Global and Regional Patterns of Demographic Convergence: Analysis of Fertility, Population Growth and Age Structure

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Abstract

This research delves into the global and regional aspects of demographic convergence. Employing a holistic approach, multiple demographic factors - including fertility rate, population growth rate, age dependency ratio, and the ratio of working age to total population, are analysed both globally and regionally for the period of 1960-2020. Convergence is evaluated using established approaches, encompassing absolute and conditional beta and sigma convergence. The results of absolute beta values on a global level revealed robust convergence in population growth, with Europe exhibiting the highest levels and Asia the lowest. The fertility rate displayed moderate convergence, with Europe leading and Africa showing divergence. The convergence in the working-age population was found to be weak. The convergence in dependency ratio was insignificant worldwide, but exhibited significance in Europe, Latin America, and the Caribbean. The findings indicate evidence for conditional convergence across all geographic regions, but the rate of conditional convergence is higher for population growth and fertility. Sigma convergence is primarily manifested in population growth rates, but some coefficients are also pointing towards divergence. Based on the results of conditional beta convergence, the study recommends strengthening human capital across developing countries to help accelerate the process of demographic convergence.

Keywords: Age Dependency Ratio; Working Age Population; Absolute Beta and Conditional Beta Convergence; Sigma Convergence; GMM.

Introduction

As the world undergoes economic, technological, and cultural transformations, one of the significant transitions observed pertains to the demographic characteristics and processes of the countries. The theories of demographic transition in their initial form classified countries into three major groups based on demographic characteristics, i.e., countries with high growth potential, countries facing incipient decline, and countries facing transitional growth. Subsequently, it is pertinent to inquire whether the demographic transition has resulted in a global convergence of demographic characteristics, i.e., is the world moving towards a unified demographic pattern? (Wilson, 2001). According to Bloom and Williamson (1998), the outcome of the demographic

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transition would be a stability/convergence towards lower birth and death rates, resulting in zero or negative natural growth rates.

The term "demographic convergence" signifies the narrowing of the demographic gap and movement towards a unified demographic regime (Wilson, 2001). Various factors, as noted by McMichael (2004) and Moser, Shkolnikov, and Leon (2005), are believed to embody this process, such as encompassing the balance and imbalance in global birth and death rates. On the other hand, Lee and Mason (2010) and Wilson (2001) emphasize that the convergence in fertility rates plays a pivotal role in propelling demographic convergence forward. In this context, disparities in the economic performance of countries may be attributed to the varying demographic characteristics (Buyukkececi & Englehardt, 2021). For instance, Sachs (1997) points to the working population as the key demographic indicator that may explain the varying outcomes for the nations, especially when comparing East Asia with South Asia. In fact, Anderson and Kohler (2015) reflect on regional disparities in demographic trajectories as a feature that can explain future inequalities in nations' social and economic achievements.

Looking back into the last century, one can infer a global tendency towards demographic convergence. The second half of the 20th century saw an unprecedented worldwide population shift. The UN Population Division predicts that life expectancy at birth increased from 46.5 years in the 1950s to 65.4 years during 1990, primarily based on the worldwide population (United Nations 1999-1998). The time period from 1960 to 1990 shows convergence in average life expectancy (Becker, Philipson & Soares, 2005). However, the decade of the 1990s witnessed divergence in life expectancy owing to a significant decline in men's life expectancy in Eastern Europe and Russia and the prevalence of HIV/AIDS in sub-Saharan Africa (SSA) (Neumayer, 2004; Goesling & Firebaugh, 2004). Over the same time (1961-1990), the fertility rate reduced from a worldwide average of 5 to 2.7 (Wilson, 2011). Almost all less developed nations began the transition to low fertility over the period of fifty years, though in two phases. The majority of Asian, Latin American, and Caribbean (LA&C) countries were included in the first wave. The second wave, which was during the 1990s, included North Africa, much of West Asia, and SSA. While the global fertility rate dropped from approximately five live births per woman in 1950 to 2.5 births in 2015, fertility rates in most SSA countries remain above four children per woman (United Nations DESA, 2020). Apart from South Africa and Mauritius, no other SSA countries have fully undergone the fertility transition. However, even in these two nations, fertility rates vary significantly across different socioeconomic groups (Bruni, Rigolini, and Troiano, 2016). Some countries have yet to begin their fertility transition, while others have experienced initial declines, though these reductions have often been temporary, leading to what is referred to as fertility stalls in some instances (Grimm et al., 2022).

This makes the possibility of global demographic convergence ambiguous. The prevalent hypothesis in many of the UN World Population Prospects Revisions (UNWPPR) is the notion of weak convergence. This entails a reduction in variability within a supposedly homogeneous group of countries. The uncertain trajectory of demographic transition, along with the absence of a unanimous agreement on the likelihood of demographic convergence, makes it imperative to reexamine the issue thoroughly.

