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Convergence Hypothesis and Economic Growth in ECO Countries: An Insight from MM-QR Approach

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Abstract
This study assesses the convergence hypothesis and economic growth in ECO countries spanning from 1990 to 2021. Employing the MM-QR technique, it investigates the relationship between various factors and GDP growth. The study incorporates gross fixed capital formation, life expectancy, the effective rate of depreciation, secondary school enrollment, and the initial logarithm of GDP per capita as independent variables, with GDP growth as the dependent variable. Two distinct measures are employed: absolute convergence and relative convergence. Absolute convergence analysis reveals a positive and statistically significant trend. It indicates that poorer nations are experiencing higher growth rates compared to their wealthier counterparts. Moreover, the study investigates sigma convergence, explaining that the standard deviation of per capita income during the first and second decades signifies the existence of sigma convergence. However, during the third decade, although sigma convergence persists, it lies between the levels observed in the first and second decades. The study points out the significance of implementing pertinent policies to bolster GDP growth. It emphasizes the need for targeted strategies aimed at fostering economic development within the ECO countries.
Keywords: GDP growth, Gross fixed capital formation, Secondary school enrollment, Life expectancy, Effective rate of deprecation

1. Introduction

Economic growth refers to the progressive increase in the value of final goods and services produced within an economy over time. It is commonly quantified as the percentage rise in GDP. The significance placed on economic growth stems from its pivotal role in mitigating poverty, reducing unemployment, and addressing income inequality (Gallo, 2002; Hull, 2009). Enhanced economic growth has the potential to elevate living standards, stimulate investment, generate employment opportunities, and alleviate unemployment (Anwar and Sampth, 1999).

Human capital accumulation stands out as a fundamental driver of economic growth, complementing physical capital accumulation (Mankive and Romer, 1992). The pivotal role of economic growth in poverty alleviation is evident as it fosters income and wealth creation, which can be more equitably distributed across the populace (Sumner, 2008). Furthermore, economic growth catalyzes technological advancements and innovation. As businesses expand and invest, they often spearhead the development and adoption of new technologies to enhance productivity and efficiency. These technological breakthroughs can engender spillover effects, benefiting other sectors of the economy and propelling further growth (Macky, 2008; Ali et al., 2023).

In the realm of economics, the concept of convergence posits that the per capita income of poorer economies tends to grow at a faster pace than that of wealthier economies. This phenomenon, known as catch-up, is driven by diminishing returns to capital, with the convergence rate being positively correlated with the population growth rate (Barro, 1991). However, there exists concern regarding convergence, particularly regarding the widening gaps in living standards between countries. This can manifest as either a decrease or an increase in absolute convergence, whereby those who are affluent today are assumed to become even wealthier in subsequent years, potentially exacerbating income inequality among nations over time (sigma divergence) (Martin, 1996).

Convergence in terms of economic growth is often referred to as the catch-up effect. This hypothesis suggests that economies with lower per capita incomes tend to grow at a faster rate than those with higher incomes, leading to a narrowing of the income gap between rich and poor countries over time. Eventually, all economies are expected to converge towards similar levels of development in terms of average output and income per capita. These convergences are the cases where the economies with initially low incomes grow at faster rates than the ones with high initial incomes. In the early stage, countries are usually with weaker income levels and have higher rates of economic growth (Martin, 1994; Malik, 2017). Therefore, as economies under the process of convergence flatten out, the economic indicators tend to converge, that is, they become more and more similar among the participating economies. Beta and sigma are coefficients that characterize features of convergence (Martin, 1994).

The convergence hypothesis which is an economic theory widely-accepted believes that low-income countries can mimic more advanced ones to eventually develop in terms of economics. This argument, among others, suggests that as poor countries transition to adopt and apply more advanced technologies, train human capital, and fortify their institutions, the revenue gap between them and the richer nations will narrow. This research explores the link between the convergence hypothesis and the member states of the Economic Cooperation Organization (ECO) to identify opportunities and challenges in regional integration. The intended aim of this study is to better grasp the manner convergence processes arise within a regional economic integration framework by the way of a particular focus on the cases of the above-mentioned nation-states.

It is pivotal to the policy formation process that policymakers, economists, and development practitioners should fully grasp the concept of the convergence hypothesis and its effect on economic growth. To test its veracity, appropriate policy measures and key sector investments should be implemented to boost long-term economic growth and improve the lives of those at the bottom of the income ladder. Through the case study countries, the research sees that these ECO nations have particular problems and chances that will be part of their convergence process. The geographical adjacency, the cultural harmonization and the common visions about the regional economic process complemented with the policy instruments supplying sustainable economic growth make ECO the neighborhood having all the prerequisites for convergence.

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In addition, analyzing the convergence hypothesis in the case of ECO countries has had a significant bearing on the existing literature on convergence, which largely has directed its focus on the developed and developing countries outside of these countries. The research study may reveal the place of regional economic integration and cooperation dynamics in the process of converging, as it analyzes clusters of countries sharing characteristics. This research will do that by trying to uncover whether ECO countries exhibit patterns of convergence in general, whether similar factors influence convergence as in other areas, and whether regional economic integration is the driver of convergence dynamics in the region as a whole.

The research focuses on clarifying income convergence processes within the framework of regional economic integration and with recourse to the convergence hypothesis and growth of ECO countries. It intends to contribute to the understanding of how convergence dynamics work and to inform policymakers about actions that can lead to sustainable economic growth and help in the reduction of income inequalities by considering the particular difficulties and opportunities of these countries. Moreover, the findings of this paper will add to the existing literature on convergence by focusing on a group of countries having shared features and by analyzing the extent to which regional economic integration can have on the process of convergence.

This study empirically considers the method of moments quantile regression method to test the validity of the convergence hypothesis and economic growth in ECO countries from 1990 to 2021. It has six sections. section 2 focuses on the definition and metrics of convergence and Section 3 reviews prior research. Section 4 introduces the data and methods used. Section 5 deals with the way the results are interpreted and analyzed. The last section highlights the conclusions and the policy recommendations.

2. Convergence Hypothesis: Concept and Measurement

The concept of convergence in economics posits that the per capita income of poorer economies tends to grow at faster rates than that of wealthier economies, a phenomenon known as the catch-up process. This convergence is driven by diminishing returns to capital, and the rate of convergence is positively correlated with the population growth rate (Barro, 1991). In the revised endogenous dynamic Solow-Swan model, convergence implies that the real interest rate and the growth rate of income per capita within an economy move in tandem. When countries with lower levels of GDP per capita narrow the gap with those possessing higher levels of GDP per capita, this is termed convergence. Numerous economists, such as Barro and Martin (1991, 1992), Mankiw et al. (1992), and Lall and Yilmaz (2000), Karhan (2017) have observed tendencies of per capita income convergence between rich and poor countries over time.

Convergence is often assessed through regression analyses, which involve regressing the growth in per capita GDP on its initial level across various countries or regions within countries (Barro, 1991). Two primary mechanisms drive convergence. Firstly, technology transfer enables developing countries to bypass the early stages of technological development by adopting innovations from wealthier nations. Secondly, convergence can also be attributed to similarities in factor accumulation. Developed economies typically boast higher levels of physical and human capital, leading to diminishing returns. Conversely, developing economies often possess lower capital stocks and a higher abundance of labor, making investments in these areas yield higher returns.

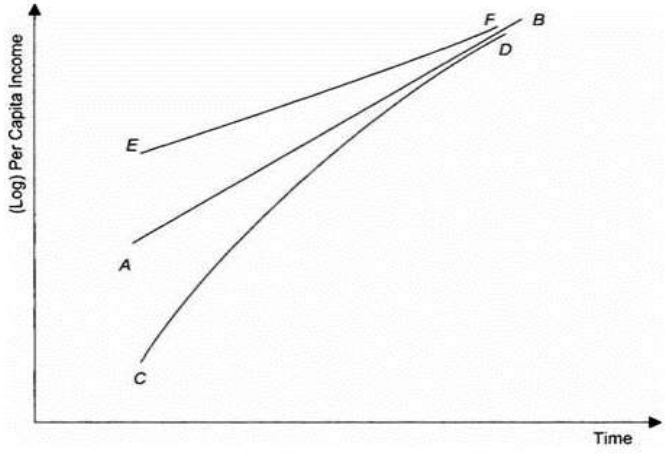
2.1. Concept of Convergence

There are two key concepts regarding convergence: absolute convergence and conditional convergence. Another term for absolute convergence is beta convergence, while conditional convergence is also known as sigma convergence. These concepts, beta convergence, and sigma convergence, were first introduced by Barro and Martin in 1995.

a) Beta convergence

The hypothesis of beta convergence, as articulated by Barro and Martin (1992), suggests that poorer economies tend to experience faster per capita growth compared to wealthier ones, without any specified conditions or reasons for this phenomenon. When two economies share identical growth rates in investment, savings, population, steady-state values, capital and output per capita, and capital depreciation, the one with initially lower per capita income tends to grow at a faster rate than the economy starting with higher initial per capita income. Beta average growth convergence indicates a negative relationship between the initial level of gross domestic product (GDP) per worker and its growth rate (Ray, 1995). This hypothesis posits that, in the long run, GDP per capita in all countries converges to the same growth path (Sorensen et al., 2005; Audi et al., 2023).

