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CONVERGENCE HYPOTHESIS AND ECONOMIC GROWTH: EVIDENCE FROM ORGANIZATION OF ISLAMIC COOPERATION (OIC) COUNTRIES

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Abstract

This paper aims to investigate the convergence hypothesis and economic growth in a panal of selected OIC countries over the period of time 1960-2018. Two measures have been used i.e beta and sigma convergence. Results of calculations of beta and sigma convergence through regression analysis clearly reveals that beta convergence is positive among OIC countries. Findings confirm that overall income gap has widened in OIC nations in first three decades thus showing poor annual growth performance however income gap narrowed down in last subsequent decades exhibiting good growth performance. Lastly, pooled OLS regression analysis for Conditional Convergence under Solow Swan framework by using initial value method has been performed. Furthermore, in the context of policy implications, important policies are recommended to enhance GDP growth rate in these countries. Policymakers may adopt such strategies which enhance the life expectancy, enrollment rate i.e. variables related to human capital formation and physical capital so that GDP growth of the selected economies may be accelerated.

Keywords: Convergence Hypothesis,Unconditional and Conditional convergence,Panal Regression
JEL Code: O47, F43

1. Introduction

To investigate income gap and standard of living over time and space has been a major concern of economists. Countries with higher savings and low population are expected to experience high growth (Solow, 1956). Development economists state "For the past hundred years the rate of growth of output in the developing world has been depended on the rate of growth of output in the developed world. When the developed world grows fast, the developing world grows fast, and similarly when the developed world slow down, the developing world also slows down". The needle-pointed segregation among rich and poor economies since the industrial advancements in the early era of 19th century is now weakening since 1990 when rapid per capita income growth in developing economies has accelerated in a sustainable manner and is substantially higher than in advanced economies. It shows a major structural shift in the global economy.Convergence in the context of economic growth (also sometimes known as catch-up effect) i.e. the poor economies with low per capita income tend to grow at faster rate than the rich economies with high per capita, so income gap between the rich and poor countries will narrow overtime in long run and all economies eventually coverage to same development level in terms of equal average output and income per capita. In economic growth scenario, literature reals convergence occur in cross section of economies, if there is a negative relationhip between future growth rates and initial level of income (Sala-i-Martin, 1994). "In neoclassical growth models with diminishing returns, such as Solow (1956), Cass (1965) and Koopmans (1965), a country's per-capita growth rate tends to be inversely related to its starting level of income per person. Therefore, in the absence of shocks, poor and rich countries would tend to converge in terms of levels of per capita income"(Mankiw et al., 1992). The Solow model does not predict convergence as it predicts only that income per-capita in a given country converges to that country's steady-state value. In other words, Solow model predicts convergence only after controlling for the determinants of the steady state, a phenomenon that might be called "conditional

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convergence." Convergence and its basic complementary measures and indicators are β and σ convergence[1] which are given by (Sala-i- Martin, 1994).

Convergence is concerned about gaps in terms of standard of living among countries whether shrinking (β convergence) or expanding i.e. economies predeicted to be richer in few years are the same that are rich today (β divergence) (Salai-Martin, 1994, 1996; Barro and Sala-i-Martin ,1995) and income inequality across nations whether it increases overtime (σ divergence) (Sala-i-Martin 1996) or decreases (σ convergence). Convergence can be achieved based on application of social and economic policies by reducing disparities between macroeconomic indicators between regions and countries especially in the level of output and income which had gone through some period of economic crisis or may be failed to achieve strong growth.

Most of studies have investigated income convergence in Euro area or a comparative analysis of low income countries with high income countries. Many researchers have provided evidence on convergence by using different approaches but these studies have given limited attention to explore the role of income convergence in OIC countries and differences in their respectives economic growth patterns. Few studies have used initial value method but have not used Solow growth model. So, in order to fill this gap, this study is based on selected OIC countries. The purpose of this study is to determine income convergence in OIC countries.The study contributes to the existing literature by calculating beta and sigma convergence in through pooled OLS regression analysis over a period 1960-2018.The second purpose is to measure beta convergence under Solow Swan framework using initial value method.

The remainder of this paper is organized as follows: Section 2 is about theoretical underpinning about convergence hypothesis while section 3 shows the review of related literature. Section 4 presents the methodology, including the theoretical framework, adopted in this study and sources of data. Section 5 shows results and discussions. Section 6 presents conclusion and policies recommendations.