In this context, the current body of literature exhibits the following notable characteristics: it primarily addresses a limited set of demographic factors, such as fertility and mortality trends (except Bloom and Williamson (1998), and Azomahou and Mishra (2008) for population), when studying demographic convergence. Further, it concentrates mainly on the trend analysis of specific demographic variables to analyze demographic convergence. Therefore, the primary

objective of the study is to examine multiple demographic variables through a rigorous inferential analysis to conclude demographic convergence. We argue that relying solely on fertility and mortality rates is inadequate for a comprehensive understanding of the status of global and regional demographic convergence contemporaneously. Therefore, our research delves into demographic convergence across pivotal demographic indicators that bear significant socioeconomic implications, thereby contributing to the current body of knowledge. Alongside fertility rates, we have integrated population growth rate, age dependency ratio (ADR), and the ratio of working-age population to the total population (WAPR). Needless to say, both ADR and the WAPR are crucial determinants of productivity, labor force dynamics, and overall economic well-being (Van Der Gaag & De Beer, 2015; Cruz & Ahmed, 2018). These ratios capture prospective labor market implications of demographic characteristics and changes that have significant consequences for the economy as a whole. While demographic processes of fertility and mortality directly shape both demographic characteristics, their independent importance for national prosperity makes it essential to understand their convergence paths for effective policy design.

In terms of methodology, we employ a comprehensive approach by employing established empirical techniques to assess demographic convergence, including absolute beta, conditional beta, and sigma convergence in our analysis. Furthermore, our study stands out as the pioneer in examining demographic convergence, not only on a global scale but also for distinct geographic regions (Asia, Africa, Europe, and the LA&C region) individually, spanning from 1960 to 2020. The regional analysis incorporates the geographical proximity aspect of demographic processes and characteristics, and enables us to investigate whether demographic convergence can be a regional phenomenon. Our research has yielded valuable insights into the patterns of both global and regional convergence in demographic characteristics of significant consequence.

The remainder of the study is as follows: Section 2 includes the literature review, Section 3 presents methodology and information regarding data, Section 4 presents the results, and Section 5 concludes.

Literature Review

The principle of convergence asserts that countries catch up with each other in their demographic, social, and economic characteristics over the process of development. Many economic theories set the foundations for the convergence phenomenon. To begin with, the Neo-classical growth model given by Solow (1956) and Swan (1956) emphasized that free market and diminishing returns to capital bring income convergence (Abramovitz, 1986). The idea of income convergence is later applied to different socioeconomic variables. According to the Core Nations Convergence (CNC) theory, countries with similar social characteristics achieve a similar level of economic growth. According to sociologists, convergence theory is related to modernization theories. Poor countries follow the path of development of advanced countries (Inkeles, 1999).

Similarly, in many studies about population, the idea of convergence is linked with the demographic principle. It implies that among the nations, birth and death rates would vary over the years symmetrically and predictably (Hendi, 2017). The convergence hypothesis has been supplemented through the principle of modernization as well, which describes an international shift in the direction of a new '*demographic equilibrium*' (Wilson, 2001). Traditional theory states that the speed of convergence is mainly influenced by the country's relative status, i.e., a rich country grows more slowly and a poor country grows faster; this process is defined as absolute β convergence, which predicts homogenous international demographic statistics with nearly no demographic variability (Wilson, 2001). However, according to De la Croix and Gobbi (2017),

population density, education, greater access to services like healthcare, and changes in cultural norms imply a reasonably quick rate of convergence in fertility in developing economies. Education, gender equality, women's labor force participation, and women's empowerment are also rendered significant for demographic convergence/divergence (Sala-i-Martin, 2006).

The geographical considerations in demographic transition research have been varied. There is research dealing with demographic convergence among sub-national regions, while others are based on a cross-section of global economies. Dorius (2008) used an experimental approach and indicated a significant trend of beta convergence over fifty years from the 1950s to the 2000s, while the incidence of sigma convergence was delayed. On the other hand, Herbertsson, Orszag, and Peter (2001) found both absolute and conditional convergence in global birth rates. Nakagaki (2019) confirmed fertility convergence among 187 world countries for the time period 1990 to 2017, but no evidence before 1990.

In contrast, some studies indicate the absence of world fertility convergence (Papagni, 2023). Moser, Shkolnikov, and Leon (2005), using the Dispersion Method Mortality (DMM), exhibited a continued convergence trend in infant mortality during the second half of the last century. Garbero and Sanderson (2012) confirmed convergence in death rate by using estimates of women's life expectancy. Convergence in global mortality from 1990 to 2015 was affirmed by Gabrielli et al. (2021) as well, except for SSA countries, which exhibited monotonic trends.

Furthermore, a study by d'Albis, Esso, and Arolas (2012) furnished evidence for convergence clubs and convergence in adult death rates. Furthermore, Moser, Shkolnikov, and Leon (2005) found life expectancy to be declining between the 1950s and 1980s, but after that, it continued to increase, corroborating the existence of demographic convergence replacing the previous divergence trend. d'Albis, Esso, and Arolas (2012) also indicated conditional convergence in life expectancy in the world.

In regional analyses, Hrzic et al. (2021) found no trace of both sigma and beta convergence in mortality rates in European Union member countries. As far as the convergence of fertility rates of the European Union is concerned, eminent evidence of σ-convergence, γ-convergence, and unconditional beta convergence was found in the Region during 1977-2007. During this time period, some divergence was reported by Lanzieri (2010). In another study, Goli et al. (2019), while analyzing health inequalities in SSA from 1950 to 2015, concluded that health status diverged over the period 1985 to 1990 in the Region due to HIV spread. While in the next decade, this divergence was replaced by convergence. Another study indicated convergence in fertility rate among female refugees from Mozambique and local South African women (Williams et al., 2013**)**. Significant convergence in infant mortality rates among diverse racial groups in the United States is indicated by Chay and Greenstone (2000). Using a distributional approach, Branisa and Cardozo (2009) analyzed the existence of both sigma and beta convergence of life expectancy in Colombian states during 1995-2005. Moving towards Asian economies, studies depict 70% of the Asian economies to be at a natural fertility condition, with the exception of Japan and Singapore. Additionally, this situation changed in the 1990s when 85% of the Asian economies started undergoing a decline in fertility (Hosseini, 2010).

