Global Social Sciences Review (GSSR)
Vol. IV, **No.** III (Summer 2019) | **Page:** 349 – 363

Estimating Convergence (and Divergence) among Developing, Emerging and Developed Economies

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Abstract *Economic growth process is explained by many scientists in order to materialize a cherished objective of economic growth across the globe. In the current study, convergence among developed, developing and emerging countries has been estimated. Convergence process was estimated by employing sigma, beta and omega techniques. Analysis was done for three time periods i.e. from 1980 to 2018, from 1980 to 2000 and from 2001 to 2018. Sigma and beta analysis for the period from 1980 to 2000 showed divergence among countries however there are difference among developed, developing and economies Omega analysis showed divergence of developed countries and convergence among developing and emerging countries. Last analysis from 2001 to 2018 showed convergence among countries. The results are consistent with the adoption of information technology. Therefore, fast spillover effects of information technology help the countries in convergence process and make this world a global village.*

Key Words:
Convergence; Divergence; Economic Growth; Information Technology Spillover; Developed; Developing Economies.

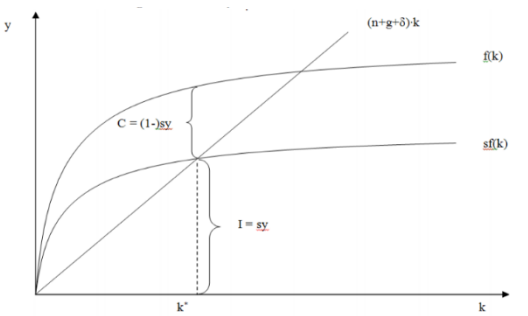
Introduction

Balanced economic growth is a goal of economic development. The policy makers found many methods to capture this balance and coordinated economic growth but the most renowned method of capturing the same is "convergence". Moreover, an important factor to encourage inclusive economic development among nations is to measure convergence of growth rate within economies. It is due to the fact that affluent and poor countries coexist in reality (Sofi & Durai, 2015). In economics, the concept of convergence means that when all the economies would converge to a specific output level per capita. Output per capita level of developed, emerging and developing countries are 47894, 1662 and 11971 respectively. When GDP per capita of developing/ emerging countries catches up the GDP output level of developed countries, it is called convergence. At this point, there would be no difference among their per capita output and poor economies will catch up the rich economies (Pesaran, 2007). Based upon the neo-classical growth theories/models, countries having lower GDP/output per capita would surely tend to move faster than high income economies. (Attila, 2010). This process may take many years. It means economies will converge but speed of convergence will not always be common (Attila, 2012). The estimation of convergence years may depend upon the varying speed of convergence of poor economies and rich economies. As there are many factors behind the speed of convergence similar to those the determinants of economic growth. But these factors may not stand for a single country; the factors of economic growth for poor and rich countries may also be taken into account. The spatial pattern of convergence would also give the clear picture of convergence among countries. This allows the policy makers for identifying the weaker side of a country or region. Without any doubt, this spatial analysis will be very helpful in policy decisions to formulate a comprehensive and concrete suggestions for economic development.

p-ISSN 2520-0348 | e-ISSN 2616-793X | L-ISSN 2616-793X | DOI: 10.31703/gssr.2019(IV-III).45 | URL: http://dx.doi.org/10.31703/gssr.2019(IV-III).45

Different growth theories tried to highlight the economic growth of economies. In the beginning of 19th century, first growth theory was developed by the Walt Rostow (Rostow, 1959). He advocated that economic growth may be achieved by passing through number of development stages which deals with exploitation of science and technology, pre-take off stage, replacement of traditional methods to modern methods (Chatterjee, 1974). Harrod-Domar growth theory explained how an economy can achieve the sustainable development (Easterly, 1999). There are two main determinants of Harrod-Domar growth theory, such as change in capital stock and saving ratio (Grinols & Bhagwati, 1976). Change in capital stock deals with investment on the capital stock for the progress of economy (Knibbe, 2014). Similarly, the relationship between saving ratio and national income of the country (Sato, 1964). Where, national income comprises of the government expenditure, consumption, net export and investment (Hagemann, 2009).