2. Convergence Hypothies: A Theoretical Underpinning

Speed of convergence across economies provide an important information in growth theories. Many economists have highlighted the query regarding per capita income tends to converge among rich and poor countries over the period of time or not. (Barro and Sala-i-Martin 1991, 1992; Mankiw et al. 1992; Sala-i-Martin 1996b; Lall and Yilmaz 2000; Michelis et al. 2004; Varblane and Vahter 2005; Bonnefond 2014). According to neo classicals, economy converges in the longrun towards a steady state due to diminishing returns in investment in physical capital (Sala-i-Martin, 1994). To test empirically whether the income gap or living standard gap across countries has narrowed or widened in past few decades and how much growth rate differences in terms of real income per capita across nations has been improved. Two indicators have been used to measure beta and sigma convergence.

a) Beta Convergence

The hypothesis that the countries with low GDP per capita (expressed relative to their steady-state levels of per capita income) tend to grow faster than those with (higher GDP per capita) also referred as catching up effect assume to converge same steady state in terms of GDP per capita growth rate. This implies negative relationship between initial income level and their average growth path (Sala-i-Martin, 1991, 1992a, 1992b). According to Romer, since developing countries have low capital endowment and capital intensity but due to higher MPK, capital will flow from the rich to the poor. As a result, the income gap between the rich and poor countries will narrow down overtime. So, in the long run all economies will converge to same development level with equal average output and income per worker. So we can conclude that beta convergence[2] shows the income convergence.

[1]Sigma convergence occurs if dispersion of income per capita across nations decline overtime.

[2] This phenomenon is sometimes described as "regression towards the mean".

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(b) Sigma convergence

This type of convergence indicates dispersion of countries' per capita GDP overtime or cross-section per capita income differences between economies decreases overtime. Sigma convergence is reduction in degree of variability in convergence i.e. decrease in degree of variation with respect to per capita output or income in a region or group of countries (Sala-i-Martin (1990),Barro and Sala-i-Martin 1992). Basically, sigma convergence analyzes the extent of income distribution contraction or expansion. Two measures of sigma convergence are used such as standard deviationa and coefficient of variation in the literature. Dispersion of income levels or variability across a group of economies can be measured through cross-sectional standard deviation of logarithm of income per capita of output among economies. In this context, convergence occurs if dispersion measured e.g. by taking standard deviation of the logarithm of per capita income or product of output across a group of countries of regions decline overtime. (Easterlin, 1960a; Dowric and Nguyen, 1989; Barro and Sala-i-Martin, 1991,1992a,1992b). Additionally, we may conduct regression of CV of GDP to verify reduction in dispersion overtime.

3. Literature Review

The significance of income inequalities and its impact on growth rates of countries has been well explained both domestically (region wise) and internationally (across nations) in the literature. Convergence is considered as primary factor influencing growth. Convergence predictions of neoclassical growth model for economies with similar tastes,technologies preferences in regions of same country are likely to converge to similar stationary state levels because these differences are likely to be negligible as compared to across nations. Furthermore, regions of same country share homogeneity by having an access to similar technology, tastes, cultural activities and share common legal and instiurtional setup by converging to similar steady state thus providing evidence of absolute convergence in regions within a country compared to across nations (Barro & Sala-i-Martin, 2003).

Studies on economic convergence for the single country case are consistent with Gomleksiz *et al.,* (2017) that confirmed the beta convergence across provinces while presence of sigma convergence across sub regions in Turkey. Similarly, Lee *et al*. (2016) provided evidence of reduction in gap of output per worker between Korea and US. As a result, Korea's lower per capita income relative to its potential level led to higher growth confirming prediction of conditional convergence theory. Catch up to US was also due to strong investment and trade openness. Young *et.,*al (2008) confirmed presence of income inequalities in sub regions of US.

Economic convergence in multiple country case was confirmed by Havlet *et al*., (2018) in EU-28. Czech Republic and Slovakia witnessed considerable catch up relative to other EU countries particularly during 2003-2008. Convergence was stronger in Slovakia in comparison to Czech mainly driven by TFP. Pre and post 2009 reported sample, convergence still hold but slowing down of convergence in EU was due to economic and financial crisis. Similarly, Goecke and Huther (2016) confirmed that poor economies catch up in 244 regions covering member states of Europe. Overall results showed that regions with higher industrial share receiving subsides from EU structure tended to have higher probability of convergence in 2000-2011. Sigma convergence test results indicated variance shrank after 2000 except in last year of sample. Results explained by Glodowska (2015) confirmed beta convergence in EU-28 countries and 276 regions. Regression results of beta convergence within EU provided the evidence of convergence which was faster in regions relative to countries. Siljak (2015) confirmed absolute convergence during 2008-2013 in EU. Although empirically significant dissimilarities between growth patterns among countries showed considerable heterogeneity growth i.e. convergence club. Lower rate of beta convergence was consistent to sigma convergence which showed small divergence in 2013 and 2010.

