



## **Exploring Intra-Group Income Convergence for the Central Asian Countries**

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### **ABSTRACT**

The main objective of this study is to explore income convergence for the Central Asian countries whereas income convergence refers to the state when all nations in a region converge to the identical level of steady state in terms of per capita. This study tested the income convergence through beta convergence and sigma convergence over period from 2003 to 2019. The beta convergence indicates that the poor economies grow more rapidly than the rich nations and catch up with them in terms of per capita income, whereas sigma convergence means that the gaps between the per capita incomes of the nations in the region decrease over the passage of time. The beta convergence is determined through panel unit root tests, whereas sigma convergence is determined through the coefficient of variation. This study finds beta convergence as well as sigma convergence henceforth; income convergence is confirmed in Central Asian countries. It can be concluded that economic integration is in favor of Central Asia, so it is recommended that these nations must ensure economic cooperation with each other through easing trade restrictions and lessening import taxes on imports. Moreover, it will also be helpful to ensure the free mobility of the labor force among Central Asian countries, as it will further help them to ensure economic integration and helps in reducing the income inequality in the region.



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## **1. Introduction**

From a widespread perception, many economists questioned whether the per capita income of nations converges over the passage of time or not. The convergence of economies is debated in the different growth theories. The neoclassical theories predict income convergence

among similar economies; the endogenous theories predict no income convergence; and the dynamic distribution theories predict income convergence based on how different economies integrate over time (Barro & Sala-i-Martin, 2004). In general, there are two concepts for testing income convergence: beta convergence and sigma convergence. Beta and sigma convergence are closely related to one another. For the presence of income convergence, unconditional beta convergence is an essential condition, which means that it is sufficient for income convergence because different economies may converge towards each other or in the form of conditional convergence, nations may converge towards distinct steady-states (Sala-i-Martin, 1996b). Besides the unconditional beta convergence, there is also a conditional sigma convergence. According to sigma convergence, there is a decline in the difference in GDP per capita over the passage of time among the members of the regional economic association (Tu & Giang, 2018; Zakaria, 2014).

The influential work of Solow (1956) introduced the notion of convergence, which was later further investigated by numerous studies in the context of endogenous growth models. The concept of beta convergence and sigma was first introduced by Sala-i-Martin (1996a). Other researchers debated income convergence and tested income convergence for the different regions of the world. According to beta convergence, the economies of the developing nations expand more quickly than those of the developed ones, catching up with developed countries in terms of per capita income. Beta convergence can be explained through the law of diminishing returns of capital as there is a negative association between the stock of physical capital per head and the rate of returns. It is suggested that, other things being held constant, nations having low physical capital per head grow more rapidly. This is due to the reason that returns to capital are faster in developing countries, which are inadequately endowed with capital as compare to developed countries.

In general, the Solow-Swan growth model suggests that capital will flow from developed to less developed economies, thereby increasing the growth rates in the developing economies. In light of this, the process of growth should guide countries toward a long-term steady state characterized by a growth rate that is based on the rate of technical innovation and increase in the labor force. The diminishing return means that the economic growth rate of poor nations must be higher and the per capita income of these nations must catch up with rich nations in the region, while sigma convergence means that the gaps between the per capita incomes of the nations in the region decrease over the passage of time. The Solow-Swan model of growth predicts that the large gap in the standard of living of rich and poor countries will vanish in the long run. It means that economies that are initially less developed might have higher economic growth rates than the initially developed nations, so income convergence will occur (Glawe & Wagner, 2021). When all nations converge to the identical level of steady-state in terms of growth rate and GDP per capita, then beta convergence is called absolute convergence. The steady-state, however, may depend on certain national characteristics; in this case, income convergence will still happen, though possibly not at the same long-term levels. It is known as "conditional convergence" when per capita income is assumed to be dependent on a number of factors, such as institutional or factor endowment, which vary over time and across countries (Nguyen, Quan, Le, & Tran, 2020; Santillán-Salgado & Ortega-Díaz, 2017).

East Asian, European, and some Latin American countries are said to have profited from regional economic cooperation. The assessment of regional economic integration and differences in real income is crucial to getting an overall glance at regional disparities. Investment, regional trade agreements and political agreements are crucial for the regional economic integration. The role of agreements in the growth and economic integration is vital as economic integration helps in declining trade restrictions, increasing competition in the goods market, increasing the size of the market, supporting regional, economic, and political institutions, in transferring technology, and attracting foreign investment. This is the reason that Głodowska and Pera (2019) argued that economic integration creates enormous opportunities and leads to income convergence.

In the beginning of the 1990s, the Central Asian countries gained independence from the USSR and began moving to a market economy rather than a state-controlled economy. These nations are following the Asian Tigers and becoming the local equivalent, the Central Asian Snow Leopards, but the reforms have been selective and gradual, because governments try hard to control the social cost and improve the living standards of the people. All the five nations are trying to increase the competition by implementing structural reforms and initiating business-friendly initiatives and fiscal policies. Moreover, these countries are attempting to modernize their industrial sector and promote the growth of the service sector in order to decrease the share of agricultural sector in the gross domestic product (GDP). All the Central Asian countries saw a fall in the share of the agriculture sector and witnessed increase in the share of industry in the GDP except Tajikistan whereas Turkmenistan has the fastest growing industrial sector compare to other Central Asian countries. Besides, the service sector flourished in all Central Asian countries (Mukhitdinova, 2015).