Some new economic growth theories are Endogenous growth theories and Malthus growth theory. Paul Romer and Robert Lucas are two well-known economists; they developed endogenous growth theory on the basis of human capital (Pack, 1994). The concept of human capital firstly was introduced in 1960 (Kiker, 1966). In the light of existing literature, human capital can be defined as, "a person who has three consecutive characteristics (education, health and training) at the same time (Becker, et al. 1990). So, endogenous growth model focuses on the human capital (Glomm & Ravikumar, 1992). The main concept of endogenous growth theory is that constant increasing trend in the economic growth mainly depends on constant level of population as well as deprecation (Howitt, 1999). There are many case studies which support the evidence of positive association between human capital and technical improvement (Dakhli & De Clercq, 2004) but technological enhancement in the economy mainly depends on the government intervention in endogenous growth theory (Ting et al., 2011). Under the classical school of thought, there is no advantage of investment on technology due to no role of government intervention. There are some assumptions related with this theory. First assumption of this theory is that, the increasing productivity of labor as well as capital (Howitt, 2000). Similarly, labor productivity does not have diminishing return (Jones, 1997). Further, there is no diminishing return found in the MP of capital as in Solow growth theory (Dowrick & Rogers, 2002). Solow growth model represents the relationship of economic growth with saving and investment. When the investment on existing capital and new capital becomes equal to saving then steady state is achieved as depicted in Figure 1. Once the steady state is achieved then the economies can only increase their growth through knowledge.



Source: Sorensen and Whitta-Jacobsen (2005)

Figure 1. Steady state in Solow Model

But it is too difficult because it depends on type of capital investment (Bosma, et al. 2004). In addition, this model is emphasized on the free markets (McFadden, 2006). Later on, another theory

was developed known as Unified growth theory (Galor, 2005). This theory was presented by Oded Galor. The theory mainly focuses on three aspects which are directly associated with economic growth due to industrial revolution, human capital and divergence of growth across the countries (Desmet and Parente, 2012). Endogenous growth theory mainly focuses on technical innovation in the economy due to the increase in economic growth; also this view is supported by number of studies that economic growth positively associated with the technical innovation (Baldwin, et al. 1999; Dupor, 1999; Tawiri, 2010). Economy of a country can work very well in the situation of free markets, and this view is supported by the endogenous as well as classical growth theory (Clark et al., 2011). It is all about the modern as well as traditional growth theories which state that how an economy can achieve sustainable economic growth in the budget constraints. There are various determinants of economic development such as capital formation, labor force participation, FDI, trade openness, unemployment, money supply, export, imports, aggregate demand, aggregate supply, foreign aid etc. and used by number of studies such as (Lee & Kim, 2009). Since the start of 21st century, innovation in information technology, media and other electronic channels of transformation made this world a "global village". In the previous century, McLuhan and Powers (989) have given a visionary understanding of today's life. The use of information technology in the field of education, health, agriculture, manufacturing and services sector increased drastically. Resultantly, the adoption rate of advance technology in every sector has increased. In any case, non-adoption of advance technology is not due to lack of knowledge but due to other factors like financial resources. Through the fast channels of technology transfer, the spillover effects among countries greatly increased and resultantly speed of economic growth among countries (convergence) emerged as an outcome of this technology transfer. Neoclassical economists advocated that poor economies will grow faster than rich economies due to differences in output per worker and their balanced growth paths, change in rate of return and capital per worker and differences in technology (David, 2011). Convergence is occurred in homogenous group of economies but divergence is occurred in heterogeneous group of economies (Gáspár, 2010). Catching up process is generally very slow in the countries as observed by Durlauf & Johnson et al. (2005).