In another country study, Hastuti et al. (2022) investigated health convergence and its determinants in 33 districts of North Sumatra and confirmed the existence of health convergence at a rate of 4.3%. Similarly, overall health was found to be converging at a steady state with high values of the Overall Health Index (OHI) in India as well (Hembram & Haldar, 2020). It was also revealed that multiple regions of India witnessed fertility changes at different time periods. Furthermore, massive divergence in fertility rates in the 1970s and 1980s is believed to be dominating the overall

results despite convergence after the 1990s (Arokiasamy & Goli, 2012). Similar results were concluded by Wilson et al. (2012), which indicated minor divergence all over India with the exception of northern areas. In Pakistan, Ahmad, Hussain, and Bhatti (2021) concluded that convergence clubs in human development are not uniformly distributed and stressed the need for a reduction in regional disparities. A similar situation was evident in Bolivia, where poor states were far from achieving long-term convergence in terms of human development (Mendez-Guerra, 2018).

Furthermore, Kuropka and Krupowicz (2021), while analyzing convergence in death rates across regions of Poland, affirmed that particularly disadvantaged regions are the main drivers of mortality in the country. A divergence in mortality rate was observed owing to increased variation within provinces. Finally, no evidence of convergence in fertility rates of Russia was indicated by Shubat (2019) for the period 1990-2016**.**

The literature points predominantly in favor of global demographic convergence in fertility and mortality rates. However, it is essential to ascertain the existence of convergence or divergence in other consequential demographic indicators, especially those affecting labor market outcomes and socioeconomic status of the populace, i.e., ADR and WAPR. Further, the demand for scarce national resources is predicated on population growth, and hence an exploration into regional and global demographic convergence in population growth is also in order. Our study is an endeavor to address these issues.

Methodology

The study is the first of its kind to analyze demographic convergence not only for the world as a whole but also for each of the geographic regions separately for the time period spanning over sixty years from 1960 to 2020.[5] The geographic analysis covers four regions, namely, Asia, Africa, Europe, and Latin America and the Caribbean (LA&C). The convergence literature has been evolving over the years, containing numerous measures for convergence.[6] Three of these are utilized to study demographic convergence, which are absolute beta convergence, conditional beta convergence and sigma convergence. The primary demographic variables considered in the analysis are age dependency ratio (ADR), population growth rate, fertility rate, and working age population to total population (WAPR).

Adapting from the traditional methodology of income convergence, absolute β demographic convergence is estimated through the following regression:

$$\ln\left[\frac{y_j(\tau)}{y_j(t)}\right] = \alpha - \left(1 - e^{1-\beta t}\right)\ln\left(y_j(t)\right) \qquad (1)$$

Y_j represents the focused demographic variable, namely, fertility rate, WAPR, ADR, and population growth. Where, τ represent 5 years ahead of t. i= 1, 2,…….213 countries (number of countries is determined by the availability of data). t=1, 2, 3,……..60 (1960 to 2020). Keeping up with the tradition of convergence analysis, a five-yearly interval of data is used. Therefore, the total time series observations are 12. The growth rate of the focused demographic variable is regressed on its initial value, and then the coefficient of convergence is calculated through point estimators of non-linear combinations. In equation (1), β is the speed of convergence.

[5]*Since data was not available for 2024 and 2025, and estimation was based on five years interval, therefore, study span extends only up to 2020.*

[6]*For a detailed review on measures of convergence see Khan (2012).*

As opposed to absolute beta convergence, conditional beta convergence is estimated by adding control variables in equation (1). These control variables are different determinants of demographic changes, such as globalization, urbanization, human capital, and per capita income growth, etc.

$$ln\left[\frac{y_j(\tau)}{y_j(t)}\right] = \mu_i + \alpha_1 Glob_{it\tau} + \alpha_2 HK_{it\tau} + \alpha_3 PG_{it\tau} + \alpha_4 UR_{it\tau} + \left(1 - e^{1-\beta t}\right) \ln\left(y_j(t)\right) + \omega_{it} \quad (2)$$

Where,

$HK_{it\tau}$ is Human capital, $PG_{it\tau}$ is Per capita income growth, $Glob_{it\tau}$:is Globalization (measured through the KOF Index), $UR_{it\tau}$ is Urbanization (urban population as a percentage of total population). Where Y_j is the j^{th} demographic variable of the i^{th} country in different time periods.

Finally, σ convergence is estimated by calculating the standard deviation of a specific demographic indicator for all the sample countries for each year, and the estimated standard deviation is regressed against the time trend.

$$\sigma_t = \delta_0 + \delta_1 t + \varepsilon_t \quad (3)$$

't' is a time trend. Negative coefficient of δ_1 indicates convergence.

