 Developed Countries (2001-2009)	Panel Data Analysis	Number of Patents, Entrepreneurship, Education, Social Climate, GDP	IN → EG (+)
Colino et al. (2014)	Spain, Italy and Greece (1960-2009)	Aggregate Production Function	Product per Worker, Capital-Product Ratio, Labor Input, Human Capital, Total Factor Productivity, R&D Jobs, Economic Growth	IN → EG (+)
Idun and Aboagye (2014)	Ghana (1990-2009)	ARDL Bounds Test	Financial Innovation, Bank Competition, Economic Growth	IN → EG (+) (Long-run) IN → EG (-) (Short-run)
Yong (2014)	14 European Countries (1988-2010)	Panel Data Analysis	Tourism Demand, Consumer Price Index, Total Patent Application	CP ↔ IN (C)
Mahmoud (2015)	Mauritania (1990-2013)	Time Series Analysis	Consumer Price Index, GDP	CP → EG (C)
Ky and Cabral (2017)	Sub-Saharan Africa Countries (1960-2014)	Generalized Moments Estimator	Global Innovation Index, GDP Growth Rate, GDP per Capita, Total Factor Productivity, Political Instability	IN → EG (+)
Terzić (2017)	10 European Countries (2008-2016)	Panel Data Analysis	Global Innovation Index, Global Competitiveness Index, GDP per Capita, GDP Growth	IN ↔ EG (+)
Pradhan et al. (2018)	G20 Countries (2001-2012)	Panel Data Analysis	GDP per Capita, Fixed Capital Formation Rate, Labor Force Participation Rate, Broadband Users Rate, Internet Users Rate, Consumer Price Index	CP → EG (C)
Avila-Lopez et al. (2019)	12 Latin American Countries (1996-2015)	Panel Data Analysis	Number of Patents, R&D Expenditure, Scientific and Technical Journals, GDP per Capita	IN ↔ EG (C)
Das et al. (2020)	13 Emerging Asian Economies (2009-2018)	Panel Data Analysis	GDP per Capita, Reverse Corruption Index, Global Innovation Index, Financial Development Index, Economic Freedom Index, Consumer Price Index	IN → EG (-) CP → EG (+)

Source: Created by authors.

As shown in Table 1, variables of this research were investigated by using different instruments in related studies. These findings showed that there could be bidirectional and unidirectional causality relationships between IN, CP and EG. Additionally, there could be positive or negative effects on each other.

For instance, there are studies (Colino et al., 2014; Galindo and Méndez-Picazo, 2013; Idun and Aboagye, 2014; Ky and Cabral, 2017) that present IN has a positive effect on EG. However, Das et al. (2020), Idun and Aboagye (2014) found opposite results. Additionally, Das et al. (2020) showed that there is a positive effect from CP to EG in.

Additionally, there are some studies that indicates causalities between these variables. For instance, Rajput et al. (2012) found that there is a bidirectional causal relationship between innovation and economic growth. Similarly, the findings of Pradhan et al. (2018) support this evidence. However, Mahmoud (2015) and Pradhan et al. (2018) discovered that there is a unidirectional causal relationship from consumer prices to economic growth.

On the other hand, related findings were differentiated due to the sample and instruments. Also, there are limited number of research that were reached. Therefore, Das et al. (2020) study was chosen as advisor research because of consisting same variables. In that direction, following operations carried out.

### 3. METHODOLOGY

This study provides econometrics methodologies such as principal component analysis (PCA), correlation, panel unit root, cointegration and causality tests to investigate relationship between economic growth, consumer prices and innovation. After literature review, framework of the research is created, and conceptual model is constituted as in Figure 1.