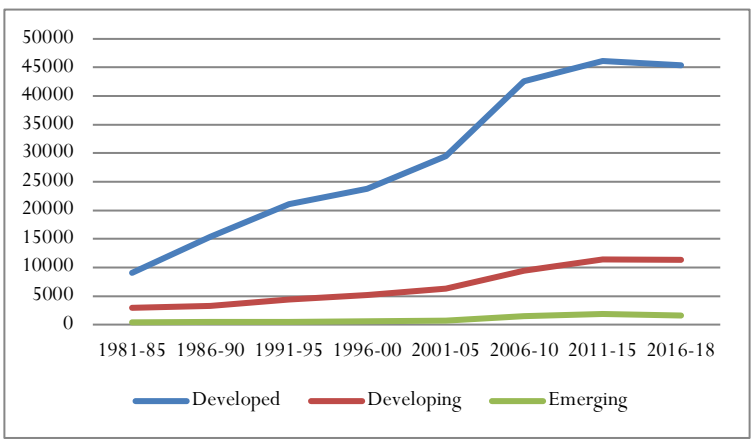


Figure 2. GDP per Capita by Country Group

Average GDP per capita during 1981-85 of developed countries remained US$ 9055 and the same has been increased to US$ 46132 since 2011-15. It is interesting to note that GDP per capita decreased to US$ 45341 during 2016-18. The percentage change in GDP per capita was observed

during the entire period of time. The slop of which can be observed from Fig 2. Significant percentage change can be observed after 2011. Similar trend can be seen in other two group of countries (see table 1).

Table 1. Gross Domestic Product per Capita by Income Group

	GDP per capita in US$ and percentage in parenthesis		
Year	**Developed Countries**	**Developing Countries**	**Emerging Countries**
1981-85	9055	2936	392
1986-90	15399 (41.2%)	3272 (10.3%)	437 (10.1%)
1991-95	21095 (27.0%)	4362 (24.9%)	491 (11.1%)
1996-00	23809 (11.4%)	5186 (15.8%)	546 (9.9%)
2001-05	29507 (19.3%)	6332 (18.1%)	734 (25.7%)
2006-10	42606 (30.7%)	9481 (33.2%)	1492 (50.7%)
2011-15	46132 (7.6%)	11402 (16.8%)	1857 (19.6%)
2016-18	45341 (-1.7%)	11348 (-0.5%)	1616 (-14.9%)

Source: Researcher's own calculation

This study aims to calculate the convergence between developed, developing and emerging economies. The next section addresses review of literature followed by methodology, results ad conclusion.

Methodology

GDP per capita is a good indicator of measuring economic growth among countries. Data of GDP per capita is also available over a longer period of time. Therefore, GDP per capita is used in the current study to estimate convergence and divergence among world economics. We used data of 166 countries. These countries are classified into three categories: developed (27 countries), developing (109 countries) and emerging (30 countries). Data of GDP per capita was available from WDI (World Development Indicators). Dataset is divided into two time periods i.e. 1980 to 2000 and 2001 to 2018. This division is made due to revolutionized information technology over these two periods of time. By using 1980 as base period and 2000 to 2018 as current years, convergence was determined by Sigma, Beta and Omega Convergence techniques as mentioned below:

Sigma Convergence

Standard deviation (SD) in its logarithmic form of GDP per capita of the world economies, is called sigma (Gáspár, 2012). Firstly, log values are weighted by the population. Secondly, sigma is classified into two categories that are "among" and "within" countries groups. These groups

are weighted by population. For calculating the partial standards deviation, developed, developing and emerging countries are used as groups.

Beta Convergence

Beta convergence can be defined as Log regression of GDP per capita and growth rate among world economies (Gáspár 2012).

Omega Convergence

Omega convergence can be measured from the following formula:

$$\left| \sum_{j=1}^{n} \sum_{i=1}^{n} \left[\left(\frac{f_{jiB} . x_{jiB} + f_{jiC} . x_{jiC}}{f_{jiB} + f_{jiC}} \right) - \left(\frac{f_B . \bar{X}_B + f_c . \bar{X}_C}{f_B + f_C} \right) \right] \right| = 0$$

Where, C = Current Period
B = Base Period
f = Population
x = GDP per capita
i = country (1, 2, … 166)
j = group (developing, developed and emerging)

Results and Discussion

Analysis is divided into three periods of time i.e. from 1980 to 2018, 1980 to 2000 and 2001 to 2018 in order to check the convergence or divergence before and after 21st century.