The major data source is World Development Indicators by the World Bank. Data for fertility rate, population growth, ADR, WAPR, per capita income growth, and urbanization are retrieved from World Development Indicators. Data for human capital is taken from PWT 10.0 (Penn World Tables). However, data for overall globalization and its dimensions (Economic, Political and Social) is taken from the KOF Globalization Index. Moving towards the estimation technique employed in the analysis, estimation for absolute beta and sigma convergence is based on the Ordinary Least Squares (OLS) technique. While conditional beta convergence is analyzed using the dynamic panel Generalized Methods of Moments (GMM) estimation technique.

Results and Discussion

Before moving towards the results of the study, it is crucial to have an overview of the data sample. Descriptive statistics of the data are given in Table 1. It gives information on the total number of observations for each variable, along with minimum, maximum values, and mean and standard deviation, for all variables used in the analysis pertaining to the global sample and its various categories. The study analyzed absolute beta convergence, sigma convergence, and conditional beta convergence separately and results are presented below.

Results for Absolute Beta Convergence

The results of absolute beta convergence of the world as a whole and its four continents are presented in Table 2 for four demographic variables, namely, population growth, WAPR, ADR, and fertility rate. Starting from the world sample for the variable of population growth, the coefficient is -0.231, where the negative sign confirms evidence for absolute β convergence. The implied rate of convergence is 5.3% which is significant at 1% level of significance. Moving towards the continents for their respective convergence coefficients, population growth is converging in Asia and Europe at the rates of 4.1% and 12% respectively. Interestingly, Africa has quite a high rate of convergence of population growth, i.e., 9.6%. Similarly, population growth is converging in LA&C economies at a rate of 8%. Comparison of convergence rates for the remaining three regions shows that Europe has the highest rate of convergence, while Asia has the lowest rate.

The variable that is closely associated with the population growth is fertility. According to the United Nations (UN) population division, fertility plays a major role in determining the trend of the global population (United Nations, 2004). De la Croix and Gobbi (2017) found that the passage of development in a society's population tends to converge in the long run. The basic reasons are better education, improved health services and awareness, accompanied by cultural harmony over time. Arthur (1981) analyzed that once an economy's age-specific birth and death rates become stable, the age structure will converge to a fixed form. This process is named as the *strong ergodic theorem* of demography (Arthur, 1982).

On the right side of Table 2, convergence figures are reported for the fertility rate. Beginning with the world sample, the coefficient is -.0091 with an implied convergence rate of 0.1%. This is in line with Dorius (2008), who concluded that fertility started to converge in the latter part of the 1990s. Further, Nakagaki (2019) also affirmed the existence of fertility convergence around the globe starting from the 20th century till 2017. European and LA&C economies indicated convergence in fertility with significant coefficients. The case of Asian economies is a bit different, as the results are insignificant. The European region came up with a high implied convergence rate of 3%. Keeping in mind the fact that the European population indicated the highest rate of convergence for population growth as well. Contrary to the results for population growth, fertility rates in Africa are found to be diverging. This trend is depicted in Nakagaki (2019) as he showed convergence in Asia and Latin America but not in Africa. This demographic pattern may be an outcome of the political economy of African nations. The study by Corker, Rossier, and Zan (2022) explains that the divergence in fertility rates in Africa is attributed to the diverse socioeconomic conditions of women. African women belonging to higher socioeconomic strata are nearing the end of their fertility transition. Hence, the fertility trends in Africa, while higher than the global average, diverge regionally on the basis of economic development.

Moving towards the next variable, that is the ADR, the coefficient of initial values for the world sample and Asia is insignificant and thus does not depict any evidence of convergence. Coefficients of initial values for Europe and the LA&C region are -1.568 and -0.0177, respectively, indicating significant convergence. Europe underwent comparatively high convergence in terms of the ADR as compared to the rest of the regions, with the implied rate of convergence of 3%. African economies, on the other hand, experienced divergence with the implied rate of 0.4%. The divergence in Africa can again be explained by the variation in age-specific death rates among African nations. In economically struggling nations, death rates among young children tend to be higher, in war-affected countries, there are higher rates of mortality among youth, and in more stable nations, mortality is primarily concentrated among very young and very old. These patterns of mortality accompanied by divergent fertility may be a major factor in explaining divergence in age composition in Africa.