Some studies had found mixed convergence. Matkowski *et al.* (2016) pointed out the real income convergence between countries of CEE which have joined EU-11 and Western Europe (EU-15) and

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confirmed beta and sigma convergence followed by some breaks and divergence. Intensive convergence was seen during 2000-2007 while crisis slowed down convergence in CEE countries reflecting changes in income gaps in observed years 2007-2015. Pretrevski et al (2016) highlighted the factors which act as catalyst for real convergence in panel of CEE using Hausman test and explained the standard variables in growth (domestic saving investment ratios). High labor productivity led to more efficient labor means fall in unemployment thus enhancing macroeconomic stability with low budget deficit and inflation while banking reforms were positively related to real convergence. Similarly mixed results were found among for EU-28 reported by Europaische (2015). Weak institutions, structural rigidities, weak productivity growth and insufficient policies were the factors contributing towards the lack of convergence. Similarly King and Dobson (2015) disclosed mixed evidence of income convergence for individual OECD economies in comparison of Latin America. FLM test provide strong evidence of deterministic convergence (that half countries show catching up with US) in which their per capita income was only small fraction of that of US. For old EU-27 and CEE, Prochniak and Witkowski (2013) reported periods of more rapid or slower convergence but the differences were not as huge as expected. Application of BMA with Blondel and Bond's GMM system estimator confirmed the fast catching up of old EU-15 countries which converged at rate of about 5% per annum that was due to convergence of new EU-27 states at the rate of 3% per annum which was a huge difference compared to 2% rate of convergence. Convergence of CEE towards EU-15 was not rapid enough to level up with EU-27. Statistical data showed EU-15 recorded on average higher growth but low growth compared to CEE. However, partial convergence among EU-28 was examined by Simineseu (2014). Empirical results explained the low degree of divergence and variation in EU-28. Likewise, Borsi and Metiu (2013) validated that CEEC and EU member in long run showed high real income growth than EU over last 40 years, but convergence was not enough to eliminate cross country disparities. Generalizations of replication of convergence test from neo classical growth model (augmented with endogenous technological process) in order to identify covergence suggested that there is no overall income convergence in EU. Similaraly, evidence of conditional convergence was found in EU-14 by Chapsa et al., (2013). GMM technique based results provided the evidence of conditional convergence in EU-14. National Macroeconomic policies should ensure macroeconomic stability by minimizing relative prices in domestic market by enhancing credibility of monetary policy. Empirical findings confirmed conditional beta convergence in group of 17 APEC & 10 East Asia in 1960-1999 in Michelis and Neaime (2004) study. However, weak evidence of conditional beta convergence was observed in group of 16-APEC and much weaker income convergence was found in Asia. Panel regression technique provide partial evidence of convergence in growth rate per capita GDP in APEC and confirmed statistically significant real income per capita convergence when whole sample was analyzed.

Some studies explain absence of convergence in CESEE by employing GMM technique provided as no evidence of absolute convergence was confirmed by Bory's et al, (2008) and Sen (2007) in OECD and non OECD. Trend test results concluded stochastic convergence with significant trend breaks occurring in World War II (1939-1945) thus confirmed no convergence.

In sum, previous literature exhibits income convergence over time and space and economic growth in single and multiple country case has been examined to explore whether the world's poor economies tend to catch up with the world's rich economies or not. Mostly work on convergence has been done on Euro States and across its regions, OECD, non-OECD,US States, APEC, ASEAN-5, low and middle income countries. and have used SD or CV to measure income inequalities. There is less work done on income convergence in less developing countries or OIC countries. All the studies have consenses that considerable convergence can be clearly observed following stronger and slower pattern of convergence. However, according to some studies some degree of sigma divergence across nations is also present. We

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can conclude that all the studies have the same view in accordance with neoclassical theory about conditional beta convergence.

An analysis of existing literature suggests that convergence hypothesis has been tested for different regions for different time spans by incorporating various related factors. Some studies have also explored the factors impelling the speed of convergence. It is in this background that the present study intends to test the convergence hypothesis for OIC countries. It also provides estimates of the level/size of disparity and time needed to bridge up these gaps. This piece of research may contribute significantly to the existing literature on economic growth and will help policy makers to design policies for reducing income disparities among countries.

4. Model Specification, Data and Technique

Theoretical linkage shows that how different economic growth rates determine economic convergence process across countries. The links between economic growth and convergence is established with the help of following models:

Model 1:

$$GDPG = \beta_0 InitialGDPG + \mu \quad (1)$$

The calculation of β is based on the following formula:

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

Where b is the coefficient on the initial GDPG and T is the time period over which growth rate is averaged.

The calculation of σ convergence is based on variance formula:

$$\sigma^2 = \frac{\sum (X_i - X)^2}{n} = \frac{\sum (GDPG_i - GDPG)^2}{n}$$

Model 2:

$$GDPG = \beta_0 + \beta_1 InitialGDPG + \beta_2 GFCG + \beta_3 SSE + \beta_4 LE + \beta_5 (n+g+\delta) + \mu \quad (2)$$

Where:

GDPG = GDP Growth Rate (%Annual)
GFCF=Gross fixed capital formation Growth Rate (%Annual)
SSE = Secondary School Enrolment (%Annual)
LE = Life Expectancy (Annual)
n+g = Population Growth rate (%Annual)
δ = Depreciation rate

The study has used annaual time series data from 1960 to 2018. The data have been collected from World Development Indicators (WDI). The dataset contains information of selected 23 OIC countries according to their data availability. The list of selected OIC countries is given in Appendix-A.