Firstly, the Results of Analysis with 1980 as Base Year and 2018 as Current Year are Presented as Follows:

Sigma Convergence

Overall divergence among countries is observed in sigma technique. Firstly, countries are diverging till 2000 and then converging after 2001 as depicted in fig 3. Standard deviation among within groups of developing, emerging and developed countries remained lowest as compared with overall and between groups. Convergence "between groups" remained higher than the "within groups" but lower than overall convergence. Disparities among world economies have been increased from 1980 to 2018. It was observed that disparities within group, between group and overall group has been increased by 0.01%, 0.22% and 0.14% respectively.

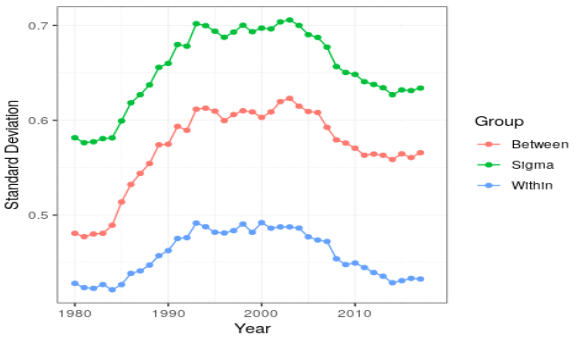


Figure 3. Sigma Convergence (Between, within and sigma) 1980 to 2018

Table 2. Sigma Convergence (Trend regression) 1980 to 2018

Sigma Convergence (Trend regression)					
	Estimate	**Std. Error**	**t value**	**Pr(>|t|)**	
Intercept	13.04289	2.696604	4.836783	2.33E-05	
Time	-0.00597	0.001349	-4.42758	8.13E-05	
Model Summary					
	Estimate	**F value**	**df 1**	**df 2**	**Pr (>F)**
R-Squared	0.34633	19.60344	1	37	8.13E-05

Source: Author's own calculation

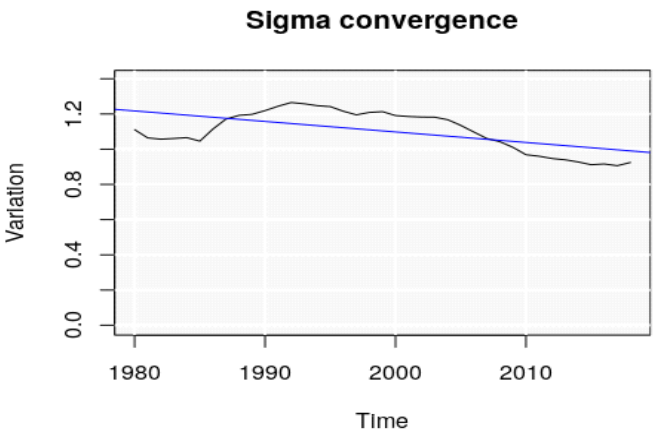


Figure 4. Sigma Convergence (1980 to 2018)

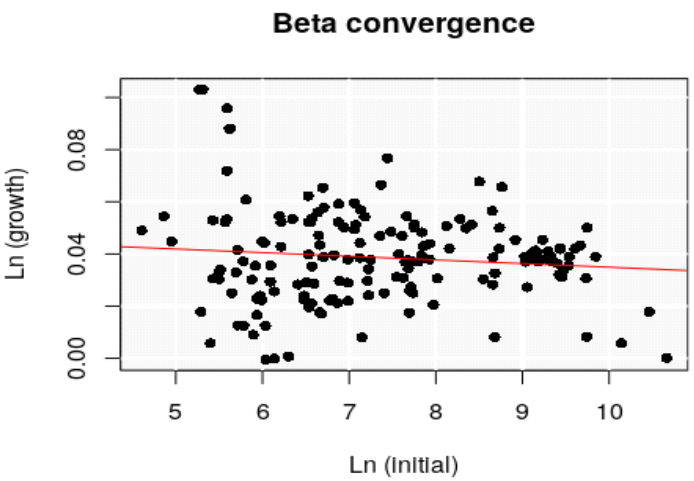


Figure 5. Beta Convergence (1980 to 2018)

