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Measuring Aging as a Function of Population Momentum: An Application with Bangladesh Population

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Abstract

Aging through population momentum reflects the degree of aging in the long term. It is now established that Bangladeshi population will become old in the coming decades. This article has tried to find out population aging measure with population momentum. This approach has been applied to project future extent of demographic aging in Bangladesh. The mean age of population will be increased by 20 years during the transition from stable population (assumed at 2001) to stationary. Measures of aging through momentum vary among the formulae under different assumptions on momentum calculation. Findings indicate that measure based on Keyfitz's formula on population momentum along with the relaxation of assumption of stable growth in it reveals good results and these are matched with aging measures with medium variant population projection data whereas measures of momentum with ratio of the proportion under age 30 in the initial population to that in the ultimate stationary population (F_{30}) and ratio of the proportion over age 60 in the initial population to that in the ultimate stationary population (F_{60}) are weak. Again, the average age of population will be increased by 30 years considering delay drop of fertility to replacement level by 10 years. A similar type of increase in mean age (31 years) is found with the assumption of fast speed of fertility decline. Therefore, an inevitable future aging of Bangladesh has been observed with all the measures of aging through population momentum.

Keywords and Phrases: Population momentum, Instant and delay drop of fertility, Population aging.

AMS Classification: 92D25, 34A34.

1 Introduction

The demographic consequences of a growing population's transition to stationary include both population aging and population momentum. Population momentum and population aging occur when an initially growing population experiences a reduction in fertility to the replacement level. Conceptually and empirically, momentum and aging expresses the same change, albeit on different scales. Fundamentally these are two manifestations of the underlying process of demographic transition. Population momentum expands middle and older age groups in particular, as younger cohorts move up the age pyramid, and population aging is a direct consequence of population momentum. Thus population momentum expresses population aging and vice versa. The two quantities are separate aspects of the same demographic phenomenon-that is, the long term changes in size and age structure that accompany a change in vital rates to replacement level. Empirically, these two are simply linear transformations of one another (Kim and Schoen, 1997).

Population momentum refers to the fact that the characteristics of a population, such as its age or sex structure and growth conditions, at any point in time are a product not only of the current forces producing change but also its historical past. It also implies that future characteristics are necessarily a reflection in part of present conditions (Myers, 1990). Population momentum depends on the annual decline in rates and the length of the time it takes for the decline to account (Ryder, 1975; Keyfitz, 1977). The potential growth (or decline) that is inherent within an age structure, assuming that the population experiences replacement level fertility (as well as constant mortality and zero migration) in the future, and ultimately become stationary. The intrinsic rate of natural increase indicates the growth rate implicit in current fertility and mortality, ignoring the age structure, but the population momentum shows the growth potential implied by the age structure alone (Pressat, 1985). Population momentum measures as the difference in size between the present population and the future stationary population.

Population aging, defined as an increase in the percentage in older ages, is attributed to the effects of changes in fertility and, to a lesser extent, mortality. These processes, however, are the underlying demographic causes of population aging in that they contribute to aging through their effects on the size of cohorts moving through the population structure. Increases in the percentage in older ages mainly arise from the entry of smaller birth cohorts at the base of the age pyramid; in other words, fertility decline reduces the representation of child cohorts, which leads to an increase in the representation of the aged in the total population. Also, growth in the numbers of the aged originates from the flow of larger cohorts into older ages. Thus fertility and mortality, together with migration, contribute to aging and numerical increases in the aged by expanding or reducing the numbers in different cohorts and thereby affecting the pattern of cohort flow. Population momentum provides a summary measure of the extent to which past trends in fertility, mortality and migration have created potential for expansion or contraction to occur in age groups through cohort flow. If the momentum in a population measures as 30 percent, for example, the population has the inbuilt potential to increase by 30 percent through the movement of larger cohorts into older ages, assuming constant fertility (replacement level) and constant age-specific mortality. Momentum statistics can contribute to an understanding of the causes and consequences of aging through focusing on cohort flow. The concept of facilities measurement of the long-run implications for older age groups of changes in the components of population growth and can identify variations in patterns of aging in different countries. Recently a number of demographers (Liao, 1996; Chu, 1997, Nath and Deka, 2006; Nath and Islam, 2009; Islam and Nath, 2010) have developed various aging indices to measure aging process of both developed and developing countries. Population momentum clarifies the nature of the process of population aging and provides a basis for comparative research through time and between countries. The utility of the concept of momentum in the demographic study of aging arises from its focus on cohort flow, from the insight it provides into the causes and consequences of aging and its ability to identify variations in the process through time (Rowland, 1996). This article has been devoted to measure population aging in terms of population momentum based on the idea presented by Kim and Schoen (1997). Different aging measures have also been calculated using these models for Bangladesh population with secondary data. Some lights have also been thrown on future aging of Bangladesh population through momentum based aging measures.