5. Results and Discussions

In this section, we explain descriptive statistics and correlation matrix shown in Table 1 and 2 respectively. Section 5.1 explains beta convergence analysis under preliminary method and Section 5.2 explains convergence analysis under Solow–Swan Model.

In aggregated analysis during the analyzed period 1960-2018, the mean value of LGDP60 with its initial value was 10.33 with minima 9.07 and maxima values 11.62 so the deviation of parameter from its mean was 1.85. Since the average value was less than the median which means left tail distribution is greater

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than right and we also know that if degree of symmetry is greater than +1 which is 1.85 so we can conclude that the variable was highly negatively skewed towards left long tailed.

Table 1: Descriptive Statistics of Key Variables

Periods	Variables	Mean	Median	Max	Min	SD	Skew	Kurt	JB	Prob.	Obs.
1960-2018	LGDP60	10.33	10.62	11.62	9.07	1.85	1.08	3.29	9.56	0.03	1357
	AAGDPg	2.11	1.99	4.34	0.99	1.81	1.87	4.23	41.01	0.00	1357
	LE	59.48	61.18	76.54	35.94	11.25	0.62	3.28	20.42	0.00	1357
	SSE	41.29	37.02	106.89	1.97	26.1	1.82	3.99	35.16	0.00	1357
	GFCF	19.94	15.57	82.67	4.99	15.26	3.26	9.15	663.04	0.00	1357
1961-1970	LGDP61	10.24	10.21	11.64	9.18	1.75	1.14	3.5	1.89	0.44	230
	AAGDPg	1.34	1.25	2.68	0.99	1.45	3.62	9.61	144.22	0.00	230
	LE	47.83	48.14	65.15	35.94	10	1.6	3.26	5.68	0.01	230
	SSE	26.06	21.71	58.24	1.97	17.6	1.49	3.4	4	0.26	230
	GFCF	13.35	11.27	29.73	4.99	6.83	2.39	4.97	21.03	0.00	230
1971-1980	LGDP71	10.64	10.71	11.88	9.47	1.84	1.1	3.03	3.69	0.29	230
	AAGDPg	1.73	1.52	3.17	1.16	1.61	2.67	5.08	29.9	0.00	230
	LE	52.57	51.78	69.22	41.24	9.19	1.69	3.48	5.99	0.08	230
	SSE	28.23	24.04	55.35	3.73	17.88	1.3	2.79	5.64	0.10	230
	GFCF	16.26	11.55	44.57	4.99	11.1	2.m 39	4.87	20.65	0.00	230
1981-1990	LGDP81	10.84	11.03	12.34	9.22	2.07	0.91	3.03	3.86	0.25	230
	AAGDPg	1.98	1.78	3.41	1.19	1.68	2.37	4.6	19.27	0.00	230
	LE	57.71	57.02	70.56	47.25	7.69	1.73	3.74	5.86	0.09	230
	SSE	30.68	22.48	83.95	5.75	20.28	2.5	5.34	26.22	0.00	230
	GFCF	20.23	12.84	64.62	8.24	17.69	2.7	5.2	31.58	0.00	230
1991-2000	LGDP91	11.14	11.27	12.48	9.45	2.01	0.61	3.43	3.96	0.23	230
	AAGDPg	2.21	2.06	3.57	1.4	1.66	2.26	4.5	16.29	0.00	230
	LE	62.73	62.07	72.05	54.69	5.42	1.66	3.83	4.84	0.12	230
	SSE	42.12	36.67	95.43	14.91	24.96	2.14	4.12	12.94	0.00	230
	GFCF	25.14	16.74	82.67	8.93	22.66	2.86	5.67	40.21	0.00	230
2001-2010	LGDP2001	11.37	11.51	12.74	9.73	2	0.68	3.36	3.57	0.28	230
	AAGDPg	2.55	2.35	4.12	1.7	1.68	2.4	4.72	20.43	0.00	230
	LE	67.91	67.03	75.4	62.68	4.61	1.96	3.79	9.46	0.01	230
	SSE	56.38	49.95	106.89	23.86	23.14	2.25	4.44	15.81	0.00	230
	GFCF	23.01	20.41	53.94	11.1	10.78	2.62	6.09	36.11	0.00	230
2011-2018	LGDP2010	11.89	12.01	13.31	10.31	1.99	0.81	3.43	2.29	0.54	230
	AAGDPg	2.94	2.79	4.34	2.28	1.66	2.48	4.73	18.33	0.00	230

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	LE	70.95	70.71	76.54	60.42	4.32	0.75	4.84	3.01	0.20	230
	SSE	70.1	70	100.88	17.65	20.61	0.81	3.87	1.57	0.07	230
	GFCF	22.85	22.6	55.35	7.51	12.77	2.09	4.63	10.33	0.00	184