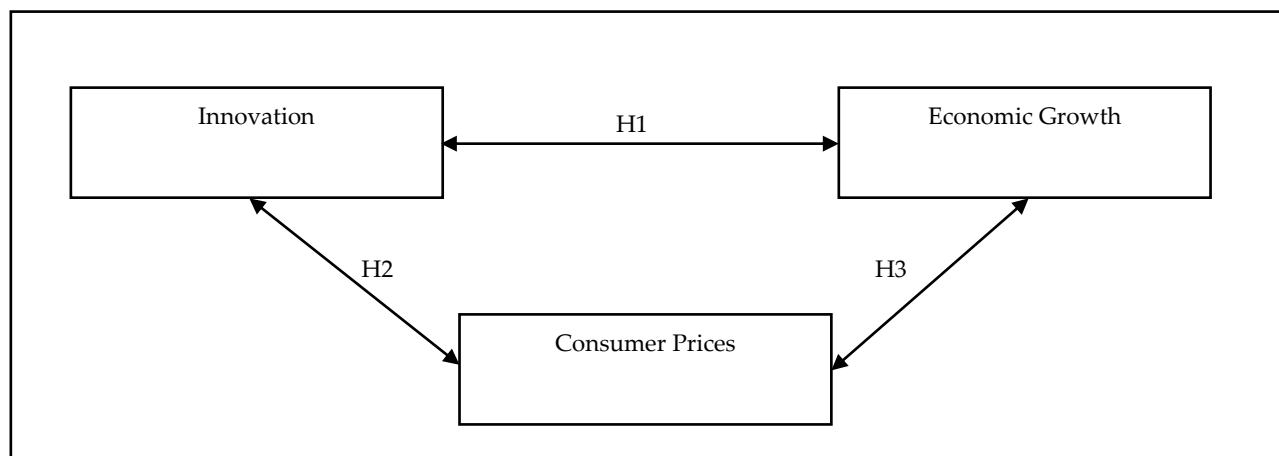


Figure 1. Conceptual Model of the Study  
Source: Created by authors.

According to Figure 1 and relevant literature review, following hypotheses are tested and discussed in upcoming sections:

- H1: Innovation causes economic growth and vice versa.
- H2: Innovation causes consumer prices and vice versa.
- H3: Consumer prices cause economic growth and vice versa.

#### 3.1. Data

In order to test hypotheses of the study, the instruments of variables are selected. Also, a sample of countries are chosen from CPEC’s impact area. Within this context, the data are extracted from World Bank (WB) and GII’s web site. Table 2 provides the related information about the sample and instruments.

Table 2. Instruments and Sample of the Research

Variable	Code	Instrument	Data Set	Source	Countries
Consumer Prices	CPIS	Consumer Price Index Score (2010=100)	Annual Data (2011-2020)	(WB, 2021a)	China, India, Kazakhstan, Kyrgyzstan, Pakistan.
Economic Growth	GDPPC	GDP per Capita (Constant 2010 US\$)	Annual Data (2011-2020)	(WB, 2021b)	
Innovation	GIIS	Global Innovation Index Score	Annual Data (2011-2020)	(GII, 2021)	

Source: Created by authors.

As can be seen in Table 2, this study deals with data from China, India, Kazakhstan, Kyrgyzstan and Pakistan. Related data set includes annual data of CPIS, GDPPC and GIIS for each country. It also covers for the period 2011-2020.

#### 3.2. The Econometric Models

To evaluate the relationship between economic growth, innovation and consumer prices in CPEC’s countries, following dynamic panel econometric models (1, 2 and 3) are created according to related literature knowledge:

$$LGDP_{it} = \alpha_0 + \alpha_1 LGIIS_{it} + \alpha_2 LCPI_{it} + \varepsilon_{it} \tag{1}$$

$$LCPI_{it} = \beta_0 + \beta_1 LGIIS_{it} + \beta_2 LGDP_{it} + \vartheta_{it} \tag{2}$$

$$LGIIS_{it} = \gamma_0 + \gamma_1 LGDP_{it} + \gamma_2 LCPI_{it} + \omega_{it} \tag{3}$$

In these models, country-specific fixed and variable effects are evaluated. Thus,  $i$  presents cross-section ( $i$ -th country) and  $t$  indicates period (2011-2020) respectively.  $\alpha_0, \alpha_1, \alpha_2, \beta_0, \beta_1, \beta_2, \gamma_0, \gamma_1$  and  $\gamma_2$  coefficients display the long-run flexibility of economic growth with compared to consumer prices and innovation. Moreover, all variables are transformed into natural logarithm forms. In accordance with literature review, the signs of independent variables (consumer prices and innovation) on dependent variable (economic growth) are expected to be positive.

### 3.3. Estimation Methodologies

For the purpose of examining the study's problem, some estimation methodologies were implemented. Firstly PCA, heterogeneity and Cross-Section Dependency tests were put account to acquire the statistics of variables. After these tests, Pearson correlation test was performed to determine bilateral relationships between variables. After that, panel unit root test was utilized to control the stationarity of each variable. Then, the panel cointegration test and estimation analysis were applied. Lastly, a causality test was conducted to check direction of causality between variables.

Just like other social science research, many methods are used in studies involving time series. As one of these methods, PCA test was conducted to interpret the summary statistical values of variables. The results of this test showed that there were no contrary or missing data in the relevant data set. Consequently, the related data was appraised suitable for Homogeneity and Cross-Section Dependency (CD) tests.