2 Methods and Materials

2.1 Population momentum

Classical demography describes population change in terms of age-specific fertility and mortality rates applied to the female population. If a population's fertility starts to change at t=0 and stops changing at t=T, or upon reaching a level that ultimately results in a stationary population. Over the time, the initial population size, P(N), will ultimately converge to some number P(L), then population momentum,

$$\Omega = \frac{P(L)}{P(N)} \tag{1}$$

According to keyfitz (1971) population momentum for initially stable female population is

$$\Omega_f = \frac{be_0^f}{r\mu}\left(\frac{R_0 - 1}{R_0}\right) \tag{2}$$

where Ω_f is the momentum for female population, b is the crude birth rate of initial (stable) population, r is the growth rate of initial (stable) population, e_0^f is the life expectancy at birth of initial (stable) population, R_0 is the net reproduction rate (NRR) of initial (stable) population and μ is the ultimate (stationary) population mean age of child bearing.

Similarly,

$$\Omega_m = \frac{bSe_0^m}{r\mu}(\frac{R_0 - 1}{R_0}) \tag{3}$$

where Ω_m is the momentum for male, e_0^m is the life expectancy at birth of initial (stable) male population, S = sex ratio at birth of initial population; b, r, μ and R_0 are the different rates for initial (stable) female population defined earlier. Combining momentum for male and female population (taking simple or weighted average) we can get momentum for person (both together). The value $(\Omega - 1)$ expresses the proportional change in population size related to momentum (Kim and Schoen 1997).

An approximation of Keyfitz's momentum is given by Frauenthal (1975) is

$$\Omega_f = \frac{be_0^f}{\sqrt{R_0}} \tag{4}$$

under usual notations.

2.2 Momentum and the increase in the proportion under age 30

The ratio of the proportion under age 30 in the initial population to that in the ultimate stationary population is

$$F_{30} = \frac{C_N(0,30)}{C_L(0,30)} \tag{5}$$

where C (0,30) represents the proportion of the population between the ages 0 and 30 and the subscripts N and L denote the initial and ultimate stationary population respectively. In general, age 30 only approximates the exact age at which initial and ultimate population have the same number of persons, but the work of Preston (1986) and Kim, Schoen and Sharma (1991) indicate that age 30 is a good approximation for population momentum i.e.,

$$\Omega \cong F_{30} \tag{6}$$

In the stable population concept Ω and F_{30} are indistinguishable (Kim and Schoen 1997).