Figure 1: Unconditional convergence



The Solow model illustrates convergence, but it manifests in various forms. Poor countries typically exhibit higher growth rates than wealthier ones. In the long run, the model does not account for differences in population growth rates, capital depreciation,

or technological progress. Thus, according to the Solow model, capital per efficiency unit of labor converges to a common value, denoted as "k*" (Ray, 1997).

Figure 1 depicts beta convergence. The vertical line represents the logarithm of per capita income, while the horizontal line illustrates the time path. The straight line represents a constant growth rate. Line AB delineates the time path of the logarithm of per capita income at the steady state, while line CD represents a country starting below the steady-state level of per efficiency unit. According to the Solow model, this country experiences a growth rate that gradually elevates it towards the steady-state level, as depicted by the AB line. As the growth rate diminishes, the economy eventually reaches the steady-state level.

When a country reaches its steady state, the growth rate initially decreases as the time path of the logarithm of per capita income, represented by EF, flattens and converges towards the AB line. This convergence highlights a negative relationship between the initial value of per capita income and its growth rate.

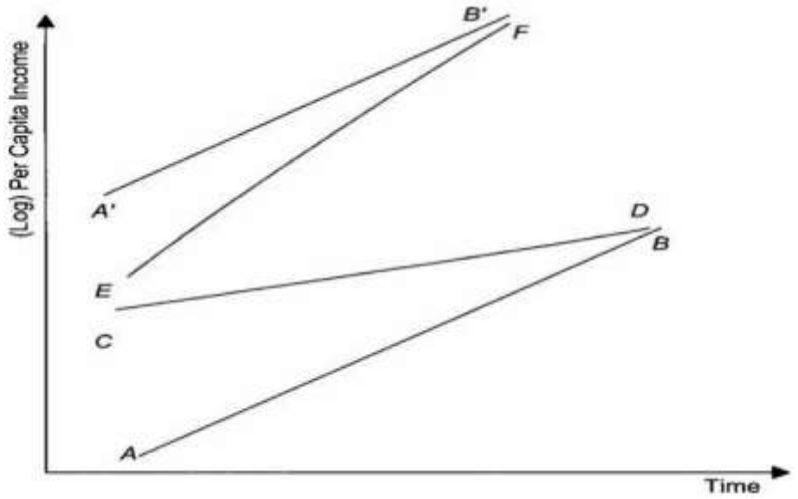
b) Sigma convergence

Economies tend to converge toward their respective steady states. Sigma convergence, in this context, denotes the phenomenon where an economy grows more rapidly the farther it is from its steady-state value. This concept implies the gradual reduction of disparities in real per capita income across a group of economies over time. Sigma convergence suggests that a country or region is moving towards a common potential level of income, as proposed by Barro and Martin in 1992. It examines whether income distribution is expanding or contracting.

Two tests commonly used to assess sigma convergence are the coefficient of variation and the standard deviation. These tests reveal a negative relationship between per capita growth and the logarithm of initial per capita gross domestic product. Cross-country data support the hypothesis of sigma convergence.

In Figure 2, the convergence in growth rates is illustrated. The horizontal line represents the steady-state time path, while the vertical line depicts the logarithm of per capita income for all countries. Different countries exhibit diverse steady-state paths, as indicated by the lines AB and A'B'.

Figure 2: Convergence in Growth rates



Upon examination, it is observed that the country initially begins at the steady state AB, deviating at point C, which lies above the steady state path. According to the Solow model, this scenario suggests that the country experiences a growth rate slower than that of the steady state path, as depicted by curve CD. Furthermore, point E is situated below the steady state path AB, yet exhibits a growth rate surpassing that of the steady state. Subsequently, the trajectory EF tends upwards towards the steady state path.

2.2. Measurement of Convergence

There are two indicators are used to measure convergence beta convergence and sigma convergence. Sigma convergence uses two measures of convergence. First, cross-sectional standard deviation, and second, coefficient of variation. The coefficient of variation formula is:

CV = Standard deviation/ Mean

The standard deviation formula is

$$\sigma = \frac{\sqrt{\sum (x_i - \bar{x})^2}}{n}$$

The measure of beta convergence was introduced by Barro and Martin (1991, 1992). The beta convergence formula is

$$B = \frac{-\ln(1+bT)}{T}$$

According to Barro and Martin (1992) symbol of Y_i shows the average growth rate of per capita output and (0, Ti) shows the period of time given this equation.

$(1/T_i) \log [Y_i T_i / Yi0] = z - (1-e^{-\beta Ti}) (1/T_i) \log (Y_i^*/Y_0)$

The z shows a constant and β shows the parameters of preference and technology and speed of adjustment of y and steady state value of y_0. The β is the higher response to the average growth rate of Y_i and the gap between Y_i and Y_0 is the higher convergence of the steady state.

3. Review of Literature

This section explains the review of the literature. Table 1 shows a glimpse of the studies on convergence hypothesis and economic growth.

Table 1: Summary of Studies on Convergence and Economic Growth

Author(s)	Country	Time period/ Observation	Methodology	Main Results
Dowrick and Nguyen	OECD	1950 to 1985	OLS	Population (+), investment (+)
Nehar and Inder (1998)	OECD	1950 to 1990	OLS	Per capita GDP (+), demand per capita (-)
Gaulier et al (1999)	OECD	1960 to 1990	OLS	Investment rate (+), government expenditure (+), openness rate (-), population growth(-), school enrolment (+),
Lall and Yilmax (2001)	US	1969 to 1995	Regression	Human capital (+), skilled labour (+),
Michelis et al.(2004)	Grace country	1981 to 1991	OLS	Welfare (-), High school education (-)
Kaitila (2005)	EU	1960 to 2002	PMG	Trade openness (+), investment (+), labour force (-), public consumption (-),
Karagiannis (2007)	European Union countries	1990 to 2003	OLS	International communication Technology (+), Information Technology (+)
Rapacki and Prochniak (2009)	27 Socialist or transition countries	1990 to 2005	Regression technique	Sigma convergence (-)
Fung (2009)	Developed countries	1967 to 2001	Fixed effect, GMM	Human capital (+) Physical capital (+) Technology (+) Economic freedom(+)
Chikte (2011)	India	1970 to 2005	OLS	Population growth (-), literacy rate (+), commercial credits (-), convergence of output (-) capital expenditure (+)
Cerevellati and Sunde (2011)	Developing countries	1940 to 1980	OLS	Life expectancy (+), population (-)
Stern et al (2012)	US country	1990 to 2005	ARMA	Industry (-),clusters (+)
Prochniak and Witkoski (2013)	European Union countries	1993 to 2010, 1972 to 2010	GMM	Investment (+). Population (+), credit growth (+), environment (+), inflation (-)
Simionescu (2014)	EU	2000 to 2012	OLS and Weighted method	Population(+), investment (+), employed per person (+),
Unal (2014)	Developing countries	1980 to 2009	OLS	Population (+) Human capital(+) Investment (+)
Mallick (2014)	India	1993 to 1994,2004 to 2005	LD, GMM	Private investment (+), public investment (+),human capital (+), population(-)
Bonnefond (2014)	China	1995 to 2009	GMM	Population (-), Education (+), investment (+), Public expenditure (-)
Chapsa (2015)	EU	1995 to 2013	GMM	Trade openness (+), inflation (-), Corruption (-), Bureaucracy (+),government consumption (+), physical capital (+)
Zahoo et al (2016)	China	1992 to 2012	LMDI	Energy intensity (+), industrial (-), agriculture (+), transport (+), energy emission (-), carbon intensity (-), economic activity (-), economic share (-)
Satti and Malik (2017)	OECD	1960 to 2010	OLS, SVA, linear trend method	Employment (+), Capital (+), Labour (+)