Source: Authors' calculations

Similarly, the average value of parameter AAGDPG was 2.11 with lower limit 0.99 and upper limit value 4.34 so the deviation of AAGDPG variables from its mean was 1.81. Means of AAGDPG was positively skewed with right long tailed (since their means were greater than median values) with skewness rate 1.87. The average value of LE was 59.48 and median 61.18 with lower limit 35.94 and upper limit value 76.54 so the deviation of LE parameter from its mean was 11.25.As the mean of LE was less than its middle value with skewness rate 0.62 the variable was highly negatively skewed towards left long tailed. Whereas mean of SSE was 26.06 with minima 1.94 and maxima values 58.24 so the deviation of SSE parameter from its mean was 17.6.Likewise the average value of GFCF was 13.35 and median value 37.02 with lower value 4.99 and upper value 29.73 so the standard error of GFCF parameter from its mean was 6.83.Least standard error was found in variable GFCF. Means of two variables SSE and GFCF are positively skewed with right long tailed (since their means were greater than median values) with skewness rate (1.82, 3.26) while LE moderately skewed. Kurtosis value was greater than 3 for all variables which is the case of leptokurtic above than normal distribution (which is measure of flatness and peakness). JB technique results and probability value of LGDP, AAGDPg, LE, SSE and GECF is normally distributed and thus significant.

Table 2 : Correlation Matrix of Key Variables (1960-2018)

Correlation	AAGDPG	IN-GDP	LE	SSE	GFCF	DEP
AAGDPG	1.00					
IN-GDP	0.75	1.00				
LE	0.29	0.33	1.00			
SSE	0.59	0.45	0.97	1.00		
GFCF	0.79	0.41	0.37	0.31	1.00	
DEP	0.86	0.34	0.78	-0.67	-0.66	1.00

Source: Authors' calculations

AAGDPG is positively correlated with rest of the other variables including IN-GDP, LE, SSE, GFCF and DEP. It is strongly correlated with IN-GDP[3], GFCF and DEP while it is moderate correlated with SSE and weak correlated with LE. IN-GDP also positively correlated with all remaining variables such as LE, SSE, GFCF and DEP. It is moderately correlated with rest of the other variables. LE is also positively correlated with SSE, GFCF and DEP; where it is strongly correlated with SSE and DEP; while moderately correlated with GFCF. SSE positively and moderately correlated with GFCF and moderately negatively correlated with DEP. GFCF is negative and moderately correlated with DEP.

5.1Convergence Analysis:Preliminary Method

This section measures β-Convergence hypothesis under preliminary method. Section 5.1.1 explains estimates of β-Convergence and section 5.2.2 elucidates σ-Convergence.

5.1.1 β-Convergence

To measure β-Convergence, we have estimated the equation (1) in which dependent variable is GDP growth rate while the independent variable is initial GDP. The results for β-Convergence hypothesis are shown in Table 3.

[3] Initial level of GDP per worker is used as representation of initial position of economy.

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Regression results in Table 3 point out that the sign of initial GDP which is shown by 'b' is overall positive, suggesting 'substantial convergence' in OIC countries over whole time period of 1960-2018 and in decennary period as well. In the whole time period i.e. 1960-2018, the value of coefficient is 0.5980 which is positive and statistically highly significant indicating that there exist positive relationship between log of GDP per capita and growth rate of GDP. Alternatively it can be conclude that countries who are poor initially exhibits high growth performance in future. These results are supported by previous study of Rapacki and Prochniak (2009) that investigated real beta convergence in 27 transition economies.

Table 3 : Results of β-Convergence Hypothesis

Periods	Years	Obs.	b	S.E	t-Stat	Prob.	R^2
All	1960-2018	1357	0.5980	0.0388	15.4076	0.0000	0.65
1st decade	1961-1970	230	0.1324	0.0633	2.0921	0.0440	0.48
2nd decade	1971-1980	230	3.7641	0.7627	4.9351	0.0000	0.58
3rt decade	1981-1990	230	0.5331	0.0757	7.0423	0.0000	0.51
4th decade	1991-2000	230	0.4607	0.1316	3.5003	0.0009	0.65
5th decade	2001-2010	230	0.0169	0.0167	1.0103	0.3166	0.49
6th decade	2011-2018	184	0.0503	0.0133	3.7927	0.0004	0.43

Source: Authors' calculations

During the first period 1961-1970, the value of coefficient of initial GDP is 0.1324 which is positive and statistically significant. In the next decade 1971-1980, the value of coefficient of initial GDP is 3.76 and statistically highly significant so there exist a linear relationship between initial level of income and growth. In the next subsequent decade 1981-1990, the value of coefficient of initial GDP is 0.53 and statistically highly significant. In the next two consecutive decades 1991-2000 to 2001-2010, the value of coefficient of initial GDP is 0.46 and statistically highly significant in 1991-2000 while in 2000-2010, the value of coefficient of initial GDP is 0.01 and statistically insignificant. During 2011-2018, the value of coefficient of initial GDP is 0.05 and statistically highly significant.