2.3 Momentum and the increase in the proportion over age 60

The ratio of the proportion over age 60 in the initial population to that in the ultimate stationary population is

$$F_{60} = \frac{C_N(60,\omega)}{C_L(60,\omega)} \tag{7}$$

where C (60, ω) represents the proportion of population age 60 and above and subscript N and L denote the initial population and ultimate stationary population and ω is the upper limit of population age distribution. According to Keyfitz (1977), a second order approximation to F_{60} in a stable population is

$$F_{60} \cong 1 - r(A_{60} - A_L) + \frac{r^2}{2}[(A_{60} - A_L)^2 - (\sigma_L^2 - \sigma_{60}^2)] \tag{8}$$

where A_{60} and σ_{60}^2 are the mean and variance, respectively, of the stationary population age distribution above age 60. Similarly, A_L and σ_L^2 are the mean and variance of stationary population. Therefore, the differences in the parenthesis are positive. Over the transition to stationary, the population become older; thus F_{60} is less than one and decreases as r increases. Kim and Schoen (1997) obtained a relationship between momentum and F_{60} as

$$\Omega \cong (\frac{A_{60} - V_L}{A_{60} - A_L}) - F_{60}(\frac{A_L - V_L}{A_{60} - A_L}) \tag{9}$$

where, V_L is the mean age of reproductivity of stationary population.

2.4 Momentum with the delay drop in fertility

It is not practical to think that any country will drop immediately to stationary reproduction patterns. If drop of such patterns is delayed t years, according to Keyfitz (1971) the momentum is

$$\Omega_f = \frac{e^{rt} b e_0^f}{r\mu} \frac{R_0 - 1}{R_0} \tag{10}$$

where e^{rt} indicates that the initial stable population at each age would increase in the ratio e^{rt}.

An alternative approach of population momentum for gradual demographic transition has been proposed by Goldstein (2002) on the basis of Keyfitz's (1971) formula and approximation given by Frauenthal (1975), is

$$\Omega \approx b e_0^f (R_0)^{m - \frac{1}{2}} \tag{11}$$

where m is the speed of fertility decline and it lies between 0 and 1. He considered instant (m = 0), fast (m = 1/2, 25 years as an example), and slow (m = 1, 50 years as an example) as speed of fertility decline.

2.5 Momentum under relaxing assumption

Preston (1986) proposed an expression for population momentum considering actual growth rates instead of intrinsic growth rate. According to him population may be divided into three segments: from 0 to T, from T to 2T and from 2T to 3T, where

T is within the average age of child bearing. When the replacement level of fertility is imposed, the population of the first age segment, from 0 to T, essentially stops growing immediately. If mortality remains constant, which is the normal assumption of population momentum, then the age segment from T to 2T will stop growing after about T years. Finally, the age segment between 2T and 3T will cease growing after 2T years. If the population were initially stable with growing rate r_0, then the age segment from T to 2T will grow in total by $e^{r_0 T} = R_0$ and that between 2T and 3T will grow by R_0^2. With this notion the momentum expression is

$$\Omega = \frac{{}_T N_0 +_T N_T R_0 +_T N_{2T} R_0^2}{N} \tag{12}$$

where ${}_k N_x$ represents the number of persons in the age interval x to x + k in the initial population and N is the total initial population.

In most developing countries the average age of child bearing is 28 years (Keyfitz and Flieger, 1971). So, population above 3T can be neglected for many purposes because of its small size (Preston and Coale, 1982). The mean of age specific growth rates below age 'A' that lies within the child bearing interval $[\alpha\ \beta]$, must equal to the growth rate of the stable equivalent i.e., the intrinsic rate of increase (Preston and Coale, 1982). Any population in which the intrinsic growth rate is below of the actual growth rate is almost certainly an aging population (Preston, 1986).

Keyfitz (1968) and Coale (1972) proposed an expression for intrinsic rate of increase as

$$r = \frac{l_n R_0}{T} \tag{13}$$

Here T is the mean length of generation which is very close to the average of the mean ages of child bearing in the stationary equivalent and stable equivalent populations (Keyfitz, 1968).