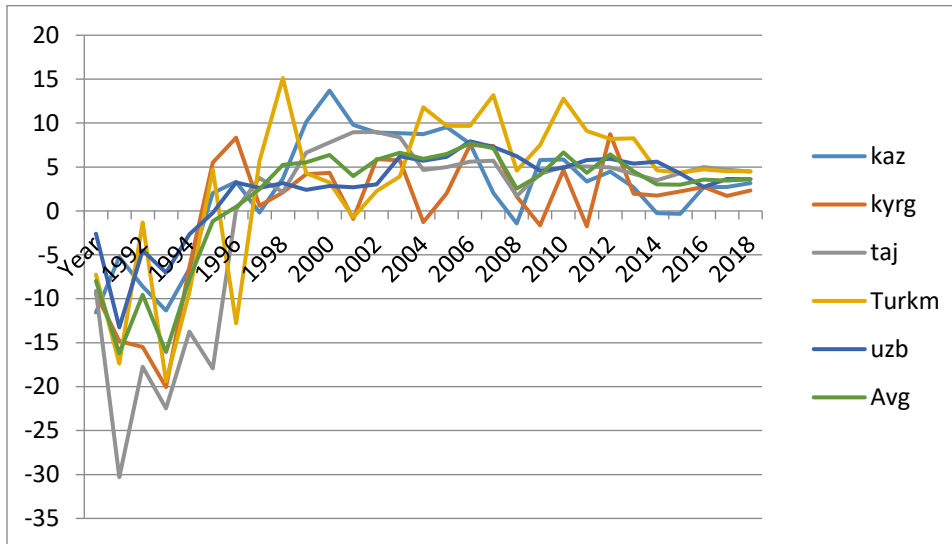
The governments of Central Asia priorities are protecting the political and economic sectors from external shocks in their public policies. This entails reducing governmental debt as far as possible, keeping trade balances positive, and increasing foreign reserves. They cannot completely cut themselves off from the negative external forces, such as the steadily weak recovery of international trade and global industrial production since 2008. Despite this, these nations have emerged relatively safe from the global financial crisis in 2008-09. Growth declined shortly in Tajikistan, Kazakhstan and Turkmenistan, but Uzbekistan did well as economic growth was more than 7% per annum on average between 2008 and 2013. Turkmenistan achieved an extraordinarily high growth rate of 14.7% in 2011. The performance of Kazakhstan was more inconsistent, but this phenomenon was noticeable well prior to 2008. These countries benefited greatly from the commodities boom in the first decade of the twenty-first century. Uzbekistan is self-sufficient in oil and natural gas, which are abundant in Turkmenistan and Kazakhstan. Kazakhstan has the largest uranium reserves in the world, and Uzbekistan, Tajikistan, and Kyrgyzstan also have sufficient gold reserves (Mogilevskii, 2012).

Tajikistan's principal exports are raw cotton and aluminum, the country has suffered greatly in recent years from unpredictable global demand for these commodities. Aluminum is the primary industrial asset of Tajikistan. The top exporters of cotton are Turkmenistan and Uzbekistan, which ranked fifth and ninth internationally in terms of volume in 2014. Due to their reliance on the export of raw materials, the countries of Central Asia are exposed to economic shocks, Small manufacturing capacity and a limited number of trading partners, as well as their limited manufacturing ability. Kyrgyzstan has many disadvantages due to its lack of resources, but it has plenty of water as well as producing a handsome amount of hydroelectricity. Kazakhstan has attracted more foreign direct investment (FDI) than any other Central Asian country, accounting for more than 70% of all FDI inflows in the region. China is regarded as the dominant economic player in the Central Asian region, owing to the Belt and Road Initiative (BRI), which was launched in 2013 as a one-road, one-belt investment plan. From 2007 to 2019, the inflow of FDI in the Central Asian Nations was \$378.2 billion, of which the share of Kazakhstan was 77.7%. Kazakhstan has the largest economy of the Central Asian countries because it accounts for more than 60% of the GDP of the region as well (Mukhitdinova, 2015).

The Central Asian countries possess a lot of valuable resources, but they also face several challenges for their economic development. The benefits for the region are that it has an educated labor force, numerous natural reserves, cultural diversity, and a strategic location, especially closeness to China that could provide a good platform for the development of nations in the region. Contrary to this, the Central Asian countries are landlocked and have no access to deep harbors and are isolated from the most worldwide economic centers. They have a small market size due to their small population size. Some areas of the region also face insecurity and political instability. These are all the factors that can restrict human development. Numerous variables impact the region's economic growth, among which the most important is foreign trade, since the Central Asian nations are heavily dependent on it. Due to the limitations on the access

of the world markets, trade among the nations of the region is very important. Over the past 20 years, Tajikistan and other Central Asian nations have tremendously profited from growing economic cooperation. The expansion of trade is the engine of economic growth, which significantly reduces poverty and shares prosperity in the region (Mogilevskii, 2012).

Figure 1 depicts the annual GDP growth rates of the nations of Central Asia over the period 2003-2019. The initial value of the growth rate was negative for all the member countries, and then it started to improve and became positive and growing rapidly. This clearly shows that the per capita of all the countries increases over the passage of time and becomes close to the average value of the group of these countries and converges towards the average value of the member countries.