Table 1: Descriptive Statistics

Variables	Adr	FR	PG	Popg	Urbn	WTP	Hc	Og	Eg	Sg	Pg
World sample											
obs.	2514	2346	1946	2595	2793	2520	1570	1778	1710	1835	1834
Min	15.7	0.8	-54.64	-4.1	2.0	45.23	1.0	14.1	10.5	4.8	1.1
Max	121.0	8.8	53.97	19.9	100	86.39	3.7	90.6	94.4	91.8	98.1
Mean	71.2	4.0	1.38	1.7	51.1	59.19	2.0	48.7	48.7	49.1	48.5
SD	20.1	2.02	6.3	1.6	25.8	7.03	0.7	16.4	16.5	21.4	25.3
Asia sample											
obs.	793	738	572	803	871	793	441	518	518	546	545
Min	15.7	0.8	-54.64	-3.8	3.4	45.89	1.0	14.4	10.5	6.5	2.6
Max	117.8	8.8	53.97	15.9	100	86.39	3.7	84.4	94.4	90.3	92.0
Mean	69.7	4.2	1.96	2.1	50.4	59.77	2.0	45.9	48.9	46.0	42.3
SD	19.9	1.8	7.5	1.8	27.5	7.38	0.6	14.9	17.0	20.0	23.8
Africa sample											
Obs	694	634	534	640	700	700	459	509	501	511	511
Min	41.4	1.3	-24.96	-3.8	2.0	46.76	1.0	14.1	12.5	4.8	4.2
Max	113.7	8.4	37.53	8.85	90.0	70.59	2.8	71.7	82.6	77.5	2.8
Mean	87.5	5.8	0.95	2.5	32.6	53.60	1.4	38.3	40.0	31.3	43.7
SD	13.6	1.3	6.0	1.0	18.9	4.33	0.3	10.6	11.4	13.9	18.7
Europe sample											
Obs	546	528	404	612	650	546	363	392	342	399	399
Min	34.8	1.1	-15.20	-3.5	14.3	52.06	1.2	29.3	23.2	31.6	1.1
Max	92.0	6.4	24.19	5.9	100	74.15	3.7	90.6	92.1	91.8	98.1
Mean	53.0	2.0	1.85	0.5	64.4	65.4	2.8	65.3	63.5	69.9	65.2
SD	7.7	0.7	4.7	0.9	20.0	3.1	0.4	15.7	15.9	13.6	28.1
Latin America and Caribbean sample											
obs.	455	417	406	504	533	455	283	329	319	349	349
Min	39.3	1.3	-27.77	-4.1	12.2	45.23	1.1	23.0	18.2	18.8	2.1
Max	121.0	7.5	42.78	19.9	100	71.75	3.4	76.3	73.9	84.8	91.1
Mean	71.8	3.7	0.65	1.6	58.0	1.61	2.0	48.3	45.7	54.0	45.0
SD	18.9	1.6	6.2	1.67	22.0	1.67	0.4	9.9	11.8	15.4	23.11

Table 2: Absolute Beta Convergence: Global Analysis

Region/ Results	Population growth			Age dependency ratio			Working to total population			Fertility rates		
	Coefficient on lag	Implied coefficient on convergence	(n)	Coefficient on lag	Implied coefficient on convergence	(n)	Coefficient on lag	Implied coefficient on convergence	(n)	Coefficient on lag	Implied coefficient on convergence	(n)
World	-.231*** (-16.06)	0.053*** (14.04)	2085	-.0070 (1.36)	0.01 (1.35)	2320	-.014*** (2.46)	0.002*** (2.84)	2326	-.0091** (2.47)	0.001** (2.46)	2142
Asia	-.19*** (-6.81)	0.041*** (6.13)	680	.0083 (0.77)	-0.001 (0.77)	732	-.0069 (0.64)	0.001 (0.64)	732	-.0082 (1.05)	0.001 (1.04)	674
Europe	-.439*** (-12.03)	0.12*** (8.89)	400	-.1568*** (8.38)	0.034*** (7.68)	504	-.159*** (8.90)	0.03*** (8.15)	504	-.1475*** (9.21)	0.031*** (8.50)	481
Africa	-.382** (-9.63)	0.096*** (7.5)	571	.0251*** (1.79)	-0.004*** -(1.81)	640	0.0104 (0.72)	-0.002 (0.72)	646	.0669*** (7.24)	-0.012*** -(7.48)	588
Latin-American and Caribbean	-.34** (-10.07)	0.08** (8.12)	406	-.0177*** (1.48)	0.003**** (1.46)	420	-.030** (2.52)	0.0062** (2.48)	420	-.0325*** (3.92)	0.0066*** (3.86)	381

Notes: In this table t-statistics are presented in (.). [n] Indicates the total number of observations in the regression. *** denote 1% level of significance while ** and * denote 5% and 10% level of significance respectively.

The next variable in the analysis is the WAPR. According to the regression results, the world economies witnessed significant convergence of almost 0.2% with the coefficient of initial value of -0.146. Moving further to different geographic regions, we see an insignificant coefficient value for Asia. The European region, however, depicted significant convergence during the sample period. Like Asia, the continent of Africa has no significant evidence of convergence/divergence for this indicator. Finally, the coefficient for the LA&C region is -0.030, which tells us that WAPR is converging in this region. Looking further into the performance of each region across different demographic variables, starting from Asia, we see that the rate of convergence for WAPR and fertility is exactly the same, while the variable of ADR indicates divergence. In contrast, the convergence rate of the ADR is highest in Europe.

The implied rate of absolute β convergence is the highest for population growth as compared to other variables in both Asia and Europe. Europe has shown strong evidence of absolute convergence in all demographic indicators, while Asia has not indicated any evidence for convergence in the other three demographic indicators. For Africa, except for population growth, remaining demographic indicators are either showing no evidence of convergence or divergence. Just like Europe, LA&C has also shown evidence of convergence for all demographic indicators. The results depict that despite global convergence in demographic indicators, there is significant variability in convergence/divergence. Indicating the importance of geopolitical, economic, and cultural aspects in explaining demographic trends and similarities.

Results of Conditional Beta Convergence

The concept of conditional beta convergence can be interpreted as a modified version of the absolute beta convergence that analyzes the relationship between the initial value and growth rate of a variable while incorporating the differences in steady state levels of economies. This measure was basically introduced by Barro and Sala-i-Martin (1992) and Mankiw et al. (1992). The inference of this concept was first given in the Solow-Swan Model, and later it became a part of the economic literature. These differences in steady state can be captured by adding control variables in the regression. In this study, independent variables included in the model as controls are human capital, globalization, urbanization, and per capita income growth.