Table 3. Absolute Beta Convergence (1980 to 2018)

Model coefficients (Estimation method: OLS)					
	Estimate	**Std. Error**	**t value**	**Pr (>|t|)**	
Alpha	4.89E-02	0.007684	6.361094	1.79E-09	
Beta	-1.40E-03	0.001035	-1.34969	1.79E-01	
Lambda	3.62E+02	NA	NA	NA	
Half life	2.05E+02	NA	NA	NA	
Model summary					
	Estimate	**F value**	**df 1**	**df 2**	**Pr (>F)**
R-Squared	0.010602	1.821651	1	170	0.178911

Source: Author's own calculation

As mentioned in table 3, value of lambda is 3.62E+02 which show the speed of convergence. This means that developing countries will catch the growth of developed economies in 362 years. Half-life value is 2.05E+02 which show the years required to diminish the inequalities among countries. This means that 205 years are required to diminish the inequalities.

Omega Convergence

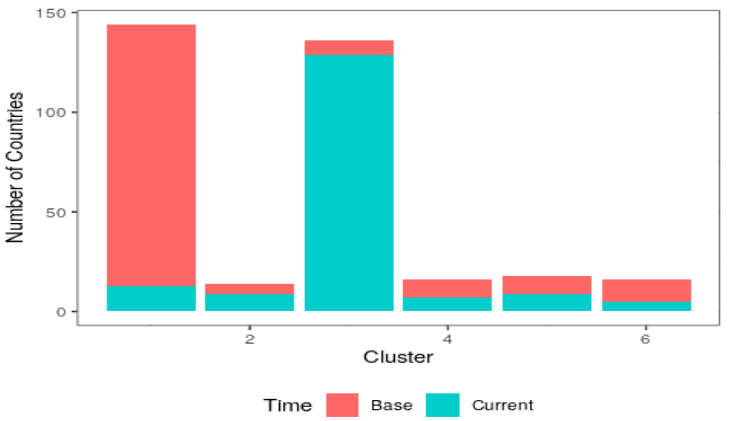


Figure 6. Clustering (1980 to 2018)

In first step, clustering of countries on the basis of GDP per capita was made and six clusters were formulated as depicted in figure 6. Therefore, an indicator called omega is created as mentioned in methodology section (see table 4).

Table 4. Results of Omega Technique (1980 to 2018)

Sr. No.	**Group**	**Wi**
1	Developed	5.793156
2	Developing	-4.53092
3	Emerging	-0.26224

Source: Author's own calculation

Secondly, the Results of Analysis with 1980 as Base Year and 2000 as Current Year are Presented as Follows:

Sigma Convergence

Partial sigma convergence shows "between" and "within". Results show that during the first period of time, countries were diverging as the standard deviation increasing from 1980 to 2000. Figure 7 showed the results of sigma divergence. The disparities among all countries have been increasing over the period of time. The disparities among countries groups have been increasing very fast. But, disparities among countries of same group increased from 1980 to 1994 and then these disparities started decreasing as mentioned in Figure 7. The disparities within group, between group and overall group has been increased by 0.26%, 0.61% and 0.53% respectively.