Gomleksiz et al (2017)	Turkey	2004 to 2014	OLS	Investment (+), government expenditure (+), initial level of gross domestic product (-)
Sharma (2018)	Developing countries	1870 to 2013	GMM	Inflation(-), population (+), investment (+), life expectancy (+), human capital (+)
Bhattacharya (2019)	Developed countries	1990 to 2015	PS, ML	Energy productivity (+), industry (+), capital labour ratio (+), renewable energy (+).
Hussain et al (2019)	Developing, emerging and developed countries	1980 to 2018,1980 to 2000, 2001 to 2018	OLS	Information technology (+)
Signorelli (2019)	Italy	1995 to 2016	GMM	Population (+),human capital (+), investment (+).trade openness (+), migration (-)
Bhattacharya (2019)	Developed countries	1990 to 2014	ML, PS	Urbanization (+), industry (+), Renewable energy(+)
Haller et al (2020)	European countries	2012 to 2018	OLS	Tourist (+),restaurant coffee shop(-)
Churchill (2019)	OECD	1921 to 2014	Probit model and unit root test	Population (+), Trade (+), Gross domestic product (+)
Wang (20190	Developed and developing countries	2005 to 2007	ADF test, superlative index approach	Education (+), Capital (-), Labour (-).
Li et al (2019)	China	2005 to 2014	Sigma and beta method, Markov chain method	Foreign direct investment (+), human capital (+), resource endowments (-)
Zhang et al (2019)	China	2003 to 2016	Fixed effect, panel unit root test, entropy weight method	Consumption (+), industry (+), Wastewater(+), Per capita gross domestic product (+), electricity consumption (-)
Sun et al (2020)	Developing countries	1980 to 2016	ML	Population (-), Consumer price index (-) Globalization (-)
Bai et al (2020)	China	1997 to 2015	Probit model, regression T-test	Investment (+), nationalization degree (-) Carbon intensity (-)
Butnaru et al (2020)	OECD	1960 to 2015	Semiparametric and parametric	Renewable energy (-), energy consumption (+)
Dong (2021)	China	2001 to 2014	GML	Population (+), industrial convergence (+), energy price (-), labour density (-)
Ghatak (2021)	SAARC	1970 to 2017	GMM	Gross domestic product (-), labour rate (-), human capital(+), government expenditure (+), trade openness (-), investment (-)
Sheikh et al. (2021)	Organization Islamic countries	1960 to 2018	OLS	Initial GDP (+) ,Secondary School Enrollment (+), Life Expectancy (+), Gross fixed capital formation Growth rate (+), depreciation rate (-)
Li et al (2022)	Asian countries	1990 to 2015	Beta,sigma convergence method, multiple regression technique	Foreign direct investment (+) Trade openness (+)

In this section, we have reviewed empirical studies focusing on the impact of population, investment, and inflation on economic growth. These studies employ various methodologies, including the general method of moments, ordinary least squares technique, semiparametric and parametric approaches, linear trend method, and multiple regression techniques. They encompass analyses of economic trends across organizations for economic cooperation and development, developing countries, and developed countries, utilizing time series data.

The findings of these studies reveal diverse outcomes. Firstly, factors such as investment, population, information technology, physical capital, GDP per capita, consumption, life expectancy, government consumption, secondary school enrollment, and trade openness exhibit a positive correlation with economic growth. Conversely, inflation exerts a negative influence on economic growth. As inflation rises, prices escalate, diminishing the purchasing power of money, consequently leading to reduced consumption and a subsequent decline in GDP.

In contrast to previous methodologies such as ADF, OLS, and ARDL, this study employs the MMQR technique. Furthermore, it introduces variables like gross fixed capital formation, secondary school enrollment, initial GDP per capita level, effective rate of depreciation, and GDP growth, which were not previously considered in these studies.

4. Model Specification, Data and Methodology

To examine the convergence hypothesis, we have used annual average gross domestic product growth, initial logarithm gross domestic product per capita, gross fixed capital formation growth, secondary school enrollment, life expectancy, and effective rate of deprecation in the following model.

AAGDPG = *f* (ILGDPPC, GFCFG, SSE, ER, ERD) (1)

The econometric model is:

$$AAGDPG_{it} = \delta_{\circ} + \delta_1 ILGDPPC_{it} + \delta_2 GFCFG_{it} + \delta_3 SSE_{it} + \delta_4 ER_{it} + \delta_5 ERD_{it} + \varepsilon_{it} \quad (2)$$

Table 2 shows the description, measurement unit, and data sources of variables.

Table 2: Variables Description, Measurement Unit, and Data Sources

Variables	Description	Measurements units	Data Sources
AAGDPG	Annual average gross domestic product growth	Current US	World Bank national accounts data, and OECD National Accounts data files.
ILGDPG	Initial logarithm gross domestic product growth	Percentage of GDP	World Bank national accounts data, and OECD National Accounts data files.
GFCFG	Gross fixed capital formation	Percentage of GDP	World Bank national accounts data, and OECD National Accounts data
SSE	Secondary school enrollment	Percentage of GDP	UNESCO Institute for Statistics (UIS). https://apiportal.uis.unesco.org/bdds.
LE	Life expectancy	Total year	(1) United Nations Population Division. World Population Prospects: 2022 Revision. (2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) United Nations Statistical Division.
ERD	The effective rate of deprecation	Annual percentage	(1) United Nations Population Division. World Population Prospects: 2022 Revision. (2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) United Nations Statistical Division.

The method of moments Quantile regression investigates the distributional and heterogeneous effect quantiles (Sarkodie and Strezov, 2019). The method of moments Quantile regression technique is used with fixed effect (Machado and Silva, 2019). The conditional Quantile shows the Q_x (t/Y) and the model of location-scale is given by:

$$X_{lt} = a_l + Y_{lt} b + (c_l + R_{lt}' d) u_{lt} \quad (3)$$

P represents the probability, thus facilitating the estimation of these parameters. 'L' signifies the individual fixed, while 'R' denotes the S-vector which examines the components of Y. The differentiation of these elements is expressed by 'L'.

$$R_l = R(Y), l = 1, ...S \quad (4)$$

Xlt demonstrates the independent and identical distribution for any fixed and independent time (t). "ult" signifies the independent variable among individuals and time (t). Equation (4) is expressed as:

$$Q_x(t / Y_{lt}) = (a_l + c_l q(t)) + Y_{\partial lt}' b + R_{lt}' dq(t) \quad (5)$$

From Equation (3), Y_{lt} represents the vector of control variables, including the natural logarithm of gross domestic product per capita (LGDP), the natural logarithm of squared gross domestic product per capita ($LGDP^2$), democracy (DEMOC), the natural logarithm of electricity production per capita (LELEPD), the logarithm of oil production per capita (LOILPD), the logarithm of trade per capita (LTRD) and $Q_x(l / Y_{lt})$. The equation also explores the quantile distribution of the dependent variable X_{lt} (natural logarithm of CO2 per capita) and the control variables. The scaled coefficient of the quantile t fixed effect l is employed for individual analysis.

The general equation is given as;

$$Q_{AAGDPG_{it}}(\tau \mid \gamma_i, \delta_t, X_{it}) = \gamma_i + \delta_t + \beta_{1,\tau} ILGDPPC_{it} + \beta_{2,\tau} GFCFG_{it} + \beta_{3,\tau} SSE_{it} + \beta_{4,\tau} LE_{it} + \beta_{5,\tau} ERD_{it} + \varepsilon_{\tau} \quad (6)$$

Where τ shows the quantiles 10^{th}, 25^{th}, 50^{th}, 90^{th}, i = l,……..N is for cross sections, and t shows a time period starting from t= 1, ……T.

5. Results and Discussions

5.1. Descriptive Statistics and Correlation Analysis

In this section, we explain the results of descriptive statistics and correlation analysis shown in Tables 3 and 4 during the period 1990 to 1999, AAGDPG has a mean of -0.06, median is 0.04, maxima is 0.52, minimum is -0.90, standard deviation is 0.29, skewness is 0.79 is negatively skewed and kurtosis 2.96 which is platykurtic distribution because the value of this variable is less than 3 and Jarque bera shows AAGDPG is not normally distributed. ILGDPPC has a mean of 2.85, a median 2.78, maxima of 3.65. minima 1.78, standard deviation 0.37, skewness -0.70 which is negatively skewed, and kurtosis 2.81 which is platykurtic because the value of ILGDPPC is less than 3 and JB shows ILGDPPC is normally distributed. GFCFG has a mean of 25.09, median of 23.05, maxima of 3.65, minima of 11.21, and the standard deviation is 13.70, skewness of 4.46 which is positively skewed, kurtosis of 31.88 which is leptokurtic because the value of GFCFG is greater than 3 and Jarque bera shows GFCFG is not normally distributed SEE has a mean 76.75, median is 81.90,maximia 102.63, minima is 25.27,standard deviation 18.91, skewness -0.90 which is positively skewed, kurtosis 3.10 which is leptokurtic because the value of SSE is greater than 3and Jarque bera shows SEE is not normally distributed.