As is common in literature on conditional β convergence, the dynamic panel GMM technique has been used to estimate conditional β demographic convergence. The results of GMM for the world sample are reported in Table 3. Human capital as a regressor has a significant and negative impact on the fertility rate with a coefficient value of -0.0145. Similar results have been reported earlier by Pommeret & Smith (2005) and Zhang (2014). Likewise, human capital is also exerting a negative and significant impact on the other two indicators, namely, the ADR and population growth. Existing literature confirms that higher human capital would lead to decline in fertility through increasing the opportunity cost of having children and improved access and knowledge of birth control (Lee and Mason, 2010). This would translate into a lower number of young dependents, leading to lower ADR and population growth. However, the coefficient of human capital in its impact on WAPR is positive and significant with a value of 0.04, indicating that an increase in human capital will improve the WAPR. Human capital is associated with higher labor market outcomes, resulting in an enhancement in the rewards for labor market participation.

According to the results in Table 3, the coefficient of globalization turned out to be positive, but it is statistically insignificant in its impact on fertility rate, population growth, and the WAPR. Opposite to that, the coefficient value of globalization for the ADR is -0.045 and significant, signaling a negative impact of globalization on the ADR. Globalization is believed to reduce ADR

directly through increasing employment opportunities because of higher economic growth, trade and foreign investment. Moreover, the indirect impact may be the outcome of women empowerment and reduced fertility. The next regressor is per capita income growth, which has a negative and significant impact on population growth validating the *demographic-economic* theory. As per capita income increase, family invest in quality of children (education and health) instead of quantity, lowering the subsequent population growth. Also, cultural and life style changes owing to increased income results in smaller family sizes. Per capita income growth is insignificant in its impact on all other demographic variables, namely, fertility rate, ADR, and WAPR.

As far as the impact of urbanization in Table 3 is concerned, the coefficient is negative and significant. This can be explained as in today's time, people are moving towards urban areas for the sake of job opportunities, better health, and education, which might change their traditional mindset of having big families. Apart from that, they gain better access to the advanced birth control, facilitating them with the choice to decrease the family size (White et.al, 2008). As mentioned earlier, urbanization decreases fertility rates through the channel of female education and delayed childbearing (Yi & Vaupel, 1989). That would translate into urbanization having a negative impact on the ADR, with the value -0.042. However, it has a positive impact on population growth. This is attributed to a high level of urbanization, resulting in increased economic activity, including immigration. Further improved healthcare services and better infrastructure also result in improved longevity. Both factors may counteract the decline in fertility, resulting in higher population growth. Finally, the coefficient for urbanization for WAPR is positive and significant with the value 0.023. Urbanization reduces the number of dependent people, which results in an increase in WAPR.

As far as the focused variable of initial values and implied rates of convergence in Table 3 are concerned, the coefficient of initial fertility rate turns out to be -0.269, indicating conditional β convergence in fertility rates. The implied rate of convergence is 6.3% per annum and is quite high. Earlier Dorius (2008), Nakagaki (2019) & Dyson and Murphy (1985) also found fertility rates to be converging throughout the globe starting from the later part of the 19th century till 2017. ADR is also found to be converging at an implied rate of 4.1% per annum, while the WAPR has a conditional convergence rate of 4.7% per annum throughout the globe. The highest rate of conditional β convergence for the world sample is observed in population growth, with a value of 8.1%. It is evident that population growth and fertility rates are converging at a higher rate as compared to other demographic variables.

The GMM results for different regions are presented in Table 4, which reports the coefficients on initial values as well as implied rates of convergence in all four continents separately. Results of individual control variables are excluded for the sake of brevity. Focusing on each continent individually, we see the evidence for convergence in population growth for Asia with an implied rate of convergence equaling 5.8%. The conditional β convergence rate for the European region is quite high, i.e., 18%. Similarly, the African continent has shown strong evidence of convergence with a rate of 11% which is the highest rate for the African continent.

Table 3: Conditional Demographic Convergence in World Countries				
Variable	**Total fertility**	**Age Dependency ratio**	**Population growth**	**Working to total population ratio**
No of observations	1004	1004	1090	1004
Log of initial Fertility rate	-0.269*** (-10.83)	-	-	-
Log of initial ADR	-	-0.186*** (-7.23)	-	-
Log of initial population growth	-	-	-0.332*** (-3.09)	-
Log of initial WTPR	-	-	-	-0.209*** (10.4)
ln Human Capital	-0.145*** (-3.01)	-0.0909*** (-3.04)	-0.73*** (-3.81)	0.04*** (3.47)
ln Globalization	0.009 (0.26)	-0.045** (-2.18)	-0.028 (-0.13)	0.012 (1.42)
Per capita income growth	-0.002 (0.73)	0.0007 (0.32)	-0.004* (-1.81)	0.0001 (0.12)
ln Urbanization	-0.146*** (6.3)	-0.042*** (-2.66)	0.158** (1.98)	0.023*** (3.49)
Implied rate of convergence	**0.063*** (9.22)**	**0.041*** (6.51)**	**0.081*** (2.51)**	**0.047*** (9.23)**
Hansen test (p value) H_0 = All instruments are valid	0.1553	0.6664	0.152	0.6516