In order to determine homogeneity of panel data, Hsiao (2003) test was used. In this test, the null hypothesis states that the coefficients in the econometric model are homogeneous. Also, the hypotheses such as homogeneity of the coefficients in the model ( $H1_{(Hsiao)}$ ), the heterogeneity of the panel ( $H2_{(Hsiao)}$ ) and the partial heterogeneity of the panel ( $H2_{(Hsiao)}$ ) are evaluated.

Since data from five countries (N) and ten years period (T) were considered in this study ( $T > N$ ), CD-LM1 test is chosen to determine the cross-section dependency. The null hypothesis in this test states that there is no cross-section dependency between the values in the series (Breusch and Pagan, 1980). After CD-LM1, Pearson correlation test was utilized.

Additionally, researchers generally use unit root tests to determine stationarity of time series in the studies containing panel data. According to CD-LM1 and homogeneity tests results, CADF test was chosen as one of the second-generation unit root tests. This test evaluates the cross-sectional IPS (Im, Pesaran and Shim), shortly CIPS statistics (Pesaran, 2007). Also, IPS test was implemented to the variable that has cross-section independency.

Moreover, Westerlund (2007) cointegration test is chosen to determine long-run relationships between variables. This method provides four types of group test statistics due to homogeneity status. If the slope coefficients are heterogeneous in the cointegration relationship,  $G_\alpha$  ve  $G_\tau$  test statistics are considered. If not, Z and U test statistics need to be taken into account (Aytun and Akın, 2014).

Lastly, Fully Modified Ordinary Least Squares (FMOLS) cointegrating regression analysis and Granger (1969) causality tests were performed. The results from all these estimations are tabulated. Explanations and interpretations are also indicated below the tables.

## 4. EMPIRICAL FINDINGS

The data in time series of variables change according to cross-section and years. However, summary statistics can be determined with PCA test. In this context, the data without natural logarithms were evaluated in their raw form. These findings are shown in Table 3.

Table 3. Findings of PCA Test

Countries	CPIS			GDPPC			GIIS		
	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
China	128.11	105.55	116.43	8,405.18	4,961.23	6,731.07	54.80	44.66	49.49
India	184.33	108.86	148.82	2,152.22	1,410.43	1,787.70	36.60	31.70	34.83
Kazakhstan	201.24	108.42	150.41	11,518.52	9,603.24	10,636.80	32.75	28.60	31.29
Kyrgyzstan	165.52	116.64	142.17	1,117.48	905.17	1,016.03	29.79	24.50	27.41
Pakistan	200.08	111.92	150.88	1,197.54	992.88	1,098.74	26.75	22.30	23.85
<b>Panel</b>	<b>201.24</b>	<b>105.55</b>	<b>141.74</b>	<b>11,518.52</b>	<b>905.17</b>	<b>4,254.07</b>	<b>54.80</b>	<b>22.30</b>	<b>33.37</b>

Max: Maximum; Min: Minimum

Source: Created by authors.

Table 3 shows the maximum, minimum and mean statistics of time series of variables. It is understood that Kazakhstan had the highest value in GDPPC in the relevant period. However, China draws the attention by having the highest GIIS and the lowest CPIS. These descriptive statistics are considered as important indicators for following analyzes. Within this context, the natural logarithms of variables were taken. The results of Homogeneity test made on these values are shown in Table 4.

Table 4. Results of Homogeneity Test

Models	(1)		(2)		(3)	
	F	p	F	p	F	p
H1(Hsiao)	2,102.929	0.001*	30.386	0.001*	76.535	0.001*
H2(Hsiao)	15.549	0.001*	11.697	0.001*	1.076	0.382
H3(Hsiao)	1,693.560	0.001*	22.663	0.001*	222.925	0.001*

\*: p &lt; 0.01

Source: Created by authors.

According to Table 4, the coefficients in all models are heterogeneous. After this test, CD-LM1 test was utilized. Findings of CD-LM1 test are shown in Table 5.

Table 5. Findings of CD-LM1 Test

Variable	CD-LM1 Test Statistics	p
LCPIS	9.755	0.001*
LGDPPC	9.307	0.001*
LGIIS	0.686	0.493

\*: p &lt; 0.01

Source: Created by authors.

Table 5 provides the findings of CD-LM1 test. There is no cross-section dependency in LCPIS and LGDPPC series. However, results for the LGIIS series show otherwise. In this context, the relationships between variables need to be evaluated in detail. To interpret correlations, Pearson correlation analysis was employed. Results of Pearson correlation test are shown in Table 6.