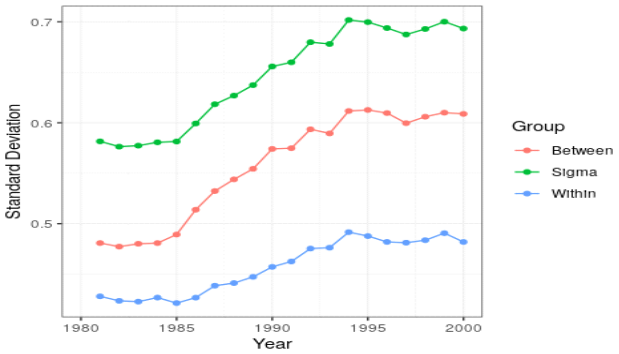


Figure 7. Sigma Plot for Groups (1980 to 2000)

Table 5. Sigma Convergence Values (1980 to 2000)

Sigma Convergence (Trend Regression)					
	Estimate	**Std. Error**	**t value**	**Pr(>|t|)**	
Intercept	-17.3344	3.521855	-4.92194	9.47E-05	
Time	0.009299	0.00177	5.254281	4.52E-05	
Model Summary					
	Estimate	**F value**	**df 1**	**df 2**	**Pr (>F)**
R-Squared	0.59234	27.60747	1	19	4.52E-05

Source: Researcher's own calculation

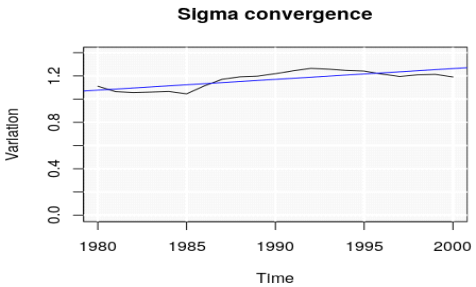


Figure 8. Sigma Convergence (1980 to 2000)

Beta Convergence

Results of beta convergence also show divergence among countries during first period of time. As depicted in Figure 9, countries with less GDP per capita will grow faster than the countries of higher GDP per capita.

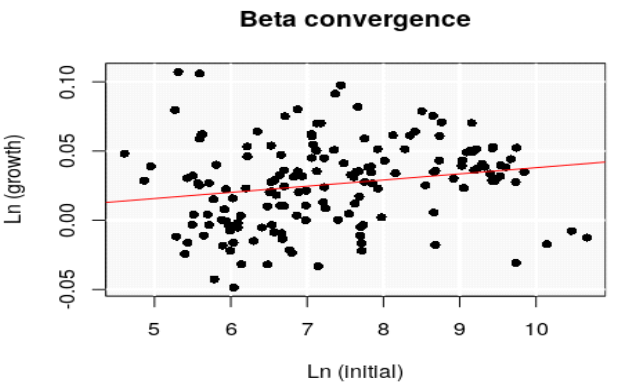


Figure 9. Beta Convergences (1980 to 2000)

Table 6. Absolute Beta Convergence (1980 to 2000)

Model coefficients (Estimation method: OLS)				
	Estimate	**Std. Error**	**t value**	**Pr (>|t|)**
Alpha	-0.00655	0.012774	-0.51268	0.608844
Beta	0.004455	0.001721	2.588716	0.010468
Lambda	NA	NA	NA	NA
Halflife	NA	NA	NA	NA
Model summary				
	Estimate	**F value**	**df 1**	**df 2**	**Pr (>F)**

Omega Convergence

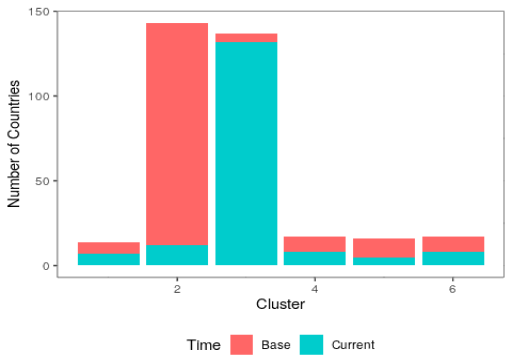


Figure 10. Clustering (1980 to 2000)

Omega results show convergence among developing and emerging countries while divergence among developed economies. Strong convergence is observed in developing economies.