Now we discuss the speed of convergence[4] in various time periods. Table 4 exhibits the speed of convergence. For the entire period 1960-2018, the estimated speed of adjustment is 0.06 meaning that it requires less than half month to cover the distance towards their common steady state. Similarly during first decennary period 1961-1970, the estimated speed of adjustment is 0.08 which shows that countries require approximately less than one month to narrow down the distance towards their common steady state. For time period 1971-1980, estimated speed of convergence is 0.38 impling that OIC countries need more than one quarter and less than half year to cover the gap. For the time span 1981-1990, speed of adjustment is 0.18 which exhibits that the nations require less than one quarter of year to narrow by half the distance towards their common steady state. Speed of convergence which is 0.17 per year for time duration 1991-2000 indicating that it will take more than one quarter less than half year to eliminate gap in per capita income. During 2001-2010, speed of adjustment is 0.01 which means that countries will need approximately just a few weeks or less than a month to cut by half the distance towards their common steady state. For the period 2011-2018, adjustment speed is 0.04 implying that countries need approximately few weeks or less than a month to decrease half the distance towards their common steady state. Overall fastest convergence in OIC countries is recorded during 1971-1980 with 0.36 and slowest

[4] The "speed of convergence" interpreted as the annual rate of convergence, is measured by the following expression:

$$\beta = -\ln(1+bt)/T.$$

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pace of convergence during time period 2001-2010, since higher β corresponds to less number of years to move towards steady state.

Table 4: Speed of β-Convergence

Periods	Years	b	β	Speed of Convergence based on Half-Life Computation Formula (years)
All	1960-2018	0.5980	0.06	1.16
1st decade	1961-1970	0.1324	0.08	5.24
2nd decade	1971-1980	3.7641	0.36	0.18
3rt decade	1981-1990	0.5331	0.18	1.30
4th decade	1991-2000	0.4607	0.17	1.51
5th decade	2001-2010	0.0169	0.01	41.01
6th decade	2011-2018	0.0503	0.04	13.78

Source: Authors' calculations

Now we are explaining speed of income convergence based on half-life computation formula[5] which shows the number of years it takes for income gap to be cut in half. The findings display the estimates based on half-life for overall periods is 1.16 which corresponds to half-life of 1 month and 16 days to reduce by half the distance in order to reach a common steady state. The estimates during 1961-1970 is 5.24 which shows half-life of 5 months and 24 days to narrow the gap required to bridge up of the actual expanse from the steady state. The estimated half-life for decade 1971-1980 is 0.18 which points out 18 days are required by a country to reach steady state. The estimated speed of convergence during 1981-1990 is 1.30 exhibiting that half-life of one month and 30 days. During 1991-2000 half-life estimates is 1.51 which means countries will need approximately one month and 51 days to cut by half the distance towards their common steady state. Similarly during next subsequent decennary period 2001-2010, estimated β is 41.01 which indicates countries require approximately 41 years to eliminate the distance towards their common steady state. Speed of convergence is 13.78 for time duration 2011-2018 impling that it will take more than 13 years or less than 14 years to eliminate gap in per capita income. Our findings are also consistent with Furceri (2005) which pointed out that there will be positive speed of convergence, if difference in GDP is small. Positive speed of convergence lead to less unequal income distribution or less income per capita gap only when speed is relatively high and variance of in per capita income at beginning and end of period was small.

5.1.2.σ-Convergence

To measure σ-Convergence, we have estimated the σ-convergence through sample variance. The results for σ-Convergence are shown in Table 5.

[5] Half-life computation formula helps to estimate the time needed by a country to reach steady state and is given by $t = - \ln (0.5) / \beta$.

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Table 5 demonstrates that overall dispersion of income per capita is 2.65 which shows that overall income gap widened in selected OIC nations from 1960-2018. The results in the first 3 decades shows that variance of income per capita has increased from 2.62 in 1961-1970 to 3.06 in 1961-1970 which is an evidence for sigma divergence indicating that income gap has widen in OIC countries overtime.

Table 5 : σ-Convergence Hypothesis

Periods	Years	Observation	Variable	Variance
All	**1960-2018**	1357	LGDP60	2.65
1st decade	**1961-1970**	230	LGDP61	2.62
2nd decade	**1971-1980**	230	LGDP71	2.64
3rd decade	**1991-1990**	230	LGDP81	3.06
4th decade	**1991-2000**	230	LGDP91	2.94
5th decade	**2001-2010**	230	LGDP2001	2.92
6th decade	**2011-2018**	184	LGDP2011	2.89

Source: Authors' calculations

However, decline in variance of income per capita led to narrowing income gap thus providing evidence of income convergence since the gap decrease from 2.94 in 1991-1990 to 2.89 in 2011-2018. It means substantial σ-convergence observed from 4th decade to onwards thus showing good growth performance in OIC world.