Notes: Panel GMM estimation technique is used to estimate the results for the world sample. Panel data with five yearly intervals over the period 1960-2020 is used for the analysis. Here (.) denotes the t-/z statistics of the coefficients. ***,**,* indicate significant at 1%, 5% and 10% levels of significance respectively. P-values are reported for the Hansen test

Table 4: Conditional beta convergence: Global Analysis (GMM Estimation Technique)

Regions/ Results	Population growth			Working to total population			Fertility rate			Age dependency ratio		
	Coefficient on lag	Implied coefficient on convergence	(n)	Coefficient on lag	Implied coefficient on convergence	(n)	Coefficient on lag	Implied coefficient on convergence	(n)	Coefficient on lag	Implied coefficient on convergence	(n)
Asia	-0.25*** (-2.63)	0.058** (2.27)	310	-0.313*** (-5.31)	0.075*** (4.37)	261	-0.323*** (-5.72)	0.078*** (4.67)	261	-0.276*** (-3.87)	0.064*** (3.28)	261
Europe	-0.591*** (-6.26)	0.18*** (3.88)	182	-0.265*** (-3.29)	0.0615*** (2.81)	213	-0.543*** (-6.93)	0.16*** (4.57)	213	-0.272*** (-3.34)	0.064*** (2.84)	213
Africa	-0.424 (-6.29)	0.11*** (4.71)	350	-0.186*** (-4.91)	0.041*** (4.43)	310	-0.198*** (-5.55)	0.044*** (4.96)	310	-0.164*** (4.22)	0.036*** (3.85)	310
Latin America	-.357*** (-3.10)	0.088** (2.46)	228	-0.184*** (-5.83)	0.041*** (5.26)	208	-0.23*** (5.36)	0.052*** (4.69)	204	-0.17*** (5.23)	0.037*** (4.76)	208

Note: z-statistics of each coefficient are reported in (). ***show the level of significance at 1%, ** show level of significance at 5% and * show level of significance at 10%.

Table 5: Sigma Convergence in Demographics: Evidence from the World

Regions	World		Asia		Europe		Africa		Latin America	
Indicator	**δ_0**	**δ_1**	**δ_0**	**δ_1**	**δ_0**	**δ_1**	**δ_0**	**δ_1**	**δ_0**	**δ_1**
Average Dependency ratio	3.458*** (31.12)	.0861*** (19.58)	1.403*** (8.63)	.0889*** (15.38)	3.37*** (57.86)	.0293*** (10.70)	1.702*** (31.84)	-.001*** (-0.80)	1.71*** (18.63)	.059*** (14.29)
Fertility rate	1.635*** (12.74)	.0037 (1.13)	1.678*** (27.50)	-.008*** (-5.25)	.848*** (65.54)	-.01*** (-26.48)	.674*** (29.67)	.011*** (10.63)	1.48*** (37.82)	-.0175*** (-18.78)
Working to total population ratio	5.86*** (18.98)	.0101 (1.04)	4.51*** (34.08)	.0372*** (7.76)	3.28*** (37.69)	-.025*** (-9.77)	1.82*** (14.38)	.054*** (16.11)	4.73*** (37.95)	-.020*** (-5.21)
Population growth	16.24 (0.07)	13.15 (1.1)	1.29*** (14.95)	-0.004*** (-2.09)	0.946*** (21.70)	-0.002* (-1.68)	1.26*** (14.51)	-0.003* (-1.70)	1.94*** (11.09)	-0.016*** (4.90)

Note: t-statistics of each coefficient are reported in (). *** show the level of significance at 1%, ** show level of significance at 5% and * show level of significance at 10%.

among all demographic variables of the study. Finally, for the LA&C region, the coefficient for the initial value is -0.357 with an 8.8% implied rate of convergence. Earlier studies have also found the population to be converging over the last fifty years (Wilson, 2011). The next demographic variable in Table 4 is the WAPR. According to reported results, all coefficients obtained from the GMM analysis for conditional β convergence confirm convergence and are significant. Comparison of implied rates of convergence reveals that Asia has the highest rate of convergence, followed by Europe, while Africa and the LA&C region are both converging at a rate of 4.1%.

Another key demographic indicator in this study is the fertility rate. The coefficient for initial fertility is -0.323 for the case of Asia, and for Europe's it is -0.543. Europe here has a comparatively high implied rate of convergence with a value of 16% per annum, while for Asia, it is 7.5%. Lanzieri (2010) also indicated the incidence of convergence in the European region with traces of divergence in a few years. The fertility rate of the LA&C region is converging at a rate of 5.3%. Africa has the lowest convergence rate of 4.4%.

Finally, we have conditional convergence rates for the ADR. Asia and Europe came up with the coefficients equaling -0.276 and -0.272, respectively, and almost similar convergence rates, indicating that these two regions have been moving hand in hand in terms of convergence in the ADR. The coefficients for the initial ADR for Africa and LA&C regions are -0.164 and -0.17, respectively, with almost similar convergence rates for these two regions, i.e., 3.6% and 3.7%. One fact that is worth mentioning is that the results of this analysis indicated similarities among regions in terms of their implied rates of convergence.