LE has a mean of 64.49, median of 64.65, maxima of 71.04, minima of 52.87, standard deviation is 3.57, skewness of -0.51 which is negatively skewed, kurtosis 3.42 which is leptokurtic because the value of LE is greater than 3and Jarque bera shows LE is normally distributed.

Table 3: Descriptive Statistics of Key Variables

Periods	Variables	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis	J.B	Prob.	Obs.
1990-1999	AAGDPG	-0.06	0.04	0.52	-0.91	0.29	-0.79	2.96	8.49	0.01	81
	ILGDPPC	2.85	2.78	3.65	1.78	0.37	-0.01	2.81	0.12	0.94	81
	GFCFG	25.09	23.05	121.92	11.21	13.70	4.46	31.88	3083.76	0.00	81
	SSE	76.75	81.90	102.63	25.27	18.91	-0.90	3.10	11.06	0.00	81
	LE	64.49	64.65	71.04	52.87	3.57	-0.51	3.42	4.09	0.13	81
	ERD	1.49	1.61	3.91	-2.01	1.16	-1.04	4.44	21.70	0.00	81
2000-2009	AAGDPG	0.22	0.22	1.08	-0.18	0.17	1.92	10.87	287.67	0.00	90
	ILGDPPC	3.05	2.95	4.03	2.14	0.47	0.27	2.15	3.82	0.15	90
	GFCFG	23.77	23.10	57.71	6.30	8.73	1.02	5.69	42.69	0.00	90
	SSE	77.83	84.77	101.61	22.51	19.00	-1.43	4.25	36.41	0.00	90
	LE	67.71	67.40	74.77	62.10	3.06	0.48	2.68	3.83	0.15	90
	ERD	1.46	1.41	3.14	-0.25	0.57	0.03	4.44	7.84	0.02	90
2010-2021	AAGDPG	0.14	0.15	0.46	-0.26	0.12	-0.60	4.12	12.17	0.00	108
	ILGDPPC	3.52	3.62	4.14	2.82	0.41	-0.15	1.47	10.87	0.00	108
	GFCFG	30.68	26.05	109.98	12.52	18.80	2.58	9.58	314.65	0.00	108
	SSE	83.82	91.93	114.24	22.63	23.68	-1.35	3.49	33.97	0.00	108
	LE	70.85	70.38	77.83	64.44	3.22	0.26	2.46	2.58	0.28	108
	ERD	1.65	1.63	2.87	0.49	0.45	-0.01	2.87	0.07	0.96	108
1990-2021	AAGDPG	0.11	0.15	1.08	-0.91	0.23	-1.07	7.38	275.84	0.00	279
	ILGDPPC	3.17	3.11	4.14	1.78	0.50	0.11	2.14	9.10	0.01	279
	GFCFG	26.83	24.20	121.92	6.30	14.97	3.33	17.51	2961.14	0.00	279
	SSE	79.84	87.01	114.24	22.51	21.08	-1.15	3.42	63.91	0.00	279
	LE	67.99	68.15	77.83	52.87	4.18	-0.13	3.29	1.72	0.42	279
	ERD	1.54	1.53	3.91	-2.01	0.76	-1.21	7.79	334.05	0.00	279

The mean value of ERD is 1.49, median 1.61, maxima 3.91, minima – 2.01 and standard deviation 1.16, skewness -1,04 which is negatively skewed, kurtosis 4.44 which is leptokurtic because the value of ERD is greater than 3 and Jarque bera shows ERD is not normally distributed. During the period analyzed period 2000 to 2009, AAGDPG had a mean of 0.22, median of 0.22, maxima of 1.08, minima of -0.18, standard deviation of 1.16, skewness of 1.92 which is positively skewed, kurtosis 10.87 which is leptokurtic because the value of greater than 3 and Jarque bera shows the AAGDPG is not normally distributed.

ILGDPPC has a mean value of 3.05, median of 2.95, maxima, of 4.03, minima of 2.14, standard deviation of 0.47, skewness of 0.27 which is positively skewed, kurtosis of 2.15 which is platykurtic and Jarque bera shows the ILGDPPC is normally distributed. GFCFG has a mean value of 23.77, median of 23.10, maxima 57.71, and minima 6.30. standard deviation 8.73, skewness 1.02 which is positively skewed, kurtosis 5.69 which is leptokurtic and Jarque bera shows the GFCFG is not normally distributed.

SEE has a mean of 77.83, median of 84.77, maxima of 101.61, minima of 22.51, a standard deviation of 19.00, skewness of -1.43 which is negatively skewed, kurtosis 4.25 with leptokurtic and Jarque bera shows the SSE is not normally distributed. LE has a mean value of 67.71, median of 76.40, maxima of 74.77, minima of 62.10, standard deviation of 3.06, skewness of 0.48 which is positively skewed, kurtosis 2.68 which is platykurtic and Jarque bera shows the LE is normally distributed. ERD has a mean of 1.64, median of 1.41, maxima of 3.14, minima -0.25, standard deviation of 0.57, skewness of 0.03 which is positively skewed, kurtosis 4.44 which is leptokurtic and Jarque bera shows the ERD is not normally distributed. During the analyzed period 2010 to 2021, AAGDPG has a mean of 0.14, median of 0.15, maxima of 0.46, minima of -0.26, standard deviation of 0.12, skewness -0.60 which is negatively skewed, kurtosis 4.12 which is leptokurtic and Jarque bera shows the AAGDPG is not normally distributed. ILGDPPC has a mean of 3.52, median of 3.62, maxima of 4.14, minima of 2.82, a standard deviation of 0.41, skewness -0.15 which is negatively skewed, kurtosis of 1.47 which is platykurtic and Jarque bera has not normally distributed. GFCFG has a mean of 30.68, median of 26.05, maxima of 109.98, minima of 12.52, standard deviation of 18.80, skewness of 2.58 which is positively skewed, kurtosis 9.58 which is leptokurtic and Jarque bera shows the GFCFG is not normally distributed. SSE has a mean of 83.82, median of 91.93, maxima of 114.24, minima of 22.63, standard deviation of 23.68, skewness -1.35 which is negatively skewed, kurtosis 3.49 which is leptokurtic and Jarque bera shows the SSE is not normally distributed. LE has a mean of 70.85, median of 70.38, maxima of 77.83, minima of 64.44, standard deviation of 3.22, skewness of 0.26 which is positively skewed, kurtosis 2.46 which is platykurtic and Jarque bera shows the SSE is normally distributed. ERD has a mean of 1.65, median of 1.63, maxima of 2.87, minima of 0.49, standard deviation of -0.01 which is negatively skewed, kurtosis 2.87 which is platykurtic and Jarque bera shows the ERD is normally distributed. During the period analysis from 1990 to 2021, AAGDPG has a mean of 0.11, median of 0.15, maxima of 1.08, minima of -0.91, standard deviation of 0.23, skewness -1.07 which is negatively skewed, kurtosis of 7.38 which is leptokurtosis and Jarque bera shows the AAGDPG is not normally distributed. ILGDPPC has a mean of 3.17, median of 3.11, maxima of 4.14, minima of 1.78, standard deviation of 0.50, skewness of 0.11 which is positively distributed, kurtosis 2.14 which is platy kurtosis and Jarque bera is not normally distributed. GFCFG has a mean of 26.83, median of 24.20, maxima of 121.92, minima of 6.30, standard deviation of 14.97, skewness of 3.33 which is positively skewed, kurtosis 17.51 which is leptokurtic and Jarque bera shows the GFCFG is not normally distributed. SSE has a mean of 79.84, median of 87.01, maxima of 114.24, minima of 22.51, standard deviation of 21.08, skewness -1.15 which is negatively skewed, kurtosis 3.42 which is leptokurtic and Jarque shows the SSE is not normally distributed. LE has a mean of 67.98, median of 68.15, maxima of 77.83, minima, of 52.87, standard deviation of 4.18, skewness of -0.13 which has negatively skewed, kurtosis 3.29 which is leptokurtic and Jarque bera shows the LE is normally distributed. ERD has a mean of 1.54, median of 1.53, maxima of 3.91, minima -2.01, standard deviation of 0.76, skewness -1.21 which is negatively skewed, kurtosis 7.79 which is leptokurtic and Jarque bera shows the ERD is not normally distributed.