**Figure 1: Central Asian Countries' Annual GDP per capita Growth Rates**

Source: Author's calculation

Regional economic integration is very significant for the developing nations due to the reasons that it increases the rates of development in developing countries by removing barriers to cross-border labor movement and may help to expand job opportunities. These regional economic agreements encourage capital formation and trade by removing the restrictions by decreasing or removing the taxes, which results in less expensive products for the customers in the member countries of the regional economic associations. It reduces the income inequalities in the region. The regional associations have empowered countries to pay attention to those issues which are related to their stages of economic development and also speed up trade among their neighbors. Regional similarities and understanding promote political collaboration among the member nations (Druzhinin & Prokopyev, 2018). There are many reasons which suggest that regional economic integration is significant for the development a country. Initially, regional economic integration promotes labor and capital mobility in the area, which could enhance labor productivity within the region. Secondly, trade agreements in a number of forms, such as free trade agreements or custom unions that benefit every nation in the course of increasing the quantity of goods traded in the area. Thirdly, regional economic integration facilitates the spread of technology by exchanging ideas, knowledge, and products that could direct domestic firms to adopt technologies that are revolutionary on an international level that increase the quality of a product and reduce the cost of production domestically (Sohn & Lee, 2006).

Researchers did not find any study that determines the income convergence for Central Asian countries thus; the main objective of the current study is to empirically investigate whether there is income convergence or not in Central Asia. The Central Asia Countries comprise the five member nations, including Kazakhstan, Kirghizstan, Tajikistan, Turkmenistan, and Uzbekistan.

The income convergence in the region can be explored by employing many indicators as suggested by different economists in the literature; the most commonly employed indicator is per capita income.

## **2. Literature Review**

This section reviews literature based on the concept of regional income convergence. The study of Sohn and Lee (2006) concludes income convergence for those nations that established the Free Trade Arrangement. Furthermore, it is concluded that those countries that liberalize trade, this rate of income convergence is much higher for eight member nations of European nations. The empirical findings show that regional economic integration promotes economic growth in these European Union nations through the use of the technology transfer mechanism.

Monfort (2008) uses the methodology of beta and sigma convergence to investigate the existence of income convergence for European Union countries. The findings show that convergence occurs for European Union member countries. Stronger methods for confirming convergence, according to the study, should not be dependent on a single measure but rather on panel measuring instruments and their proper justification. For the comparative analysis of a few SAARC member countries and the original ASEAN members, Haider, Hameed, and Wajid (2010) investigated the income convergence hypothesis. The findings of the study concluded the presence of per capita income convergence in Southeast Asian nations and found no convergence for the South Asian nations for the period of 1984-2012.

Dey and Neogi (2015) examined the unconditional beta convergence and sigma convergence for seven SAARC economies from 1970 to 2011 and found an excellent opportunity for China to integrate with SAARC economies. The findings show that there is income convergence in the SAARC region and furthermore, the integration of China into the SAARC block confirmed the presence of income convergence also, and the rate of convergence increased with the integration of China into the SAARC block.

G. Khan and Daly (2018) examined the growth convergence and divergence for the countries of SAARC for the period spanning from 1960 to 2017. The results of the study could not confirm the income convergence for the countries of SAARC for the selected period by employing the beta ( $\beta$ ) and sigma ( $\delta$ ) convergence. Kant (2019) conducted an empirical study to test the catch-up hypothesis and income convergence for the South Asian and Sub-Saharan economies of Africa from 1971 to 2013. The results could not find the income convergence in any region by using the beta and sigma convergence for income convergence.

Głodowska and Pera (2019) have conducted a study to explore the process of income convergence for Eastern and Central European nations (CEE10) towards Western European nations and to show the relations among the regional economic integration, income convergence, growth, and business environment. The time period for analysis is 1995–2016 by utilizing distinct kinds of quantitative procedures like descriptive statistics, regression analysis (panel and OLS), and literature analysis. The findings conclude the relationship between regional economic integration and income convergence; additionally, it concludes that growth is dependent on a favorable business environment for the EU10 nations. The important thing about this study is the grouping of three crucial research problems like the business environment, the presence of income convergence, and regional economic integration. Zia and Mahmood (2019) tested the income convergence for the trading blocs of ASEAN and SAARC for the time period of 1999-2015. The conclusion of the study support income convergence for ASEAN member countries while finding no convergence for SAARC economies.

Malik and Masood (2020) employed the techniques of cointegration analysis, panel unit root, and deterministic and stochastic income convergence. The time period spanning from 1971

to 2017 was chosen to examine the sources of enhancement of productivity and its convergence for the nations of the MENA. They examined the contributions of total factor productivity (TFP), human and physical capital, and labor in the output function. Furthermore, the findings show that the share of labor, human and physical capital in the output increase is direct, while the contribution of labor and human capital is significantly smaller than that of physical capital; the contribution of total factor productivity is negative. Additionally, the analysis comes to the conclusion that for the output per worker, stochastic convergence exists but not deterministic convergence.

Safdar and Nawaz (2020) analyze the income convergence for the six SAARC nations from 1972 to 2012 in the framework of Solow and Swan's (1956) growth model using Hadri z-statistics and the Levin, Lin, and Chu test for panel data. The study's findings did not confirm the existence of convergence for the SAARC countries for the specified period of time and did not support Solow- Swan's growth model. Likewise, Ghatak (2021) conducted a study for the SAARC and ASEAN nations from 1970 to 2017. The conclusion of the study confirmed the convergence for the ASEAN countries, while it could not find the convergence for SAARC countries, but for the block of ASEAN and SAARC countries, it found the income convergence. Ghatak and De (2021) examined income convergence in Asia from 1990 to 2017 and concluded that there was income convergence during the chosen period and income inequality decreased among the countries.