5.2 Convergence Analysis under Solow-Swan Model

Now we are discussing convergence analysis under the framework of Solow Swan model. Findings of the regression for conditional beta convergence in OIC nations using 1960 as initial value 1960-2018 are given Table 6.[6] The extent of estimated coefficient value of LGDP60 is 0.7242 which is positive for conditional convergence; it means one percent increase in LGDP60 will increase GDP growth with the rate of 0.7242 percent. Estimated effect of log of per capita GDP on subsequent growth when all other variables are held constant will have overall significantly positive impact on GDP growth exhibiting that OIC countries exhibit good growth performance. Our results are consistent with Borys et al. (2008).

Table 6 :Regression Results for Conditional Convergence using 1960 as initial value (1960-2018)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-6.5350	0.4405	-14.8349	0.0000
LGDP60	0.7242	0.0399	18.1559	0.0000
LE	0.0109	0.0040	2.7049	0.0072
SSE	0.0034	0.0021	1.5833	0.1143
GFCF	0.0150	0.0024	6.2156	0.0000
DEP	-0.1073	0.0548	-1.9595	0.0509

Source: Authors' calculations

There exist a positive relationship between GDP growth and LE as the coefficient value of LE is 0.0109. GDP rise with the rate of 0.0109 percent if one unit of LE increases. Since LE is a key measure of

[6] Disaggregated results of conditional convergence are given in Appendix-B.

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population's better health and mortality rates are associated with growth rates. It means that improving health of workers by their greater access to high quality of health care services, proper hygiene, better education, housing and lifestyle can notably allow working people to be more productive. In other words with reduced mortality, individuals live longer which means with great number of years and higher savings economic growth rises. Since the sign and significance of variable is positive thus implying that LE eventually have positive impact on GDP growth and will enhance overall standard of living. Our results are consistent with the generalizations of Sharma (2018) who provided empirical evidence on the relationship between health and economic growth. Population's health is proxied by life expectancy exert a positive and statistically significant effect on real income per capita growth. Similarly one unit increase in SSE will increase GDP growth with the rate of 0.0034. SSE is percentage in gross enrollment ratio which is the ratio of total enrollment to the population regardless of age that corresponds to the level of education. Secondary education means basic education with lifelong learning and participation of skilled oriented more specialized people increase the stock of human capital by better education infrastructure that will strongly enhance growth since additional year of schooling increases individual earnings so we can conclude that education is important factor to increase in income that brings positive impact on overall well-being of economy. So we can conclude that increase in SSE will have positive and significant effect on GDP growth. Our results can be relatable with Curaresma et al. (2013) that presented income projection models primarily based on human capital dynamics in order to assess role of improvements in education which act as driving force for income convergence. Similarly Micer (1995) explained that the growth of human capital is likely to be an important key to sustained economic growth. Increase in school enrollment and average years of total schooling by additional year would increase the growth rate of GDP per capita. So association between growth in human capital per person based on year of schooling and economic growth is positive and both are vital for sustained economic growth.

The value of coefficient GFCF is 0.0150 which is positive means one percent increase in GFCF will increases GDP by 0.0150 percent. So there is positive relationship between GFCF and GDP growth. In other words, it means that rise in net acquisition of valuables like increase in fixed assets e.g direct public investment in capital expenditure on physical infrastructure like machinery and industries, private residential and commercial buildings including schools and road would increase the real national income of economy which will have positive impact on GDP. Thus this rise in capital will generate employment by increasing labor productivity making companies more efficient enhancing the standard of living. Gross fixed capital formation is often used as the best available proxy for direct public investment. Our results also support the important findings by Gibescu (2010).

The magnitude of estimated coefficient DEP is -0.1073. It means one unit increase in DEP will result in one percent decrease in the GDP growth with the rate of -0.1073. So we can conclude that on average when investment is less than depreciation of capital then capital will last -0.1073 per year, so there is negative relationship between DEP and GDP growth. Reduction in value of a long-term assets, wear and tear of old capital which cause fall in capital stock or estimated useful life of a fixed asset since they are not consumed completely in production activities during single accounting period like machinery and industrial plants which are expected to last more than one year are going to depreciate. So depreciation is the amount of investment necessary to maintain the current level of capital meaning that with increase in capital goods which are going to worn out or obsolete every year since more and more investment is required to maintain these levels because we have to sacrifice more by saving and consuming less. Thus, depreciation will ultimately have negative impact on sustained GDP growth rate. Our results are consistent with Sarker (2016).