2.6 Mean age, Mean and variance of age at child bearing of the stationary population

The age distribution of a stationary population is identical with the survival function for a cohort in that population. Ryder (1975) explained age distribution of stationary population with 'West' set of model life tables. According to him, the expression of mean age of stationary population is

$$A_L = \frac{\int_0^\omega x l_x dx}{\int_0^\omega l_x dx} = \frac{1}{2}\frac{\int_0^\omega x^2 d_x dx}{\int_0^\omega l_x d_x dx} = \frac{e_o(1+C^2)}{2} \tag{14}$$

where l_x and d_x are the conventional life table columns, e_0 is the expectation of life at birth (the mean age at death) of person and C is the coefficient of variation in the age at death.

Again net maternity function of a stationary population is

$$\varphi(x) = p(x)m(x) \tag{15}$$

where p(x) is the female survival function at age x, m(x) is the female birth rate among child bearing women of age x.

The n-th moment of net maternity function is

$$R(n) = \int_{\alpha}^{\beta} x^n \varphi(x)dx; \quad n = 0, 1, 2, \ldots \tag{16}$$

where α and β represent the lowest and upper limit of child bearing age. Therefore,

$$NRR = R_o = \int_{\alpha}^{\beta} \varphi(x)dx = \int_{\alpha}^{\beta} p(x)m(x)dx \tag{17}$$

The mean and variance age of child bearing of stationary population (Land et al., 2004) are

$$\mu = \frac{\int_{\alpha}^{\beta} xp(x)m(x)dx}{\int_{\alpha}^{\beta} p(x)m(x)dx} = \frac{R(1)}{R(0)} \tag{18}$$

And

$$\sigma^2 = \frac{\int_{\alpha}^{\beta} (x-\mu)^2 p(x)m(x)dx}{\int_{\alpha}^{\beta} p(x)m(x)dx} = \frac{R(2)}{R(0)} - \mu^2 \tag{19}$$

2.7 Discrete formula

For discrete age distribution NRR, mean and variance age of child bearing of stationary population are

$$NRR = R(0) = \sum_{x=\alpha}^{\beta} \frac{L_x}{l_0} F_x \tag{20}$$

$$\mu = \frac{\sum_{x=\alpha}^{\beta} (x+2.5) L_x F_x}{\sum_{x=\alpha}^{\beta} L_x F_x} \tag{21}$$

And

$$\sigma^2 = \frac{\sum_{x=\alpha}^{\beta} (x+2.5)^2 L_x F_x}{\sum_{x=\alpha}^{\beta} L_x F_x} \tag{22}$$

Here l_x and L_x are the conventional life table components. F_x is the observed birth rate among women aged x to x + 4 at the last birthday. Child bearing ages are considered as five-year age group.

2.8 Momentum as a function of stable growth

Keyfitz's (1977) expressed a second order approximation of be_0 and R_0 as follows

$$be_o^f = exp(rA_L - \frac{r^2}{2}\sigma_L^2) \tag{23}$$

And

$$R_o = exp(r\mu - \frac{r^2}{2}\sigma^2) \tag{24}$$

under usual notations.

From equation (2), (23) and (24) Kim and Schoen (1997) obtained the following expression

$$\Omega_f \cong 1 + r(A_L - V_L) \tag{25}$$

and

$$V_L = \frac{\mu}{2}(1 + \frac{\sigma^2}{\mu^2}) \tag{26}$$

Mean age V_L is the mean of the tail distribution of the net maternity function (i.e., the mean of the distribution that represents the reproductive value of each age multiplied by the probability of survival to that age).

2.9 Aging measures

Equation (25) represents the relationship of momentum between stable growth rate and mean age of stationary population. Thus momentum is linearly related to aging if it can be shown that aging is linearly related with the growth rate r.

The mean age of initial stable population, A_N, and that of ultimate stationary population, A_L, are related by

$$A_N \cong A_L - r\sigma_L^2 \tag{27}$$

where higher order terms are ignored (Keyfitz, 1977).

Kim and Schoen (1997) established the following relationship of population momentum and measure of population aging as

$$\Omega \cong 1 + \triangle A(\frac{A_L - V_L}{\sigma_L^2}) \tag{28}$$

Here, $\triangle A = A_L - A_N$ is a measure of aging. This measure expresses an amount of change of mean age of population during the transition from initial (stable) to ultimate stationary.