By using the quantile regression methodology, Tran, Le, and Nguyen (2021) investigate the effects of institutional, labor force, trade openness, and inflation characteristics on the growth of 48 Asian economies for the panel data set from 2005 to 2018. The study's findings show that institutional traits have a strong beneficial influence on income convergence. They also show that Asian countries with low per capita incomes have institutions with greater growth rates than countries with higher incomes. The data also indicate a nonlinear relationship between institutional quality and economic growth, but this relationship is reversed when an institutional indicator passes a particular threshold. The findings further support the notion that the expansion of Asia's economies over the chosen time period was positively impacted by the labor force, trade openness, and inflation. The report makes policy recommendations for Asia's countries, especially Vietnam, to enhance institutional quality and increase their contribution to economic growth.

In order to address the potential endogeneity and nonlinearity issues, I. Khan, Nawaz, and Saeed (2021) used the dynamic panel system-generalized moments method (SYS-GMM) technique to assess the effects of FDI and trade liberalization on the distribution of income in five countries in South Asia between 1990 and 2016. The model is further expanded in the second stage to look into how education affects how income is distributed in these nations. In this study, it is being investigated whether secondary education increases the use of modern technologies while decreasing inequality. According to the study's findings, trade liberalization significantly reduces income inequality directly.

For the BRICS countries, Lohani (2021) has been examined in panel research to investigate the impact of trade liberalization on the convergence of income. Additionally, using the unit root technique, to ascertain whether economic association has a positive or negative effect on the degree of income disparity in this block, it is evaluated in terms of how it influences trade between these nations as well as income convergence. The BRICS nations' income convergence is tested using the measurements of convergence and convergence. The results of the period of trade openness between the BRICS countries and their major trading partners show diverse results, but all groups of export-based economies aside from the Indian economy and groups of import-based economies indicate the presence of income convergence. The results of the study suggest that the BRICS nations should actively engage in global trade and investment.

In order to identify the dynamics of integration, clarify the external determinants that have effects on this process of integration, and identify the key problems that the EAEU member countries are dealing with, Kheyfets and Chernova (2021) looked into the relationships between the nations that make up this economic union. The underlying factor behind the integration process in the union's member states is the involvement of China's Belt and Road Initiative program. Finding the degree of per capita income convergence for the member countries of the EAEU reveals that this degree of convergence dropped, indicating that these countries are far behind other EAEU members in the process of catching up with integration. Due to China's financial assistance, the EAEU's member countries are beginning to favor it. The study also identified the main obstacles and limitations facing all of the participating countries in China's Belt and Road Initiative program. It also underlines the necessity of increasing support for Russia and the EAEU members' technological and innovative advancements in order to provide them with a competitive edge in discussions with China over discipline, globalization, and economic integration, Global economics, innovation and investment strategies, technological collaboration, and political and international relations.

AlKathiri (2022) used the nonparametric production frontier technique to perform an empirical analysis for both developing and developed countries from 1995 to 2014 to examine the convergence in the sector of manufacturing and the rise in labor productivity. The growth of labor productivity in the Sector of manufacturing is broken down into capital accumulation (the motion along the frontier), change in technical efficiency (the move towards or away from the frontier), and technological advancement (the movement in the production frontier). According to the study's findings, capital accumulation and technological innovation only have a small role in driving labor productivity growth, while technical efficiency has been declining over the studied time period. The findings also suggest that the expansion of the global manufacturing output frontier along with increased capital accumulation makes technical progress appear to be advantageous for highly industrialized economies and non-neutral overall. The study's findings also support the unconditional convergence of labor productivity in the industrial sector, with capital accumulation serving as the primary driver of this unconditional convergence. Additionally, the study contends that capital accumulation is crucial for impoverished nations to catch up with rich nations if they are to catch up.

For the member states of the European Union, Nagy and Šiljak (2022) carried out an empirical study to examine the income convergence following the financial crisis of 2008–2009. Their goal was to determine whether the EU could be viewed as a convergence machine following this financial crisis. For this purpose, the period is separated into three sub periods: from 2004 to 2008; from 2009 to 2013; and from 2014 to 2018. This study seeks to establish the association between macroeconomic factors and per capita income from 2004 to 2018. The study's findings corroborate the convergence theory and show that there was income convergence for the time period in question. They highlight how developing nations outpace industrialized nations in terms of economic growth and catch up in terms of GDP per capita as well. The study also establishes the rate of convergence at 1.71% to 4.51%. Additionally, this study's findings show that inflation, trade openness, and the integrity of the government all have a large direct influence on growth, but the results for unemployment are negligible for these countries for the time period in question.

Using the estimation techniques of mean group (MG), maximum likelihood (ML) and (ARDL) Saibu, Ikechukwu, and Nwosa (2022) conducted an empirical panel study for 14 West African countries to evaluate the impact of trade liberalization, foreign aid, and FDI on income convergence for the period of 1980-2018. The study's findings support the notion that FDI advances foreign technology in addition to improving the quality and effectiveness of factor inputs due to the expansion of the regional market and the diversification of intermediate inputs, several West African countries adopted the policy of trade liberalization rather than relying on FDI and foreign aid. According to the study's findings, trade liberalization, foreign direct investment, and foreign aid all have significant effects on the development of West African

countries. Additionally, it is advised that trade liberalization be increased in order to accelerate economic growth and income convergence and that export of primary commodities be replaced by secondary goods in order to boost regional economic integration and promote economic growth while reducing inequality.