Results of Sigma Convergence

As mentioned earlier, apart from absolute and conditional beta convergence, this study analyzes sigma convergence. Results of sigma convergence are reported in Table 5. In this Table, $\boldsymbol{\delta_1}$ denotes the trend or incidence of convergence, while $\boldsymbol{\delta_0}$ denotes the constant value as explained in equation 3. To begin with, we see the coefficient of ADR for the world sample to be significant and positive this tells us that the dispersion among global economies in terms of ADR has increased during the sample period. Among various demographic regions, only Africa is depicting evidence of sigma convergence but results for all other regions are confirming sigma divergence. Asian region has the coefficient value .0889 for ADR which provide strong evidence of sigma divergence as compared to the coefficient values (δ_1) for European and LA&C regions. The results support the trend analyzed by Narayan (2017).

As far as sigma convergence in fertility rate is concerned, results are insignificant for the world sample. Asian, European and LA&C regions have shown sigma convergence in fertility rates with their negative and significant coefficients. Coefficient value is largest for LA&C region followed by Europe and Asia. African continent has exhibited sigma divergence with a positive and significant trend coefficient in Table 5 i.e., 0.011.

The regression results of sigma convergence for fertility rate, WAPR and population growth for the world sample are statistically insignificant corroborating neither convergence nor divergence. The WAPR is confirming sigma convergence for European and LA&C regions but sigma divergence for other two geographic regions namely, Asia and Africa. The negative trend coefficient for Europe is slightly higher than that in LA&C region. While the positive trend coefficient for Africa is bigger in size than that of Asia indicating robust evidence of sigma divergence in Africa. Earlier studies have also found sigma convergence in Europe for this variable (Peshev and Pirimova, 2020; Glodowska, 2015). Finally, focusing on population growth for which

world sample has not shown any evidence of convergence, there is sigma convergence in every region and trend coefficient of dispersion is negative and significant. The highest value of trend coefficient for population growth pertains to LA&C region while coefficients for the remaining three regions are quite small though significant.

Conclusion

Interest of policy makers and researchers in demographic convergence is growing day by day, just because of its importance and crucial implications for individual economies as well as the global economy. As mentioned earlier, the concept that was put forward by Solow (1956) and Swan (1956) in the context of per capita income can be considered as the pioneering work in empirical literature available on demographic convergence. After that, multiple empirical analyses and econometric tools have been used to look for the evidence of convergence in various regions round the world.

This study analyses absolute beta convergence, sigma convergence and conditional beta convergence for almost last sixty years. Apart from analyzing global demographic convergence, this study divides the world economies into four geographical regions, namely Asia, Africa, Europe, and the LA&C region. Starting from Absolute beta convergence which is analyzed using Ordinary Least Squares method (OLS) world economies witnessed convergence in all the demographic indicators (population growth, WAPR ratio, fertility rate) with the exception of ADR. Furthermore, the highest rate of convergence is 0.2% per annum for the WAPR. The results for the continent of Asia are quite surprising because the incidence of convergence was confirmed only for the population growth; the coefficients for the rest of the indicators are statistically insignificant. Unlike the world sample and Asian region, the results of European sample indicated strong evidence of convergence for all indicators. In Africa all the coefficients were significant with the exception of the coefficient of convergence of WAPR. Moreover, fertility rates were found to be diverging in Africa. Absolute beta convergence was confirmed in all variables for the LA&C region. Summing up we can say that all the regions underwent convergence except Asia whose coefficients are insignificant in most cases and Africa where fertility rates were diverging.

Moving towards the results of conditional beta convergence, from the world sample, we found conditional beta convergence in all the demographic indicators, with the highest implied rates of convergence in population growth and fertility rate of 8.1% and 6.3% respectively. A similar situation was confirmed for all demographic indicators across all geographic regions exhibiting strong evidence for conditional beta convergence. It is worth mentioning that the European region witnessed high rates of convergence in population growth and fertility rate as compared to the rest of the world.. African region has highest rate of convergence for population growth and almost similar rates of implied convergence for the remaining demographic indicators. Furthermore, the last category, which is the LA&C region turns out to experience convergence in all indicators; though, we found strong evidence for conditional beta convergence for population growth and fertility rate.

The results of the Sigma convergence depicted significant sigma divergence in the ADR globally. Rest of the indicators exhibited neither the trend of convergence neither divergence for world sample. Asian economies were found to be diverging in ADR and WAPR but converging in fertility rate and population growth. On the contrary, Europe exhibited sigma convergence in all indicators but ADR. Western and Northern Europe have much older populations with low fertility and high life expectancy as compared to Eastern and Southern European countries, resultantly creating different trajectories in ADR for the region as a whole. Sigma convergence is confirmed

for African region for ADR and population growth while the remaining two indicators are showing sigma divergence. Finally, there is evidence of sigma convergence for all demographic indicators except ADR due to heterogeneous fertility decline, migration flows, unequal socio-economic development and uneven progress in aging.

After providing a detailed analysis of the results this study concludes that results indicate absolute beta convergence in some instances but wider evidence of conditional beta convergence in demographic variables confirming the important role of different variables in determining the path of convergence.. As we all know, that convergence phenomenon is crucial to keep the global economy at balance. Wide gaps in between the population in terms of any demographic indicator is not good for the individual economies as well as the international system. It is further posited that global and regional disparities in demographic tendencies is attributed to countries' differing socioeconomic statuses as is evidenced by the results for conditional beta convergence. Therefore, it is important to work towards eradicating intra- and inter-regional socioeconomic disparities. In this regard investment in human capital and forging international linkages may be helpful in in improving economic as well as demographic outcomes for the nation.

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