Since the momentum and measure of aging are linearly related, hence from equation (28) the following expression can be obtained.

$$\triangle A \cong C(\Omega - 1) \tag{29}$$

where $C = \frac{\sigma_L^2}{A_L - V_L}$

This is the expression of measure of aging in terms of population momentum.

Although equation (28) is derived from relations in stable population and limited only to the first two moments of the stationary age distribution, it is quite robust and broadly applicable to any population (Kim and Schoen, 1997). Therefore, measure of aging given in equation (29) is a robust measure.

Similarly, on the basis of equation (6) another aging measure is

$$\triangle A \cong C(F_{30} - 1) \tag{30}$$

under usual notations.

Again, from equation (9), Kim and Schoen (1997) suggested the following expression:

$$F_{60} = \cong 1 - \triangle A(\frac{A_{60} - A_L}{\sigma_L^2}) \tag{31}$$

And from equation (31) another aging measure is

$$\triangle A \cong K(1 - F_{60}) \tag{32}$$

where $K = \frac{\sigma_L^2}{A_{60} - A_L}$, under usual notations.

Momentum and aging measures have been calculated with Bangladesh-2001 initial population. Life table-2001 of Bangladesh population is considered as model stationary population and stable population has been obtained by Population Analysis Spreadsheet (PAS version 4.1) using life table population and age specific fertility rate of 2001. Model stationary life Table-2001 for male, female and person has been downloaded from WHO website (http://apps.who.int//whosis/database/life/life_tables/life_tables.cfm) and ASFR has been taken from the Bangladesh Demographic and Health Survey (BDHS), 2004 conducted by NIPORT, Mitra and Associates, and ORC Macro (2005). Various fertility and mortality measures have been obtained from Sample Vital Registration system, 2002 conducted by Bangladesh Bureau of Statistics (BBS 2004). A medium variant population projection has been performed with Spectrum 3.2 software for 2001-2086. Various calculations have been done with MS Excel software.

3 Results and Discussions

The structural aging process of Bangladesh population has been observed with the theory of population momentum in this paper. For the empirical study, we consider Bangladesh population at 2001. The stationary life table and model stable population of Bangladesh at 2001 have been presented in Table 1.

Table 1: Model Stable and Life Table Stationary Population of Bangladesh, 2001

	Initial stable population			Life table stationary population		
Age group	Male	Female	Person	Male	Female	Person
< 1	2144	2161	4305	100000	100000	100000
1 to 4	8106	8149	16255	93490	93915	93697
5 to 9	9580	9597	19177	91828	91633	91733
10 to 14	9055	9056	18111	91134	90779	90961
15 to 19	8556	8541	17097	90680	90193	90443
20 to 24	8058	8024	16082	89945	89244	89604
25 to 29	7570	7517	15087	88887	87988	88450
30 to 34	7102	7026	14128	87758	86586	87189
35 to 39	6640	6540	13180	86454	84952	85724
40 to 44	6170	6049	12219	84790	82910	83878
45 to 49	5675	5548	11223	82516	80340	81461
50 to 54	5135	5022	10157	79272	77065	78203
55 to 59	4524	4454	8978	74621	72739	73712
60 to 64	3836	3837	7673	67934	66935	67470
65 to 69	3074	3154	6228	59127	59579	59391
70 to 74	2252	2389	4641	47919	49735	48849
75 to 79	1436	1593	3029	34536	37312	35916
80+	1090	1344	2434	33090	39896	36349
Total	100000	100000	200000			

3.1 Characteristics of stable and stationary population of Bangladesh, 2001

Various estimates on the above mentioned measures are given in Table 2.