In a study, Joshi (2022) examined the effects of exports, imports, gross capital formation, and money supply on Nepal's economic growth from 1965 to 2020. ADF is a method used to assess the autocorrelation of data, and the Johansen Cointegration Test is employed to test whether a long-term association exists or not. The test's findings support the variables' long-term relationships, and the Granger Causality Technique is also employed to examine their causal relationships. The findings support the hypothesis that economic growth and gross capital formation are correlated in both directions.

Korwatanasakul (2022) reviews the development of major Asian regional economic blocs in the context of the impact of regional economic integration on income convergence in the region. The study's findings could not support the impact of economic integration on income convergence in the whole continent of Asia because some parts of the Asia are less globalised and integrated, and as a result, the integration process has largely been restricted to the East and Southeast Asian nations. Furthermore, it is proposed that the process of gradual integration, through mechanisms of technological advancement, capacity building, growth in the labor supply, and market expansion, along with the completion of the ASEAN single market and Comprehensive Regional Economic Partnership, will be mutually advantageous for all members of the regional economic association.

The literature discussed here indicates that different studies determined income convergence for the different regions of the world through different techniques and concluded income convergence. However, the results in the Asia is contrary to the results of the other regions of the world as there are few studies that tested income convergence in South East Asia and South Asia with mix results but there is no such study which found the income convergence for the Central Asian countries, so this study is going to fill the research gap in the literature to explore the income convergence for Central Asia.

### **3. Research Methodology**

This is a panel study to test the intra-group per capita income convergence for Central Asian countries. Data are gathered from the World Bank's online database (World Development Indicators) for the years 2003 to 2019. This study follows the work done by Malik and Masood (2020) that employed panel unit testing for the testing of beta convergence and coefficient of variation for the testing of sigma convergence.

#### **3.1 Beta Convergence**

According to beta convergence, the economies of the developing nations expand more quickly than those of the developed ones and catching up to them in terms of per capita income. For assessing the income convergence the panel unit root tests Levin-Lin-Chu (LLC) developed by Levin, Lin, and Chu (2002); Im-Pesaran-Shin (IPS) test developed by Im, Pesaran, and Shin (2003) and ADF-Fisher Chi-square and PP-Fisher Chi-square test, developed by Choi (2001), are employed. According to the Levin-Lin-Chu (LLC) test, Assume the null hypothesis ( $H_0$ ), which states that every time series has a unit root and is therefore non-stationary, in contrast to the alternative hypothesis ( $H_1$ ), which states that every series is stationary. In contrast, the IM Pasaran, the Fisher-PP, and the Fisher-ADF panel unit root test assume the null hypothesis ( $H_0$ ), which states that the series is non-stationary, in contrast to the alternative hypothesis ( $H_1$ ), which states that some series are stationary.



$$Y_{it} = \beta Y_{it-1} + \epsilon_{it} \tag{1}$$

To avoid the unit root extra lags are included and can be written as under;

$$\Delta Y_{it} = \beta Y_{it-1} + \sum_{j=1}^p \delta_{ij} \Delta Y_{it-j} + \epsilon_{it} \tag{2}$$

Where  $Y_{it}$  is the average per capita income of the sample countries. When value of  $\beta$  is negative, it shows the existence of beta convergence, while its positive value depicts the divergence.

### 3.2 Sigma Convergence

Beta-convergence finds the expected catching up processes, while sigma convergence means the decline of inequalities in per capita income among the regions or nations over the passage of time. For testing the sigma-convergence, the coefficient of variation (C.V) is used, which is calculated by the formula as under:

$$CV = \frac{SD}{AM} * 100 \tag{3}$$

Where SD denotes standard deviation and AM denotes the sample countries' arithmetic mean per capita income. The widely used measure for testing the sigma ( $\delta$ ) convergence is the coefficient of variation of average per capita income, which shows a low or high degree of variability in relation to the average value. If the coefficient of variation decreases over time, the per capita income is less spread and there is the presence of sigma ( $\delta$ ) convergence.

## 4. Results and Discussion

### 4.1 Results of beta Convergence

For testing the beta convergence, the panel unit tests are applied. The findings of these tests are given in Table 1, which depicts the conclusion of the Levin-Lin-Chu (LLC) panel unit root test. The test's statistical value is (-5.93248) with a probability value of 0.0000, which is highly significant. The results show that the series is stationary or has no unit root, rejecting the null hypothesis that it is non-stationary, while the value of the coefficient (statistics) is negative also; it demonstrates the presence of beta convergence for the time period specified for the Central Asian countries. Table 2 depicts the findings of the Im-Pesaran-Shin (IPS) test panel unit root test. The test's statistical value is (-3.86028) with a probability value of 0.0001, which is highly significant. The results reject the null hypothesis that the series has a unit root and conclude that there is no unit root or the series is stationary. Additionally, the coefficient's (statistics) value is negative as well, indicating that there is existence of beta convergence in the average per capita income of Central Asian countries over the given time period.