Table 4: Correlation Matrix of Key Variables (1990-2021)

Correlation	AAGDPG	ILGDPPC	GFCFG	SSE	LE	ERD
AAGDPG	1					
ILGDPPC	0.19	1				
GFCFG	0.13	0.30	1			
SSE	-0.13	0.20	0.25	1		
LE	0.27	0.75	0.16	0.32	1	
ERD	0.09	-0.12	0.06	-0.26	-0.10	1

Table 4 presents the correlation matrix results of the key variables. AAGDPG exhibits a positive relationship with all variables except SSE. However, the relationship between AAGDPG and all variables is weak. ILGDPPC also shows a positive relationship with all variables except ERD. Its relationship with GFCF is moderate, while it exhibits a strong relationship with LE and a weak correlation with SSE. GFCF demonstrates a positive relationship with all remaining variables, including SSE, LE, and ERD but its relationship with all variables is weak. There is a positive relationship between SSE and LE except for ERD. SSE has a moderating effect on the correlation with LE, while its correlation with ERD is weak. LE is negatively and weakly correlated with ERD.

5.2. Cross-Sectional Dependence and Slope Homogeneity Tests

In this section, we explain cross-sectional dependence and slope homogeneity tests shown in Table 5 and Table 6. Table 5 depicts the results of the Pesaran sectional dependence test.

Table 5: Pesaran's Cross-Sectional Dependence (CD) Test

Variable	1st decade		2nd decade		3rd decade		All	
	CD-test	P-Value	CD-test	P-Value	CD-test	P-Value	CD-test	P-Value
AAGDPG	5.2620	0.0000	2.5110	0.0120	7.5490	0.0000	11.4000	0.0000
ILGDPPC	2.3340	0.0200	17.1380	0.0000	7.7110	0.0000	29.5810	0.0000
GFCFG	-1.0630	0.2880	1.6030	0.1090	0.5890	0.5560	-1.1840	0.2360
SSE	-1.9490	0.0510	0.3970	0.6910	12.4840	0.0000	5.8040	0.0000
LE	6.2410	0.0000	13.5890	0.0000	15.7360	0.0000	30.4580	0.0000
ERD	8.2460	0.0000	1.0740	0.2830	3.8270	0.0000	4.6050	0.0000

In the first decade, all variables exhibit cross-sectional dependence, except for gross fixed capital formation. Similarly, in the second decade, average annual gross domestic product growth, the initial logarithm of gross domestic product per capita, and

life expectancy demonstrate cross-sectional dependence, except gross fixed capital formation and the effective rate of depreciation, alongside secondary school enrollment. Moving to the third decade, all variables display cross-sectional dependence, barring gross fixed capital formation.

Table 6: Slope Homogeneity Test

Countries	Delta Test	P-Value	HAC Robust Adjusted Delta Test	P-Value
Basic Beta Convergence Base Model				
1st decade	2.3200	0.0200	1.1340	0.2570
2nd decade	1.6280	0.1040	-0.2690	0.7880
3rd decade	0.6620	0.5080	-0.7770	0.4370
All	0.7950	0.4260	-0.0860	0.9320
Solow-Swan Model Based Beta Convergence				
1st decade	0.8860	0.3760	-2.1540	0.0310
2nd decade	1.7050	0.0880	-4.0810	0.0000
3rd decade	0.5180	0.6040	-1.2240	0.2210
All	7.5880	0.0000	-1.7690	0.0770

We have also elucidated the outcomes of the slope homogeneity test presented in Table 6, focusing on both the basic beta convergence base model and the Solow–Swan model-based beta convergence. We also explain the slope homogeneity test based on the Delta test and the HAC Robust Adjusted Delta test.

In terms of decades, all the values of the Delta test and HAC Robust Adjusted Delta test demonstrate slope homogeneity, except for the first decade. When considering the Solow-Swan model-based beta convergence, the delta test reveals results. In the first and third decades, the values exhibit slope homogeneity, except for the second decade. The HAC Robust test indicates that in the first and second decades, all the values display slope heterogeneity, except for the third decade.

5.3. Unit Root Tests

We have applied a second-generation panel unit root test in Table 7, specifically utilizing the unit root test based on the CD-based Im-Pesaran-Shin method.

Table 7: Unit Root Tests

Variables	Second Generation Panel Unit Root Test Cross-Section-Dependence based Im-Pesaran-Shin (CSDIPS) Unit Root Test Without Trend			With Trend		
	Lags	Zt Statistics	P-Value	Lags	Zt Statistics	P-Value
AAGDPG	0	-5.6240	0.0000	0	-7.5080	0.0000
ILGDPPC	1	-3.3080	0.0000	1	-2.4030	0.0080
GFCFG	0	-2.6980	0.0030	0	-1.4270	0.0770
SSE	1	-0.2870	0.3870	0	-1.3350	0.0910
LE	0	-4.0130	0.0000	0	-1.6070	0.0540
ERD	1	-3.8070	0.0000	0	-5.4030	0.0000

In the case of without trend, all the variables are stationary except the secondary school enrollment. In the case of with trend, all the variables are stationary.

5.4. Panel Cointegration Analysis

In this section, we present the results of panel cointegration analysis and apply three tests to ascertain cointegration: the Kao test, which is based on the Dickey-Fuller test, the Augmented Dickey-Fuller test, and the Philips Perron test; the Pedroni test, which relies on the Augmented Dickey-Fuller test and the Modified Philips–Perron test; and the Westerlund test, incorporating two tests for group dimension and two for panel dimension.

The basic beta convergence model yields results under the Kao test. In the first decade, there is evidence of a long-run relationship (cointegration). In the second decade, the Dickey-Fuller test and Modified Dickey-Fuller test confirm the presence of a long-run relationship except for the Augmented Dickey-Fuller test. However, in the third decade, the Dickey-Fuller test and the Modified Dickey-Fuller test show no evidence of a long-run relationship except for the Augmented Dickey-Fuller test.

The basic convergence-based model's results under the Pedroni test reveal that during the first three decades, there is no evidence of a long-run relationship, except for the Modified Philips Perron test. Similarly, in the case of the Westerlund test, the first two decades show evidence of a long-run relationship, but the third decade does not.

Furthermore, we explain the results of the Solow–Swan-based beta convergence under the Kao test. In the first three decades, all values indicate no existence of a long-run relationship, but in the second decade, the Modified Dickey-Fuller test indicates the presence of such a relationship. Under the Pedroni test, all values suggest no existence of a long-run relationship. Similarly,

under the Westerlund test, all values indicate no existence of a long-run relationship, except for the first decade in the panel dimension, which demonstrates evidence of its presence.

Table 8: Cointegration Test Results

Countries	Cointegration Tests									
	Kao Test			Pedroni Test			Westerlund Test			
	Dickey-Fuller test	Augmented Dickey-Fuller test	Modified Dickey-Fuller test	Phillips-Perron test	Augmented Dickey-Fuller test	Modified Phillips-Perron test	Gt	Ga	Pt	Pa
	Basic Beta Convergence Base Model									
1st decade	-0.1719	0.9710	0.5054	-2.2345	-4.0827	1.0970	-0.2500	1.2030	-0.1810	0.3510
	0.4317	0.1658	0.3066	0.0127	0.0000	0.1363	0.4010	0.8860	0.4280	0.6370
2nd decade	-1.2364	-3.5199	-0.4860	-1.5529	-4.4970	1.0089	-0.7330	2.0210	-0.6240	0.2740
	0.1081	0.0002	0.3135	0.0602	0.0000	0.1565	0.2320	0.9780	0.2660	0.6080
3rd decade	-5.2019	-1.1473	-2.4439	-6.3259	-5.9050	-0.9638	-2.0760	-1.8450	-2.5300	-4.8160
	0.0000	0.1256	0.0073	0.0000	0.0000	0.1676	0.0190	0.0330	0.0060	0.0000
All	-5.2066	-3.3165	-3.8858	-5.1637	-7.7378	-3.1936	-4.5060	-6.1950	-4.1710	-7.4610
	0.0000	0.0005	0.0001	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000	0.0000
	Solow - Swan Model Based Beta Convergence									
1st decade	-2.9077	-1.4532	-1.2841	-5.8750	-4.9372	3.7999	1.2100	2.2300	3.1800	1.3500
	0.0018	0.0731	0.0996	0.0000	0.0000	0.0001	0.0010	0.0860	0.1200	0.0010
2nd decade	-1.3863	-3.5413	-1.1129	-4.5109	-6.8894	3.7363	2.4000	3.0860	2.1280	2.6300
	0.0828	0.0002	0.1329	0.0000	0.0000	0.0001	0.0730	0.0021	0.0640	0.0040
3rd decade	-8.3497	-4.4540	-7.4696	-8.9652	-7.1577	1.9658	2.1250	3.4010	1.7330	3.8320
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0247	0.0760	0.0190	0.0506	0.0000
All	-5.7691	-3.9696	-7.0178	-6.9568	-6.6491	-1.5307	-2.6010	-0.5550	-2.9030	-1.3080
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0629	0.0050	0.2900	0.0020	0.0950

5.5. MMQR Results for Convergence

This section measures of absolute convergence hypothesis and relative convergence hypothesis under the Method of Moments Quantile Regression.