Birth rate of female stable population is 22.27 per thousand in 2001. The NRR is above replacement level (1.29) and growth rate (r) is 1 per 100 female populations. Life expectancy at birth for male, female and person of stable population are 61.87, 61.74 and 61.81 years respectively in 2001. Stationary mean age of childbearing (μ) is 24.89 years with mean age of reproductivity ($\mathrm{V_L}$) 25.77 years. The mean ($\mathrm{A_L}$) and variance of stationary female population age distribution are 34.12 and 584.54 respectively. These estimated values of different parameters (Table 2) have been used to estimate population aging measure for Bangladesh through population momentum.

3.2 Population Momentum: Bangladesh 2001

For the year 2001, total momentum has been computed with respect to male, female and person of Bangladesh population with different formulae considering usual female dominant model. The results are presented in Tables 3 and 4. It is observed that

Table 2: Different Estimated Parameters for Calculating Population Momentum of Bangladesh

	Stable			Stationary		
Measure	Male	Female	Person	Male	Female	Person
b		0.02227				
e_o	61.87	61.74	61.81			
r		0.01				
R_o		1.287				
μ					24.89	
V_L					25.77	
$Mean(A_L)$				33.82	34.12	33.97
$Variance(\sigma_L^2)$				567.14	584.54	575.62

estimated value of momentum varies from formula to formula. The highest momentum has been found with Keyfitz's formula (equations 2&3) followed by the method of relaxing assumption of stable growth (equation 12).

Table 3: Momentum and Aging Measures for Bangladesh with Different Formulae

	Momentum			Change of average age ($\triangle A$)		
Formula	Male	Female	Person	Male	Female	Person
Keyfitz	1.33	1.25	1.29	23.41	17.80	20.34
Relaxing Assumption	1.25	1.18	1.22	17.65	12.61	15.08

Momentum with F_{30} (equation 6) gives the lowest value. The momentum of Bangladesh female population with Keyfitz, relaxing assumption of stable growth, and F_{30} are 1.25, 1.18 and 1.14 respectively at 2001. A 29 percent further increase in total population is to be anticipated between the transition period stable and stationary under the drastic decline in fertility (replacement level) assumed. If we do not assume stable growth of population, then the rise to stationary is 22 percent. Again, from the momentum statistics it is found that male increase is higher than that of female over the transition to stationary (Table 3).

Table 4: Measures of Aging for Bangladesh with (F_{30}) and (F_{60})

	Value			Change of average age ($\triangle A$)		
Indicator	Male	Female	Person	Male	Female	Person
F_{30}	1.137	1.139	1.138	9.64	9.69	9.67
F_{60}	0.667	0.672	0.670	5.16	5.21	5.18

Assumption of instant drop of fertility to replacement level is harsh. So, we have studied momentum characteristics with delay drop of fertility to replacement level over the period of 35 years. After instant drop, we have computed momentum with 10 years delayed time and then every 5 year interval up to 35 years. Again, momentum has also been observed considering speed of fertility decline (m) proposed by Goldstein (2002) within a range of speed from 0 to 1. According to him this range covers a period of 50 years where 0, 1/2 and 1 represent instant, fast and slow pace of declining fertility respectively.

Table 5: Momentum and Aging Measures for Bangladesh with Delay Drop of Fertility (Keyfitz's Formula)

	Momentum (Keyfitz)			Change of average age ($\triangle A$)		
Time(year)	Male	Female	Person	Male	Female	Person
0	1.33	1.25	1.29	23.41	17.80	20.34
10	1.47	1.39	1.43	33.27	27.03	29.86
15	1.55	1.46	1.50	38.59	32.00	34.98
20	1.63	1.53	1.58	44.18	37.22	40.37
25	1.71	1.61	1.66	50.05	42.72	46.04
30	1.80	1.69	1.74	56.22	48.49	52.00
35	1.89	1.78	1.83	62.71	54.56	58.26

Table 6: Momentum and Aging Measures for Bangladesh with Delay Drop of Fertility (F_{30})