**Table 1**  
***The results of the (Levin, Lin & Chu) panel unit root test***

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-5.93248	0.0000

Source: Authors' calculation

**Table 2**  
***The results of the (Im, Pesaran and Shin W-stat) panel unit root test***

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-3.86028	0.0001

Source: Authors' calculation

Table 3 depicts the conclusion of the ADF-Fischer Chi-square, panel unit root test for average per capita income for the economies of Central Asia. The results reject  $H_0$  that the series is non-stationary and come to the conclusion that series has no unit root or the series is stationary with a statistic value of the test is (52.9420) and highly significant probability value of 0.0006, which shows the existence of beta convergence for average per capita income of the Central Asian economies. Table 4 depicts the conclusion of the PP-Fisher Chi-square test for average per capita income for the nations of Central Asia. The statistic value of the test is 94.0313 with highly significant probability value of 0.0000. The results reject  $H_0$  that the series has unit root and conclude that the series is stationary or it doesn't have a unit root, implying that there is existence of beta convergence for Central Asia.

**Table 3**  
**The results of the (ADF - Fisher Chi-square) panel unit root test**

Method	Statistic	Prob.**
ADF - Fisher Chi-square	52.9420	0.0006
ADF - Choi Z-stat	-4.24606	0.0000

Source: Authors' calculation

**Table 4**  
**The results of the (PP - Fisher Chi-square) panel unit root test**

Method	Statistic	Prob.**
PP - Fisher Chi-square	94.0313	0.0000
PP - Choi Z-stat	-7.12290	0.0000

Source: Authors' calculation

## 4.2 Results of Sigma-convergence

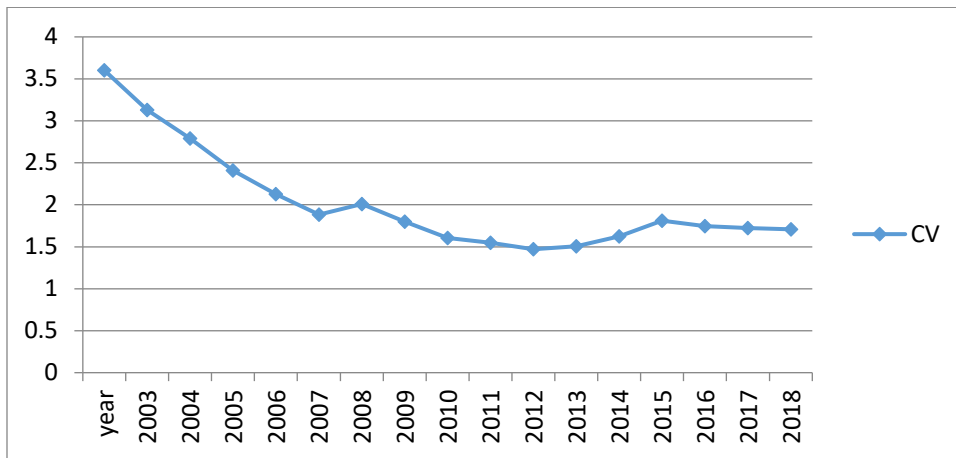
The conclusion of Table 5 depicts the sigma convergence of the average per capita of the Central Asian nations. The result of the coefficient of variation (C.V) of per capita income of Central Asian economies from 2003 to 2019 shows a declining pattern. In 2003, its value was 3.60, which was the highest value, and then it started to decline and decrease to 1.71 in the year 2019. It shows that the variation in average per capita income declined over time and concludes the existence of sigma convergence for the nations of Central Asia.

**Table 5**  
**The Results of Coefficient of Variation (CV) of Average per capita Income of Central Asian Countries**

Year	Uzbekistan	Kazakhstan	Kyrgyzstan	Tajikistan	Average	SD	CV
2003	396.37	2068.12	380.50	237.75	770.69	27.76	3.60
2004	465.12	2874.29	433.23	311.62	1021.06	31.95	3.12
2005	546.77	3771.28	476.55	340.58	1283.79	35.83	2.79
2006	654.28	5291.58	543.11	408.83	1724.45	41.52	2.40
2007	830.40	6771.41	721.76	526.64	2212.55	47.03	2.12
2008	1082.29	8513.56	966.39	715.86	2819.52	53.09	1.88
2009	1213.27	7165.22	871.22	676.12	2481.45	49.81	2.00
2010	1634.31	9070.49	880.03	749.55	3083.59	55.53	1.80
2011	1926.29	11634.00	1123.88	847.38	3882.89	62.31	1.60
2012	2137.03	12386.70	1177.97	969.29	4167.74	64.55	1.55
2013	2281.41	13890.60	1282.44	1048.23	4625.67	68.01	1.47
2014	2492.34	12807.30	1279.77	1104.17	4420.88	66.48	1.50
2015	2615.03	10510.80	1121.08	929.09	3793.99	61.59	1.62
2016	2567.80	7714.84	1120.67	802.51	3051.45	55.23	1.81
2017	1826.57	9247.58	1242.77	806.04	3280.74	57.27	1.74
2018	1529.08	9812.60	1308.14	826.62	3369.11	58.04	1.72
2019	1724.84	9812.39	1309.39	870.78	3429.35	58.56	1.71

Source: Author's estimations

Figure 2 depicts the coefficient of variation (CV) of the average per capita income of the nations of Central Asia, which clearly shows that first the dispersion among the per capita incomes of the nations was high and then it started to decline, which shows that there is sigma convergence for the countries of Central Asia for the selected period.



**Figure 2: The Results of the Sigma Convergence for Central Asia**  
**Source:** Author's calculation

The results of both the beta convergence and sigma convergence tests show that there is income convergence for the nations of Central Asia.