5.5.1. MMQR Results for AbsoluteConvergence Hypothesis (β -Convergence)

This section demonstrates the results of absolute convergence shown in Table 9. The dependent variable is average annual gross domestic product growth and the independent variable is initial logarithm gross domestic product per capita, gross fixed capital formation growth rate, secondary school enrollment, life expectancy, and effective rate of depreciation. The absolute convergence hypothesis shows the location and scale under the basic model of absolute convergence. Location means a measure of central tendency as mean and scales show the measure of dispersion as standard deviation.

In the case of the first decade under the basic beta convergence during 1990 to 1999 convergence exists because the coefficient of initial gross domestic product is negative for all quantiles except the 25^{th} quantile and ILGDPPC is significant in all the quantiles except the 75^{th} quantiles and 90^{th} quantiles. These two quantiles 75^{th} and 90^{th} are insignificant. The reason behind this phenomenon is that the larger initial logarithm of GDP per capita indicates a nation's economy is more developed and prosperous. However, maintaining high rates of GDP growth becomes more difficult as a country approaches higher levels of GDP per capita. This condition is referred to as the "middle-income trap. It is more difficult to sustain rapid economic growth in countries with greater baseline GDP per capita due to structural constraints including diminishing returns to capital and technical advancements. Developed economies may also have slower growth as a result of things like demographic shifts, resource constraints, and market saturation. As a result, the starting logarithm of GDP per capita may serve as a constraint, eventually resulting in a slower average yearly GDP growth rate. Our results collaborate with (Ghatak, 2021) and (Gomeleksiz et al, 2017). Under the modified Solow- swan model-based absolute convergence the variable of GFCFG shows the divergence exists because the coefficient of GFCFG is positive for all quantiles and GFCF is significant in all quantiles so the positive relationship between GFCF and AAGDPG means GFCF increase then also AAGDPG is increase. GFCF is an important part of the AAGDPG because the entire amount that firms and governments within a nation invest in fixed assets including machinery, equipment, and infrastructure is known as gross fixed capital formation (GFCF). The average annual growth of the gross domestic product (GDP) is significantly influenced favorably by the GFCF's expansion. An increase in GFCF indicates an increase in the economy's capacity for production and increased efficiency. As a result, more jobs are created, productivity improves, and production levels rise. Investment in capital goods supports innovation and technological developments, enhances overall productivity, and stimulates economic activity. Since the economy enjoys an increase in output, income, and consumption as a result of the higher GFCF, economic prosperity is eventually driven. Many economists also support the results of Sharma (2010) and Gibescu (2010).

Similarly, SSE has also shown that divergence exists because the coefficient of SSE is positive for all quantiles and SSE is significant in all Quantiles. Average yearly gross domestic product (GDP) growth is significantly influenced by secondary school enrollment because a better-educated workforce boosts productivity and innovation when a bigger fraction of the population has access to secondary education. Secondary education promotes economic development and raises a nation's overall output by providing people with the knowledge and abilities needed to engage in a contemporary economy. In addition, a workforce with a greater degree of competence and adaptability attracts international investment and fosters technological innovation. Improved secondary school enrolment raises human capital, which leads to greater employment prospects, higher labor productivity, and more effective resource allocation within the economy. In the end, these variables work together favorably to impact average yearly GDP growth, resulting in a positive feedback loop of economic prosperity and social advancement. Our results collaborate with Curaresma et al (2013) and (Micer, 1995)

The LE shows a positive impact for all quantiles which means divergence exists for all quantiles and LE is significant in all quantiles. GDP growth is promoted by life expectancy in many different ways. Firstly, those who live longer also have a longer period in which to contribute economically. This creates a bigger pool of labour resulting in possible higher productivity and greater economic output. Besides, longer life expectancy is often associated with better health, which in turn contributes to a more efficient workforce. In addition to contributing to the economy with their abilities and knowledge, healthy people appear to be less likely to miss work because of sickness. Along with having time to make money and prepare for old age, a longer life expectancy can also lead to higher levels of savings and investments. Through the creation of more jobs and funds, this can facilitate economic growth. In most cases, a longer life expectancy has a positive effect on the average annual GDP growth by employing a more numerous and also healthier labor force, encouraging savings and investments, and keeping economic stability and productivity. Our finding correlates with those of (Sharma, 2018).

Table 9: MMQR Results for Absolute Convergence using 1990 as initial value (1990 - 99)

DV: Average Annual GDP Growth (AAGDPG)							
Basic Model of Absolute Convergence							
Variables	Location	Scale	Q 0.10	Q 0.25	Q 0.50	Q 0.75	Q 0.90
ILGDPPC	0.216**	-0.174***	-0.539***	0.389***	-0.173*	-0.0589	-0.00802
	0.0955	0.0597	0.176	0.144	0.0939	0.0791	0.0982
C	0.677**	0.730***	2.032***	1.402***	0.499*	0.0217	0.258
	0.289	0.181	0.526	0.449	0.296	0.237	0.327
Modified Solow-Swan Model Based Absolute Convergence							
ILGDPPC	0.0693**	-0.0209	0.106**	-0.080**	-0.0700**	-0.0522*	0.0393
	0.0297	0.0202	0.0517	0.0342	0.0298	0.0307	0.0375
GFCFG	0.09***	0.002***	0.013***	0.01***	0.009***	0.07***	0.006***
	0.00173	0.001	0.00259	0.00204	0.00179	0.00185	0.00227
SSE	0.032***	-0.002	0.035*	0.035**	0.032***	0.031**	0.030**
	0.0123	0.00713	0.018	0.0142	0.0125	0.0133	0.0147
LE	0.153*	0.115**	0.339***	0.245**	0.155*	0.0433	0.00077
	0.0808	0.0464	0.131	0.0993	0.0837	0.0821	0.0888
ERD	1.197**	0.289	1.675**	1.430**	1.229**	0.935	0.81
	0.572	0.33	0.837	0.659	0.578	0.614	0.689
Constant	0.341**	0.004**	0.446***	0.005*	0.361***	0.0492	0.403***
	0.146	0.00188	0.0893	0.00287	0.137	0.0552	0.105

The variable ERD is significant and positive in all quantiles which reveals a diversification in all quantiles. On average the annual GDP growth and the effective rate of depreciation can be a positive factor. Depreciation is the word that refers to the process by which the value of capital goods goes down due to either damage or being outdated. High effective rates of depreciation suggest that capital stock is being replaced or upgraded more quickly. As newer and more sophisticated capital goods are used, this may result in a rise in the economy's productivity and efficiency. Businesses can create goods and services more effectively as a result, increasing output and possibly driving up GDP growth. A greater rate of depreciation may also encourage the deployment of new funds as companies look to replace outmoded machinery. By boosting demand and generating new job possibilities, this additional investment can promote economic growth. To increase productivity, investment, and economic growth, a greater effective rate of depreciation can be beneficial. Our results are consistent with (Ghatak, 2021).

The economic interpretation is given above now we are comparing the magnitude of the estimation of two tables in 9 and 10. During the period of 2000 to 2009 ILGDPPC shows a negative relationship which means convergence exists in Q 0.10 and ILGDPC is significant in Q 0.10. During the period 2010 to 2021, ILGDPPC shows a negative relationship which means convergence exists in Q 0.10 and ILGDPPC is significant in Q 0.10. The magnitude of the estimation of ILGDPPC is greater from 2000 to 2009. During the period of 2000 to 2009 ILGDPPC is a negative relationship which means convergence exists in

Q 0.25 and ILGDPPC is insignificant and during the period 2010 to 2021, ILGDPPC shows a positive sign which means divergence exists in Q 0.25 and ILGDPPC is significant in Q 0.25. The magnitude of the estimation of the variable ILGDPPC is greater in the period of 201 2021.