Table 6. Results of Pearson Correlation Test

Variable	LCPIS	LGDPPC	LGIIS
LCPIS	1.000		
LGDPPC	-0.147	1.000	
LGIIS	-0.453**	0.615**	1.000

\*\*: p &lt; 0.05

Source: Created by authors.

It is understood from Table 6 that there are some significant bilateral relations between the variables. Firstly, there is a positive relationship ( $r_{(LGIIS-LGDPPC)} = 0.615$ ;  $p < 0.01$ ) between LGIIS and LGDPPC. Similarly, there is a negative relationship ( $r_{(LGIIS-LCPIS)} = -0.453$ ;  $p < 0.01$ ) between LGIIS and LCPIS. However, there are no significant relationship between LCPIS and LGDPPC.

After these tests, a Vector Autoregressive (VAR) model which includes all variables was constructed. Due to Akaike Information Criteria (AIC) and Schwarz Information Criteria (SC), optimal lag length was selected as 1 in standard VAR model (Mohmand et al., 2017). Within this context, CADF and IPS tests were implemented. Findings of these panel unit root tests are shown in Table 7.

Table 7. Findings of Unit Root Tests

Variable	Level				First Difference			
	Intercept		Intercept + Trend		Intercept		Intercept + Trend	
	t	p	t	p	t	p	t	p
LCPIS	-2.457	0.071	0.708	0.008*	0.456	0.178	0.153	0.001*
LGDPPC	-4.214	0.001*	-1.518	0.469	-1.475	0.028**	0.344	0.002*
Variable	$\chi^2$	p	$\chi^2$	p	$\chi^2$	p	$\chi^2$	p
LGIIS	-0.440	0.323	0.298	0.617	-0.750	0.006*	0.446	0.001*

\*: p &lt; 0.01; \*\*: p &lt; 0.05

Source: Created by authors.

Findings of unit root tests are included in Table 7. According to the results, all variables are stationary at first difference and intercept + trend (I+T) model. After these analyzes, Westerlund cointegration test was implemented. Related results are shown in Table 8.

Table 8. Results of Westerlund Cointegration Test

Dependent Variable	Independent Variable(s)	Statistics	Value	Z	p
LCPIS	LGDPPC, LGIIS	$G_{\alpha}$	0.847	3.253	0.999
		$G_{\tau}$	0.005	6.997	0.999
LGDPPC	LCPIS, LGIIS	$G_{\alpha}$	-0.563	3.986	0.999
		$G_{\tau}$	-0.008	-0.002	0.001*
LGIIS	LCPIS, LGDPPC	$G_{\alpha}$	-3.332	2.065	0.981
		$G_{\tau}$	-3.112	-2.615	0.005*
LGDPPC	LCPIS	$G_{\alpha}$	-1.689	3.394	0.999
		$G_{\tau}$	-0.010	-0.003	0.001*
LGIIS	LCPIS	$G_{\alpha}$	-4.885	2.343	0.990
		$G_{\tau}$	-3.592	-3.372	0.001*
LGIIS	LGDPPC	$G_{\alpha}$	-9.010	-0.767	0.222
		$G_{\tau}$	-3.216	-3.581	0.001*

\*: p < 0.01

Source: Created by authors.

Table 8 provides statistical insights about relationships between dependent variable and independent variable(s). There are some dual (LCPIS → LGDPPC | LCPIS → LGIIS | LGDPPC → LGIIS) relationships that are significant. Also, there are some multiple (LCPIS, LGDPPC → LGIIS | LCPIS, LGIIS → LGDPPC) relationships that are significant. Due to these results, model 1 and model 3 are expected to be significant in cointegrating regression. Findings of FMOLS are shown in Table 9.

Table 9. Findings of FMOLS

Dependent Variable	Independent Variable(s)	$\alpha, \gamma$ or $\phi$	t	p	R <sup>2</sup>
LGDPPC	LGIIS	0.2948	3.7392	0.0008*	0.8330
	LCPIS	-0.6832	-4.1573	0.0003*	
LGIIS	LGDPPC	1.1344	3.5854	0.0013*	0.5015
	LCPIS	0.4676	1.1336	0.2667	
LGIIS	LGDPPC	0.9183	3.9316	0.0005*	0.4385
LGIIS	LCPIS	-0.4474	-1.1709	0.2512	0.2140
LGDPPC	LCPIS	-0.8186	-4.0761	0.0003*	0.7385

\*: p < 0.01

Source: Created by authors.