Table 7 . Omega Convergence (1980 to 2000)

Sr. No.	Group	Wi
1	Developed	20.51587
2	Developing	-19.1996
3	Emerging	-2.31625

Results of Analysis with 2001 as Base Year and 2018 as Current Year are Presented as Follows:

Sigma Convergence

Similarly, three groups are formulated as between and within country groups. Sigma convergence during the second period of time shows convergence among countries. These three groups are converging towards their different steady states. Similar pattern is observed for the convergence of between groups. Countries of the same groups showed lowest standard deviation among all three groups and convergence is observed since 2001.Disparities within group, between group and overall group have been decreased by 0.28%, 0.18% and 0.30% respectively.

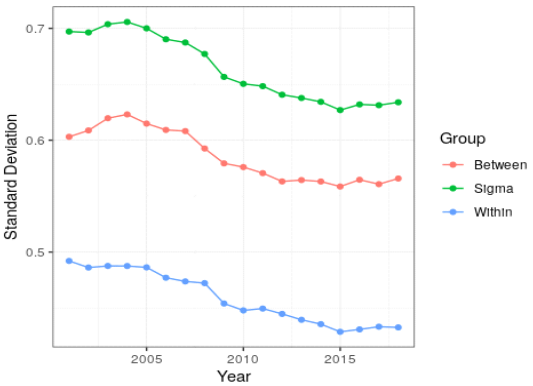


Figure 11. Sigma Plot for Groups (2000 to 2018)

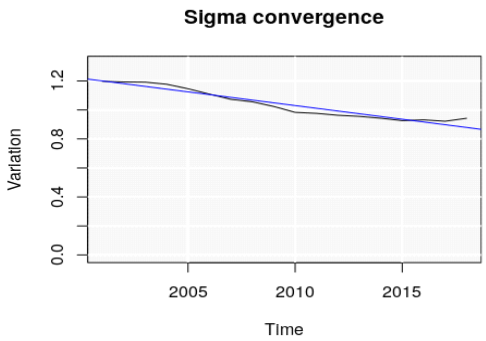


Figure 12. Sigma Convergence Values (2000 to 2018)

Table 8. Sigma Convergence (Trend regression) 2000 to 2018

	Estimate	Std. Error	t value	Pr(>ltl)	
Intercept	38.95403	2.623999	14.84529	8.93E-11	
Time	-0.01887	0.001306	-14.4492	1.34E-10	
Model summary					
	Estimate	F value	df 1	df 2	Pr (>F)
R-Squared	0.928819	208.7785	1	16	1.34E-10

Source: Researcher's own calculation

Beta Convergence

As indicated previously, beta convergence shows relationship between GDP per capita growth log and GDP per capita. Figure 13 shows that lower income economies will grow faster than richer economies. Overall convergence observed in beta analysis as depicted in Figure 13.

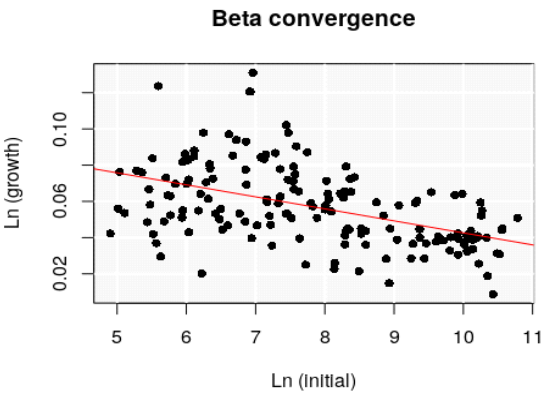


Figure 13. Beta Convergence (2000 to 2018)

Table 9. Absolute Beta Convergence (2000 to 2018)

Model coefficients (Estimation method: OLS)					
	Estimate	Std. Error	t value	Pr (>ltl)	
Alpha	1.09E-01	0.007141	15.24757	1.22E-33	
Beta	-6.63E-03	0.000897	-7.38974	6.35E-12	
Lambda	2.25E+02	NA	NA	NA	
Halflife	1.69E+02	NA	NA	NA	
Model summary					
	Estimate	F value	df 1	df 2	Pr (>F)
R-Squared	0.243126	54.60819	1	170	6.35E-12

As mentioned in table 9, value of lambda is 2.25E+02 which showed the speed of convergence. This means that developing countries will catch the growth of developed economies in 225 years.