Table 10: MMQR Results for Absolute Convergence using 2000 as initial value (2000 - 09)

DV: Average Annual GDP Growth (AAGDPG)							
Basic Model of Absolute Convergence							
Variables	Location	Scale	Q 0.10	Q 0.25	Q 0.50	Q 0.75	Q 0.90
ILGDPPC	0.0224	0.0529*	-0.089**	-0.0274	-0.077**	0.0119	-0.0344
	-0.0418	0.0318	0.0448	0.0404	0.0386	0.0533	0.0776
C	0.293**	-0.0486	0.355***	0.343***	0.297**	0.261	0.24
	0.122	0.0924	0.122	0.112	0.117	0.159	0.197
Modified Solow-Swan Model Based Absolute Convergence							
ILGDPPC	0.450***	0.490***	0.506***	-0.0473*	-0.105**	-0.092**	0.004**
	0.0892	0.0989	0.108	0.0281	0.0521	0.0464	0.00188
GFCFG	0.120***	0.0331	0.0738**	0.004*	0.117***	0.144***	0.187***
	0.0322	0.022	0.0347	0.00207	0.0315	0.0426	0.0652
SSE	1.191***	0.0454	1.254***	1.231***	1.195***	1.158**	1.099
	0.438	0.3	0.464	0.408	0.429	0.565	0.882
LE	0.380***	0.0798	0.282*	0.303**	0.386***	0.440***	0.507**
	0.136	0.0857	0.154	0.142	0.138	0.163	0.215
ERD	0.297**	-0.0439	0.360***	0.342***	0.298**	0.269*	0.238
	0.118	0.0882	0.125	0.109	0.117	0.154	0.21
Constant	0.004**	0.120**	-0.054	0.046	0.101**	0.0553	0.024
	0.00221	0.0516	0.0475	0.0355	0.0439	0.0472	0.0619

In the period of 2000 to 202I LGDPPC shows a negative relationship which means convergence exists in Q 0.50 and ILGDPPC is significant in Q 0.50 and from 2010 to 2021 ILGDPPC shows a negative relationship which means convergence exists in Q 0.50 and ILGDPPC is significant in Q 0.50. The magnitude of the estimation of the variable ILGDPPC is greater from 2000 to 2009. From 2000 to 2009 ILGDPPC shows a positive relationship which means divergence exists in Q 0.75 and the ILGDPPC is insignificant in Q 0.75. From 2010 to 2021 ILGDPPC shows a positive relationship which means divergence exists in Q 0.75 and ILGDPPC is significant in Q 0.75. The magnitude of the estimation of ILGDPPC is greater from 2000 to 2009. During the period of 2000 to 2009 ILGDPPC shows a negative relationship which means convergence exists in $Q_{0.90}$ and ILGDPPC is significant in Q 0.75. From 2010 to 2021 ILGDPPC shows a negative relationship which means convergence exists in $Q_{0.90}$ and ILGDPPC is significant in Q 0.90. The magnitude of the estimation variable ILGDPPC is greater from 2000 to 2000.

Now we explain the results under the Solow swam model based on absolute convergence. From 2000 to 2009, ILGDPPC showed positive signs which means divergence exists in Q 0.10 and ILGDPC is significant in Q 0.10. From 2010 to 2021, ILGDPPC shows a negative sign which means convergence exists in Q 0.10 and ILGDPPC is insignificant in Q 0.10 so the magnitude of the estimation of ILGDPPC is greater from 2000 to 2009. During the period of ILGDPPC shows a negative relationship which means convergence exists in Q 0.25 and ILGDPPC is significant in Q 0.25. In the period 2010 to 2021, ILGDPPC shows a negative relationship which means convergence exists in Q 0.25 and ILGDPPC is significant in Q 0.25. The magnitude of the estimation of the variable ILGDPPC is greater from 2010 to 2021.

During the period of 2000 to 2009, ILGDPPC shows a negative relationship which means convergence exists in Q 0.50 and ILGDPPC is significant in Q 0.50. In this period, ILGDPPC shows is negative relationship which means convergence exists in Q 0.50 and ILGDPPC is significant in Q 0.50. The magnitude of the estimation of ILGDPPC is greater from 2010 to 2021. During the period of 2000 to 2009 ILGDPPC shows a negative relationship which means convergence exists in Q 0.75 and ILGDPPC is significant in Q 0.75. In period of ILGDPPC shows a positive relationship which means convergence exists in Q 0.75 and ILGDPPC is significant in Q 0.75 so the magnitude of the estimation of ILGDPPC is greater from 2010 to 2021.

During the period of 2000 to 2009, ILGDPPC shows divergence exists because the positive relationship in Q 0.90 and ILGDPPC is significant in Q 0.90. From 2010 to 2021 ILGDPPC shows convergence exists because the negative relationship in Q 0.90 and ILGDPPC is significant is Q 0.90. The magnitude of the estimation of ILGDPPC is greater in the period 2010 to 2021. During the period 2000 to 2009, GFCF shows that divergence exists because the positive relationship in Q 0.10 and GFCF is significant in Q 0.10, and period of 2010 to 2021 GFCF shows a positive relationship which means divergence exists and GFCF is insignificant in Q 0.10. The magnitude of the estimated GFCF is greater from 2010 to 2021. From 2000 to 2009 and 2010 to 2021 GFCF shows a positive relationship remaining all Quantiles 0.25. Q o.50, Q 0.75, Q0.90, and GFCF are significant in all remaining in all Quantiles. The magnitude of the estimation of GFCF is greater from 2010 to 2021. From 2000 to 2009 SEE

shows a positive relationship which means divergence exists in all quantiles and SSE is significant in all Quantiles. The magnitude of the estimation SSE is greater from 2000 to 2009.

Table 11: MMQR Results for Absolute Convergence using 2010 as initial value (2010 - 21)

DV: Average Annual GDP Growth (AAGDPG)							
Basic Model of Absolute Convergence							
Variables	Location	Scale	Q 0.10	Q 0.25	Q 0.50	Q 0.75	Q 0.90
ILGDPPC	0.217**	0.00236	-0.212	0.216*	-0.218**	0.219**	-0.220**
	0.0921	0.0633	0.184	0.113	0.0886	0.0866	0.0982
C	0.0206	0.0237	0.0683	0.0349	0.0166	0.00116	0.011
	0.0267	0.0183	0.0535	0.0332	0.0257	0.0251	0.029
Modified Solow-Swan Model Based Absolute Convergence							
ILGDPPC	0.0693**	-0.0209	-0.106**	-0.080**	-0.070**	0.0522*	-0.0393
	0.0297	0.0202	0.0517	0.0342	0.0298	0.0307	0.0375
GFCFG	0.20**	0.00194	0.196	0.198*	0.200**	0.201**	0.203**
	0.0904	0.0612	0.173	0.111	0.0891	0.0878	0.103
SSE	0.0499*	0.0198	0.0886*	0.0631*	0.0487*	0.0892*	0.0565*
	0.0266	0.018	0.0512	0.0329	0.0263	0.0524	0.0337
LE	0.228**	0.00371	0.235	0.230**	0.227***	0.224***	0.223**
	0.0888	0.0614	0.172	0.111	0.0857	0.0831	0.0955
ERD	0.094***	0.0856***	-0.0632	0.0362	0.102***	0.175***	0.214***
	0.0201	0.0137	0.0467	0.0294	0.0214	0.0202	0.0293
Constant	1.155***	0.803***	2.640***	1.709***	0.956***	0.528*	0.112
	0.323	0.241	0.681	0.43	0.297	0.288	0.333

From 2000 to 2009 and 2010 to 2021, LE shows the divergence exists because the positive relationship in all Quantiles and LE is significant in all quantiles. The magnitude of the estimation LE is greater from 2000 to 2009. From 2000 to 2009 ERD shows a positive relationship which means divergence exists in all Quantiles and ERD is significant in all quantiles except Q 0.90 so the magnitude of the estimation ERD is greater from 2000 to 2009. From 2010 to 2021, ERD shows a positive relationship which means divergence exists in all Quantiles except Q 0.10, and ERD is significant in all Quantiles except Q0.10 and Q0.25 so the magnitude of the estimation of ERD is greater from 2000 to 2009.