	Momentum (F_{30})			Change of average age ($\triangle A$)		
Time(year)	Male	Female	Person	Male	Female	Person
0	1.147	1.139	1.138	9.64	9.69	9.67
10	1.257	1.258	1.258	18.06	18.06	18.06
15	1.321	1.323	1.322	22.59	22.58	22.58
20	1.389	1.391	1.390	27.36	27.32	27.34
25	1.460	1.462	1.461	32.37	32.30	32.34
30	1.535	1.537	1.536	37.64	37.55	37.59
35	1.613	1.616	1.615	43.17	43.06	43.11

According to Keyfitz's momentum, Bangladesh population will be increased by 43 and 50 percent with the assumption of delaying time in fertility decline to replacement level 10 and 15 years respectively during the projection period between base year (2001) and ultimate stationary population. Similarly, if we consider delaying time 35 years then it is seen that Bangladesh would end up with 1.83 times of its 2001 population (Table 5). Again, the increasing rate of momentum with F_{30} with delay drop of fertility is faster than that of Keyfitz's formula though the value with F_{30} indicate slow pace of increasing population. With this formula it has been found that the ultimate stationary population of Bangladesh would be 1.14, 1.26 and 1.62 times of its initial population of 2001 assuming delay drop of fertility 10, 15 and 35 years respectively (Table 6). Alternative approach (Goldstein, 2002) for estimating the long run size of populations (equation 11) that undergo transitions to replacement level fertility shows a balance result between Keyfitz and F_{30} with delayed fall of fertility.

Table 7: Momentum and Aging Measures for Bangladesh with Speed of Fertility Decline

	Momentum			Change of average age ($\triangle A$)		
Speed(m)	Male	Female	Person	Male	Female	Person
0	1.31	1.23	1.27	21.90	16.38	19.13
0.10	1.34	1.27	1.31	24.25	18.59	21.41
0.25	1.40	1.31	1.36	27.90	22.00	24.94
0.50	1.49	1.40	1.44	34.30	27.99	31.13
0.75	1.58	1.49	1.54	41.12	34.36	37.72
1	1.69	1.59	1.64	48.38	41.15	44.75

A gradual transition lasting about 50 years produces an ultimate population that is 29 percent more that implied by an instant transition (momentum 1.27 with m=0 and 1.64 with m=1). With this method momentum value is 1.44 if delaying time is 25 years (Table 7).

3.3 Aging through population momentum

The momentum of population growth can be interpreted as the aging of those already born and thus aging is a direct consequence of momentum in the absence of mortality decline (constant mortality assumption for population momentum). Therefore, it is worthwhile to study population aging with momentum. Aging measure mainly change of mean age of population has been obtained using functional relationship between momentum and aging during the transition period of reaching stationary population with the base year population of Bangladesh, 2001.

Measures of aging through momentum vary among the formulae under different assumptions. Increase of mean (20.34 year) is the highest with Keyfitz's momentum followed by measure with relaxing assumption of stable growth (15.08 year), measure with momentum, F_{30}, (9.67 year) and measure with F_{60} is the lowest (5.18 year) during the transition to stationary with base population 2001. Obviously, aging measure with F_{60} is the weakest as Kim and Schoen (1997) pointed out. From the results it is found that the mean age of male population increases faster than that of female within the projection period (Tables 3 and 4). Comparing with the aforementioned aging measures with the projected increase (medium variant projection from 2001) of mean and median age of Bangladesh population it is found that aging through momentum with Keyfitz's formula and momentum with the relaxation of assumption of stable growth match with those of projected one. But aging measures with other momentum