## 5. Conclusions and Recommendations

The main objective of the current study is to explore income convergence for the Central Asian countries. For determining income convergence, there are two well-known concepts: beta and sigma convergence. According to beta convergence, the developing economies grow quicker than those of the developed ones and are catching up with developed countries in terms of per capita income. Whereas sigma convergence indicates that the gaps between the per capita incomes of the nations in the region decrease over the passage of time. In order to test beta convergence, this study applied panel unit roots tests, whereas sigma convergence is tested through the coefficient of variation. The findings of the Levin–Lin–Chu (LLC) panel unit root test give the significant and negative value of the average per capita income of the nations of Central Asia and conclude that there is the presence of beta convergence for the countries of Central Asia for the specified period of time, while the values of the tests of Im, Pesaran, and Shin W-stat test, PP-Fisher (Chi-square) test, and ADF-Fisher (Chi-square) test also confirm the presence of beta convergence for Central Asia.

The findings of all panel unit tests confirm the beta convergence for the Central Asia. The value of the coefficient of variation confirms the decline in the dispersion of average per capita income for Central Asia. The conclusions of both the beta and sigma convergence tests depict the income convergence for the Central Asia. The results of the studies of Głodowska and Pera (2019) for Eastern and Central European Countries, Zia and Mahmood (2019) for ASEAN countries, Malik and Masood (2020) for MENA countries and Ghatak (2021) for ASEAN concluded income convergence and these studies found the similar results like this study. While, the results of the study of Kant (2019) for South Asian and Sub-Saharan countries of Africa, Zia and Mahmood (2019) for SAARC, Safdar and Nawaz (2020) for SAARC and Ghatak (2021) for SAARC concluded contradictory results as these mentioned studies did not concluded income convergence for respective regions.

It can be concluded that economic integration is in favor of Central Asia, so it is recommended that these nations must ensure economic cooperation with each other through

easing trade restrictions and lessening import taxes on imports. Moreover, it will also be helpful to ensure the free mobility of the labor force among Central Asian countries, as it will further help them to ensure economic integration and helps in reducing the income inequality in the region. One of the limitations of the study is time period due to availability of the data so researchers may determine for large period if data is available and may also apply other techniques for income convergence. This study did not determine the factors of income convergence so future studies for the Central Asia may examine the factors of income convergence. Likewise, income convergence in this study is only limited to Central Asia so future studies may consider other countries and regions with Central Asia countries that are viable for Central Asia to determine income convergence and examining the factors of income convergence.

### Authors Contribution

Hameed Gul: Conceptualization, Methodology, Data and Analysis, Initial draft, Editing

Ihtisham ul Haq: Conceptualization, Methodology, Revision and Editing

Dilawar Khan: Conceptualization, Revision and Editing

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### References

- AlKathiri, N. (2022). Labour productivity growth and convergence in manufacturing: A nonparametric production frontier approach. *Applied Economics*, 54(4), 406-429. doi:<https://doi.org/10.1080/00036846.2021.1963410>
- Barro, R., & Sala-i-Martin, X. (2004). *Economic growth* (2nd ed.). Cambridge MA: The MIT Press.
- Choi, I. (2001). Unit root tests for panel data. *Journal of international money and Finance*, 20(2), 249-272. doi:[https://doi.org/10.1016/S0261-5606\(00\)00048-6](https://doi.org/10.1016/S0261-5606(00)00048-6)
- Dey, S. P., & Neogi, D. (2015). Testing sigma and unconditional beta convergence of GDP for SAARC countries: Can inclusion of China further consolidate the convergence? *Global business review*, 16(5), 845-855. doi:<https://doi.org/10.1177/0972150915591643>
- Druzhinin, P., & Prokopyev, E. (2018). An assessment of the economic performance of the eu Baltic region states. *Baltic region*, 10, 4-18. doi:<https://doi.org/10.5922/2079-8555-2018-1-1>
- Ghatak, S. (2021). Convergence potentials in SAARC and ASEAN economies. *The Journal of Indian and Asian Studies*, 2(01), 2150004. doi:<https://doi.org/10.1142/S2717541321500042>
- Ghatak, S., & De, P. (2021). Income Convergence Across Asian Economies: An Empirical Exploration. *Journal of Asia-Pacific Business*, 22(3), 182-200. doi:<https://doi.org/10.1080/10599231.2021.1943808>
- Glawe, L., & Wagner, H. (2021). Convergence, divergence, or multiple steady states? New evidence on the institutional development within the European Union. *Journal of Comparative Economics*, 49(3), 860-884. doi:<https://doi.org/10.1016/j.jce.2021.01.006>
- Głodowska, A., & Pera, B. (2019). On the relationship between economic integration, business environment and real convergence: The experience of the CEE countries. *Economies*, 7(2), 54. doi:<https://doi.org/10.3390/economies7020054>
- Haider, A., Hameed, S., & Wajid, A. (2010). Income convergence hypothesis: a regional comparison of selected East and South Asian economies. In *Munich Personal RePEc Archive* (pp. MPRA Paper No. 23739).
- Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of econometrics*, 115(1), 53-74. doi:[https://doi.org/10.1016/S0304-4076\(03\)00092-7](https://doi.org/10.1016/S0304-4076(03)00092-7)
- Joshi, U. L. (2022). Determinants of Economic Growth in Nepal: A Johansen Cointegration Analysis. *International Research Journal of MMC*, 3(1), 40-48. doi:<https://doi.org/10.3126/irjmmc.v3i1.44192>