Now we are explaining the results from 2010 to 2021 and 1990 to 2021. During the period of 2010 to 2021, ILGDPPC shows that convergence exists because negative relationship in all quantiles except in Q0.25 and Q0.75 and ILGDPPC is significant in all quantiles except Q 0 .10. From 1990 to 2021 ILGDPPC shows negative relationship which means convergence exists in all quantiles expect Q 0.25 and Q 0.75 and ILGDPPC is significant in all quantiles expect Q0.75 and Q0.90 so the magnitude of the estimation of the variable is ILGDPPC is greater in from 2010 to 2021.

Now, we elaborate on the findings of the Solow–Swan Model regarding Absolute Convergence. From 2010 to 2021, the Initial Logarithm of Gross Domestic Product Per Capita (ILGDPPC) demonstrates convergence, as indicated by a negative relationship across all quantiles except for Q.0.75. ILGDPPC is statistically significant across all quantiles except for Q 0.90. As a similar case, over the period between 1990 and 2021, ILGDPPC exhibits the negative relationship across all quantiles, which means that countries can converge, and the tests conducted within all quantiles except the Q 0.90 show that they are statistically strong. Importantly, the 10-year span of the 2020 to 2030 period shows a more significant drop rates than the 2010 to 2020 period. The GFCF (Gross Fixed Capital Formation) from 2010 to 2021 starts to show differentiation, and this is due to the correlated relationship present in all quantiles except for the Q 0.10 percentile. It is a GFCF that is statistically valid for all the quantiles except for Q (0.10). On a different reasoning, the GFCF and its linkage with all the quantiles display a positive relationship from 1990 to 2021, signifying divergence, with a statistical significant noted in between all of the quantiles except for Q 0.90. To be more specific, the GFCF estimates could have been much larger in the period 2010 to 2021 when compared to the other periods. As SSE (secondary school enrollment) demonstrates a positive correlation, implying that it is discordant across all quantiles which was observed during the 2010 to 2021 period. SSE demonstrated to be significant at all level of education. In particular, the period from 1990 to 2021, shows a positive relationship throughout all quantiles except for Q 0.75 and Q 0.90, indicating a possible divergence, where statistical significance has transpired across all quantiles except for Q 0.75 and Q 0.90. On the contrary, the SSE estimation is defined as highly significant during the 1990 to 2021 period. Life Expectancy (LE) shows a positive association that diverges in all quantiles throughout the period 2010 to 2021, with the p-values reaching significance in all quantiles, except Q 0.25. During the sector from 1990 to 2021, LE shows inconsistency with the positive beta across all quantiles except 0.50 where the statistically significance is observed across all quantiles except 0.50. The most critical aspect of the LE estimation is the large size that has been identified for the 2010-to-2021 period. Effective Rate of Depreciation (ERD) shows a positive link among three quantiles, i.e., Q 0.25 - Q 0.75, reaching statistical significance in most of them. In

the period from 1990 to 2021, ERD demonstrates a positive sign across all quantiles, indicating divergence, with statistical significance observed across all quantiles except for Q 0.75. Notably, the magnitude of the ERD estimation is notably higher during the 1990 to 2021 period.

Table 12: MMQR Results for Absolute Convergence using 1990 as initial value (1990 - 21)

DV: Average Annual GDP Growth (AAGDPG)							
Basic Model of Absolute Convergence							
Variables	Location	Scale	Q 0.10	Q 0.25	Q 0.50	Q 0.75	Q 0.90
ILGDPPC	0.0866***	-0.0867***	-0.276***	0.138***	-0.0633***	0.0187	-0.0206
	0.0272	0.0212	0.0656	0.038	0.0241	0.0227	0.0255
C	0.165*	0.432***	-1.108***	0.420***	0.0487	0.174**	0.369***
	0.094	0.0733	0.229	0.138	0.0824	0.0776	0.0873
Modified Solow-Swan Model Based Absolute Convergence							
ILGDPPC	-1.138***	0.746***	-2.694***	-1.663***	-0.947***	-0.552*	-0.147
	0.343	0.269	0.783	0.467	0.31	0.301	0.362
GFCFG	0.0236***	-0.0107*	0.0460***	0.0312***	0.0209***	0.0152**	0.00934
	0.00702	0.00551	0.016	0.00949	0.0064	0.00623	0.00741
SSE	0.0757***	-0.0918***	0.273***	0.130***	0.0531**	0.00226	0.0397
	0.0279	0.0212	0.0647	0.0379	0.0254	0.0237	0.0272
LE	0.163*	0.445***	1.117***	0.425***	0.0539	0.193**	0.396***
	0.0943	0.0715	0.222	0.135	0.0855	0.0781	0.0916
ERD	0.0366*	0.0207	0.0731*	0.0456*	0.0324*	0.0206	0.00996
	0.0204	0.0167	0.0435	0.0245	0.019	0.0184	0.0217
Constant	0.00991	0.192***	-0.328***	0.0729	0.0493	0.159***	0.257***
	0.0433	0.0354	0.109	0.0521	0.0388	0.0376	0.0449

5.5.2. MMQR Results for Relative Convergence Hypothesis (δ -Convergence

This section measures the relative convergence hypothesis under the MMQR. The results show the relative convergence in Table 13.

Table 13: The Relative Convergence Hypothesis

Periods	Countries	Years	Observation	Variable	S.D
1st decade	9	1990-1999	90	LGDPPC	0.3691
2nd decade		2000-2009	90	LGDPPC	0.4733
3rd decade		2010-2021	108	LGDPPC	0.4056
All		1990-2021	288	LGDPPC	0.5054

For relative convergence, we have measured the standard deviation of log GDP per capita for different decades. The standard deviation value for all periods is 0.5054, which is compared across individual decades. First, when compared with the standard deviation of 0.3691 for the first decade, it is observed to be lower, suggesting the existence of relative convergence. The second feature is the fact that the standard deviation is 0.4733 for the first decade, which is notably lower than the 1.0255 standard deviation for the second decade, even though the convergence is not that obvious. Consequently, the comparison with the standard deviation of the third decade (0.4056) indicates that the relative convergence has been reached, though it is between the levels, obtained during the first and the second decades.

6. Conclusions and Policy Recommendations

This study aims to explore the association between the converging hypothesis and economic growth among the member nations of the Economic Cooperation Organization (ECO). Such a focus should provide a deeper understanding of the effect of convergence forces within the regional economic integration processes. The investigation is based on the MMQR method to find the absolute and relative convergence between ECO countries from 1990 through 2021.
The results indicate that the effect of relative convergence on ECO households is positive and significant such that poorer families are now growing faster relative to wealthier families. Relative convergence is reflected in the first and tenth years through diminishing dispersion of per capita income. Yet, though during the third decade absolute convergence continues, it does so less strongly, leaving the levels between first and second decades.
In terms of methodology, the study employs gross domestic product (GDP) as the dependent variable, while gross fixed capital formation, secondary school enrollment, life expectancy, the initial logarithm of GDP per capita, and the effective rate of depreciation serve as independent variables. The research findings indicate that life expectancy, secondary school enrollment,

gross fixed capital formation per capita, and the effective rate of depreciation positively influence GDP growth, whereas the initial logarithm has a negative impact on GDP growth.

Three important policies are recommended to bolster GDP growth in ECO countries:

- The study suggests that when governments and businesses invest in fixed assets, it enhances productivity capacity, improves efficiency, and stimulates economic activities. Increased investment fosters job creation, boosts productivity, and ultimately fuels economic growth. Therefore, policymakers should adopt strategies aimed at promoting such investments to stimulate GDP growth.
- The study emphasizes the importance of higher life expectancy in improving healthcare and reducing mortality rates. With longer life expectancy, individuals can contribute more productively to the economy and tend to save more, thus fostering economic growth. Policymakers should focus on implementing strategies to enhance healthcare and prolong life expectancy to drive GDP growth.
- Secondary school enrollment is highlighted as a factor with a positive impact on GDP growth. A better education system correlates with higher individual earnings, promotes gender equality, reduces poverty, and enhances social mobility. These factors collectively contribute to overall economic growth and development, leading to an increase in gross domestic product. Therefore, policymakers should prioritize strategies aimed at improving secondary school enrollment to boost GDP growth.

7. Recommendation for Future Research

Future researchers should concentrate more on understanding how globalization phenomena and trade openness can impact convergence and economic growth, particularly in countries within ASEAN, OIC, and OECD regions. Future research endeavors should delve into exploring the influence of technological advancements and human capital on the processes of economic growth and convergence.

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