6. Conclusions and Policy Recommendations

This study explains the results of calculations of beta and sigma convergence across selected OIC countries through regression analysis during 1960-2018 which clearly reveal that beta convergence in

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selected OIC countries is positive and statistically significant. In other words countries who are poor initially are now enjoying higher economic growth. Furthermore, mixed evidence of increasing variance in cross-section of selected OIC nations during 1991-1990 provide the evidence of sigma divergence and decreasing variance observed during 1961-1970 thus providing evidence of sigma convergence. The findings of the study confirm that overall income gap has widened in selected OIC nations in first three decades thus showing poor annual growth performance while income gap has narrowed down in last subsequent decades exhibiting good growth performance. Secondly, the results regarding calculation of speed of convergence determine that overall fastest convergence in OIC countries is recorded during 1971-1980 with 0.36 and slowest pace of convergence with value of 0.01 has been observed during time period 2001-2010. Lastly regression results for Conditional Convergence analysis under Solow model by using initial value method during 1960-2018 shows positive impact of variables LGDP,SSE,GFCF and LE on GDP growth performance of OIC countries while negative impact of DEP on GDP growth rate.
Two important policies are recommended to enhance GDP growth rate in these countries:

- The overall results of the study propose the variables related to human capital formation i.e. life expectancy and Secondary School Enrolment have positive bearing on GDPG so the policy makers may adopt such strategies which enhance the life expectancy and enrollment rate so that GDP growth of the selected economies may be accelerated.
- Besides human capital, we have taken physical capital. The findings of the study exhibit the positive association between physical capital and GDP growth rate so the planners may adopt such policies which can increase the physical capital.

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Appendix-A: List of Selected OIC Countries

1. Republic of Azerbaijan
2. Kingdom of Bahrain
3. People's Republic of Bangladesh
4. Brunei-Darussalam
5. Arab Republic of Egypt
6. Republic of Gabon
7. Republic of Indonesia
8. Islamic Republic of Iran
9. Republic of Kazakhstan
10. State of Kuwait
11. Kyrgyz Republic
12. Malaysia
13. Republic of Mozambique
14. Sultanate of Oman
15. Islamic Republic of Pakistan
16. State of Qatar
17. Kingdom of Saudi Arabia
18. Republic of Tajikistan
19. Republic of Turkey
20. Republic of Turkmenistan
21. State of the United Arab Emirates
22. Republic of Uzbekistan
23. Republic of Yemen

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Appendix-B: Disaggregated Results of Conditional Convergence

Regression Results for Conditional Convergence using 1961 as initial value (1961-1970)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.3847	0.8452	-5.1879	0.0000
LGDP61	0.5745	0.0881	6.5218	0.0000
LE	-0.0251	0.0100	-2.5000	0.0164
SSE	0.0078	0.0061	1.2792	0.2078
GFCF	0.0372	0.0105	3.5539	0.0010
DEP	-0.0451	0.1539	-0.2926	0.7712

Regression Results for Conditional Convergence using 1971 as initial value (1971-1980)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-11.5001	1.3957	-8.2397	0.0000
LGDP71	1.0475	0.1009	10.3763	0.0000
LE	-0.0293	0.0063	-4.6226	0.0000
SSE	0.0374	0.0066	5.6770	0.0000
GFCF	0.0499	0.0096	5.1918	0.0000
DEP	0.7634	0.1474	5.1811	0.0000

Regression Results for Conditional Convergence using 1981 as initial value (1981-1990)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.3327	0.5253	-10.1527	0.0000
LGDP81	0.8372	0.0424	19.7411	0.0000
LE	-0.0655	0.0081	-8.0965	0.0000
SSE	0.0326	0.0049	6.6089	0.0000
GFCF	0.0225	0.0027	8.2505	0.0000
DEP	0.1430	0.1019	1.4033	0.1679

Regression Results for Conditional Convergence using 1991 as initial value (1991-2000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.0918	0.5318	-7.6939	0.0000
LGDP91	0.9353	0.0326	28.6530	0.0000

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LE	-0.0912	0.0078	-11.6329	0.0000
SSE	0.0182	0.0015	11.7454	0.0000
GFCF	0.0202	0.0019	10.8590	0.0000
DEP	0.0801	0.0342	2.3441	0.0239

Regression Results for Conditional Convergence using 2001 as initial value (2001-2010)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.0316	1.6974	2.9643	0.0047
LGDP2001	0.6789	0.0425	15.9848	0.0000
LE	-0.1561	0.0239	-6.5411	0.0000
SSE	0.0107	0.0035	3.0813	0.0034
GFCF	0.0137	0.0045	3.0587	0.0036
DEP	-0.6778	0.1155	-5.8692	0.0000

Regression Results for Conditional Convergence using 2011as initial value (2011-2018)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.1203	0.6814	3.1119	0.0041
LGDP2010	0.6703	0.0205	32.6735	0.0000
LE	-0.1307	0.0091	-14.3667	0.0000
SSE	0.0216	0.0014	14.9332	0.0000
GFCF	0.0104	0.0017	6.2482	0.0000
DEP	-0.1066	0.0278	-3.8382	0.0006