Table 9 shows that there are some significant long-run relationships between variables of this study. Firstly, as shown in Model 1, global innovation index score has a positive effect ( $\alpha_1 = 0.295$ ;  $R^2 = 0.833$ ) and consumer prices have a negative impact ( $\alpha_2 = -0.683$ ;  $R^2 = 0.833$ ) on economic growth. Secondly, as shown in Model 3, economic growth affects global innovation index score positively ( $\gamma_1 = 1.134$ ;  $R^2 = 0.502$ ).

Conversely from the econometric models of the study, dual regressions between variables are considered. According to Table 9, economic growth has a positive impact ( $\phi = 0.918$ ;  $R^2 = 0.439$ ) on global innovation index score. On the other hand, consumer prices affect economic growth negatively ( $\phi = -0.819$ ;  $R^2 = 0.739$ ). Generally, Table 9 provides different range of statistical results. These findings differ from each other by R<sup>2</sup> level in the regressions. In this direction, Granger causality test was performed to interpret causalities. Results of Granger causality test are shown in Table 10.

Table 10. Results of Granger Causality

Dependent Variable	Independent Variable	Short-Run		Long-Run		Summary (Short-Run)	Summary (Long-Run)
		$\chi^2$	p	ECT	p		
LGDPPC	LCPIS	0.573	0.449	0.091	0.707	GDPPC ↔ GIIS	GDPPC → CPIS
LGDPPC	LGIIS	4.192	0.012**	0.141	0.763		
LCPIS	LGDPPC	2.443	0.038**	5.038	0.029**		
LCPIS	LGIIS	0.397	0.528	0.251	0.617	GDPPC → CPIS	
LGIIS	LGDPPC	3.538	0.025**	0.001	0.984		
LGIIS	LCPIS	1.025	0.311	0.249	0.618		

\*: p < 0.01; \*\*: p < 0.05; ECT: Error Correction Term

Source: Created by authors.

According to Table 10, there is a unidirectional causality from GDPPC to CPIS in short-term. Results indicate that this causality also exists in long run. Moreover, there is a short-term bidirectional causality between GDPPC and GIIS. At the end of the determination of causal relationships, the study's hypotheses are evaluated. These findings are shown in Table 11.

Table 11. Evaluation of the Hypotheses

Hypotheses	Status
H1: Innovation causes economic growth and vice versa.	Accepted
H2: Innovation causes consumer prices and vice versa.	Rejected
H3: Consumer prices cause economic growth and vice versa.	Rejected

Source: Created by authors.

As shown in Table 11, only one hypothesis is accepted. Since the conjectures of this study are based on bidirectional causal relationships, only H1 is accepted. Therefore, H2 and H3 are rejected.

## 5. CONCLUSION AND DISCUSSION

The main purpose of this research is to investigate causal relationships between economic growth, innovation and consumer prices. In order to achieve this purpose, annual data of these variables are extracted for the period 2011-2020. In line with the conceptual information and literature review, three econometric models were created.

After investigating basic statistics, homogeneity, correlation and cross-section dependency status of the data, the stationarity of the variables is evaluated. Due to these results, Westerlund Cointegration Test was conducted. The findings of this test showed that there are some significant dual and multiple relationships between variables. In this context, FMOLS analysis is used to make a more detailed examination.

According to the findings of FMOLS, GIIS and CPIS have significant effects on GDPPC in Model 1. Regression results of this model show that GIIS has a positive impact and CPIS has a negative effect on GDPPC. Additionally, regression findings of Model 3 indicate that GDPPC affects GIIS positively.

Without the econometric models of this study, dual regressions of variables are also considered. These findings showed that GDPPC has a significant and positive effect on GIIS. In addition, CPIS affects GDPPC negatively. Since FMOLS looks for cointegrating regression effects, Granger Causality Test is used for investigating causal relationships.

Statistical results of Granger Causality Test showed that there is a unidirectional causality from GDPPC to CPIS in short and long run. On the other hand, there is a bidirectional causal relationship between GDPPC and GIIS in short-term. These results are in harmony with the findings of some research (Avila-Lopez et al., 2019; Rajput et al., 2012).

In summary, consumer prices and innovation have significant effects on economic growth of five CPEC countries in the relevant periods. Increase in innovation score and decrease in consumer prices affect economic growth positively. Causality results indicate that economic growth causes consumer prices. Additionally, economic growth causes innovation and vice versa.

Consequently, it is recommended that policy makers need to follow steps which can increase economic growth. In this way, it is possible to reduce consumer prices in their countries. Similarly, it suggested that they need to focus on more innovative projects and increase R&D expenditures. Eventually, it is foreseen that these actions will have benefits for sustainable economic growth.

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