- Kant, C. (2019). Income convergence and the catch-up index. *The North American Journal of Economics and Finance*, 48, 613-627. doi:<https://doi.org/10.1016/j.najef.2018.07.017>
- Khan, G., & Daly, V. (2018). Growth convergence and divergence in SAARC. *Research in Economics and Management*, 3(4), 315. doi:<http://dx.doi.org/10.22158/rem.v3n4p315>
- Khan, I., Nawaz, Z., & Saeed, B. B. (2021). Does trade openness and FDI reduce inequality? Evidence from South Asia. *International Journal of Finance & Economics*, 26(4), 6459-6470. doi:<https://doi.org/10.1002/ijfe.2131>
- Kheyfets, B. A., & Chernova, V. Y. (2021). External Factors Encouraging Integration within the Eurasian Economic Union. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies*, 12(5), 1-10. doi:<https://doi.org/10.14456/ITJEMAST.2021.88>
- Korwatanasakul, U. (2022). Revisiting Asian economic integration: challenges and prospects. *Journal of the Asia Pacific Economy*, 27(2), 199-222. doi:<https://doi.org/10.1080/13547860.2020.1840493>
- Levin, A., Lin, C.-F., & Chu, C.-S. J. (2002). Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of econometrics*, 108(1), 1-24. doi:[https://doi.org/10.1016/S0304-4076\(01\)00098-7](https://doi.org/10.1016/S0304-4076(01)00098-7)
- Lohani, K. K. (2021). Trade and Convergence: Empirical Evidence from BRICS Countries. *Global business review*, 0972150921993057. doi:<https://doi.org/10.1177/0972150921993057>
- Malik, M. A., & Masood, T. (2020). Analysis of growth accounting and convergence in MENA countries: Panel cointegration approach. *South Asian Journal of Macroeconomics and Public Finance*, 9(2), 237-262. doi:<https://doi.org/10.1177/2277978720968416>
- Mogilevskii, R. (2012). Trends and patterns in foreign trade of Central Asian countries. *University of Central Asia, Institute of Public Policy and Administration, Working Paper 1*. doi:<http://dx.doi.org/10.2139/ssrn.3023165>
- Monfort, P. (2008). *Convergence of EU regions: Measures and evolution*: European Commission, Regional Policy Brussels.
- Mukhitdinova, N. (2015). Central Asia. *UNESCO Science Report: Towards, 2030*, 365-387.
- Nagy, S. G., & Šiljak, D. (2022). Is the European Union still a convergence machine? *Acta Oeconomica*, 72(1), 47-63. doi:<http://doi.org/10.1556/032.2022.00003>
- Nguyen, H. M., Quan, B. Q. M., Le, H. V., & Tran, T. V. (2020). Determinants of intra-industry trade between vietnam and countries in tpp. *The Journal of Asian Finance, Economics and Business*, 7(1), 123-129. doi:<https://doi.org/10.13106/jafeb.2020.vol7.no1.123>
- Safdar, M., & Nawaz, A. (2020). Testing the convergence hypothesis in Solow growth model: a statistical evidence from SAARC economies. *Bulletin of Business and Economics (BBE)*, 9(2), 60-73.
- Saibu, O. M., Ikechukwu, O. M., & Nwosa, P. I. (2022). Dynamic Effects of Foreign Aid, Trade Openness and Fdi on Economic Growth for West African Countries. *The Journal of Developing Areas*, 56(2), 49-63. doi:<https://doi.org/10.1353/jda.2022.0034>
- Sala-i-Martin, X. X. (1996a). The classical approach to convergence analysis. *The economic journal*, 1019-1036.
- Sala-i-Martin, X. X. (1996b). Regional cohesion: evidence and theories of regional growth and convergence. *European economic review*, 40(6), 1325-1352.
- Santillán-Salgado, R. J., & Ortega-Díaz, A. (2017). Is there Convergence or Divergence in the International Competitiveness of the Eurozone Countries? In *Economic Imbalances and institutional changes to the Euro and the European Union*: Emerald Publishing Limited.
- Sohn, C. H., & Lee, H. (2006). How FTAs affect income levels of member countries. *World Economy*, 29(12), 1737-1757. doi:<https://doi.org/10.1111/j.1467-9701.2006.00866.x>
- Solow, R. M. (1956). A contribution to the theory of economic growth. *The quarterly journal of economics*, 70(1), 65-94.
- Tran, O. K. T., Le, H. D., & Nguyen, A. H. V. (2021). Role of institutional quality in economic development: A case study of Asian countries. *Problems and Perspectives in Management*, 19(2), 357-369. doi:[https://doi.org/10.21511/ppm.19\(2\).2021.29](https://doi.org/10.21511/ppm.19(2).2021.29)

- Tu, M. T. C., & Giang, H. T. T. (2018). Estimating the impact of trade cost on export: A case study vietnam. *The Journal of Asian Finance, Economics and Business*, 5(3), 43-50. doi:<https://doi.org/10.13106/jafeb.2018.vol5.no3.43>
- Zakaria, M. (2014). Effects of trade liberalization on exports, imports and trade balance in Pakistan: A time series analysis. *Prague economic papers*, 23(1), 121-139. doi:<https://doi.org/10.18267/j.pep.476>
- Zia, U., & Mahmood, Z. (2019). Tests of income convergence in ASEAN and SAARC trading blocs. *South Asia Economic Journal*, 20(2), 167-183. doi:<https://doi.org/10.1177/1391561419858239>