Half-life value is 1.69E+02 which showed the years required to diminish the inequalities among countries. This means that 169 years are required to diminish the inequalities.

Omega Convergence

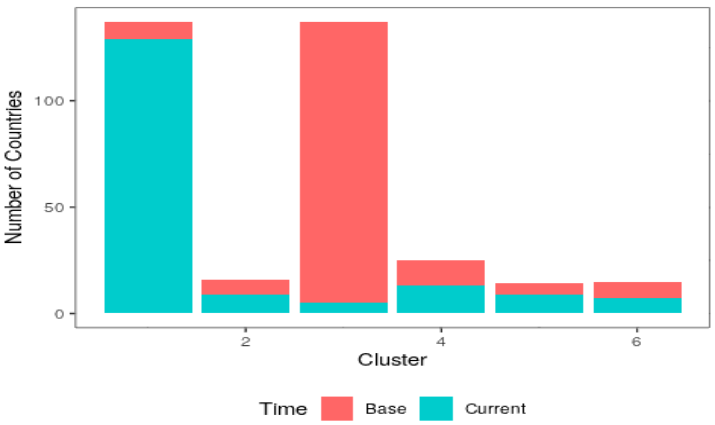


Figure 14. Clustering (2000 to 2018)

Results of omega convergence show convergence among developing and emerging countries but it is not as much stronger as observed in first period of time. But the developed countries are diverging during second period of time.

Table 10. Omega Convergence (2000 to 2018)

Sr. No.	Group	Wi
1	Developed	5.471967
2	Developing	-3.98283
3	Emerging	-0.48914

Source: Researcher's own calculation

Conclusion

The estimation of economic convergence and divergence along with its speed is of immense importance. Basically balanced economic growth leads to prosperity and welfare of the countries, so it is important to watch the existence of convergence process among world economics. Convergence can be observed among countries having same level of development/income. Thus countries are converging to steady states. In this paper different analysis were carried out to check the presence of convergence and divergence along with its speed in world economies. As we know convergence process cannot be perfect because GDP per capita alone cannot determine economic growth (results of beta analysis confirmed this). There are many other factors behind economic growth like energy consumption, trade flow FDI and research and development expenditure of a country. Out of numerous factors of economic growth, GDP per capita was used for analysis purpose. The primary aim of this paper is to find out the existence of convergence and divergence among countries. Convergence and divergence was estimated by using sigma, beta and omega convergence techniques. The analysis was split into three period of time that are

from 1980 to 2018, 1980 to 2000 and 2001 to 2018 to find the true impact of innovation in technology in 21st century. Results showed the convergence of countries when analyzed the data from 1980 to 2018. Omega technique showed the divergence of developed countries but convergence among developing and emerging countries. Then, the analysis was split into two period of time to check the impact of information technology on the convergence and divergence among world economies. First period (1980 to 2000) showed divergence among countries as analyzed from sigma and beta techniques. Omega technique showed convergence among developing and emerging countries although they have different frequency of convergence. Developed countries are diverging as per omega analysis. The analysis of sigma and beta techniques for the period from 2001 to 2018 showed the convergence of countries. Similar results of omega technique were observed for developing and emerging countries but developed countries are diverging during this period. The results of the analysis confirmed the presence of convergence among different countries which is in line with neoclassical growth theory, thus assumption and conclusion of growth theory are applicable to world economies.

The overall analysis showed the divergence of countries but when the analysis was split into two periods, this showed the divergence in first time period and convergence in second time period. Therefore, the first analysis could be misleading if we do not include the information technology.

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