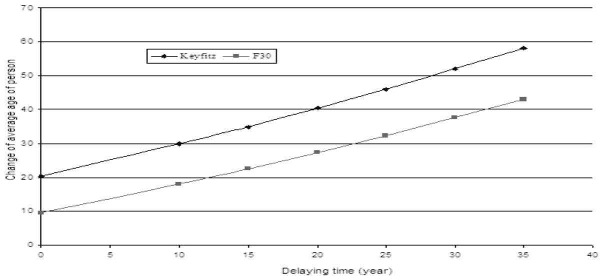

Figure 1: Aging of Bangladesh with Delay Drop of Fertility

formulae, F_{30} and F_{60}, give under estimate. Though aging measures with F_{30} and F_{60} are theoretically nice and easy to calculate these should not be recommended for projecting aging of Bangladesh population. From the projected data it is observed that mean and median age of Bangladesh population are increased by 15.36 and 18.85 years respectively between the period 2001 and 2086.

Table 8: Projected Measure of Aging, Bangladesh:2001-2086

Year	Mean	Median	Increase of mean age from 2001	Increase of median age from 2001
2001	24.53	21.27		
2036	32.64	31.28	8.11	10.01
2041	33.87	32.76	9.34	11.49
2051	36.13	35.52	11.60	14.25
2061	37.80	37.64	13.27	16.37
2071	38.96	39.11	14.43	17.84
2076	39.35	39.62	14.82	18.35
2081	39.66	39.96	15.13	18.69
2086	39.89	40.12	15.36	18.85

With the results it is also observed that mean and median age are stabilized at 40 years in stationary population though mean age was greater than median age initially (Table 8). From this it can be concluded that mean and median age show almost same process of aging for a matured population. Again, an increase in proportion of person under age 30 is 13.8 percent during the projection period to stationary with the base population 2001 whereas the corresponding increase in proportion of person aged 60 or more is 33 percent (Table 4). These differentials of age-specific momentum translate directly into population aging where aging at peak and base are increasing simultaneously.

Above measures of aging through momentum have been calculated with the assumption of sudden drop of fertility to replacement level. With the considerations of delay drop of fertility over the period of 35 years, aging measures have also been obtained. We consider a period of 35 years as it completes one generation of female cohort in the child bearing ages. Measures have been computed on some delayed time points (10, 15, 20, 25, 30 and 35) over the time span. Alternative measure of momen-

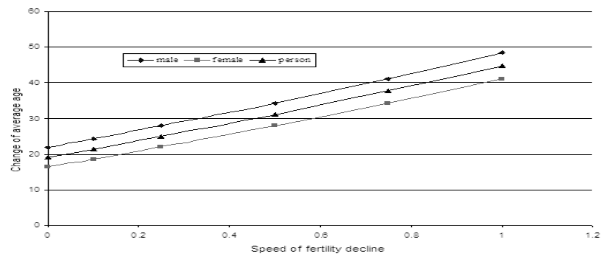

Figure 2: Aging of Bangladesh with Speed of Fertility Decline

tum (Goldstein, 2002) with speed of fertility decline (m) has also been considered to find out the measure of aging. Period of fertility decline covers 50 years with the speed range between 0 and 1 in this measure. Here instant, fast and slow pace of declining fertility are scaled by m=0, m=0.5 and m=1 respectively.

From the analysis, an upward trend has been found in increasing mean age of population during the transition to stationary considering gradual drop of fertility to replacement level with all the methods under study (Tables 5, 6 and 7; Figures 1 and 2). About 30 years increased over the mean age of population-2001 would be occurred if the drop of fertility to replacement level after 10 years according to Keyfitz's momentum formula. The corresponding increase with momentum (F_{30}) would be 18 years. The increase in mean age will be end up by 58.26 and 43.11 years for Keyfitz's and F_{30} respectively if the gradual drop of fertility occurs over the period of 35 years (Tables 5 and 6; Figure 1).

Aging measures with momentum under consideration of gradual speed of fertility decline (Goldstein's approach) give consistent result with that of momentum (F_{30}) though the increase in mean age is more or less same between Keyfitz and Goldstein approaches of momentum with sudden drop of fertility to replacement level. With the alternative approach, increase in mean age would be 31 years if fertility declines over 25 years. A gradual transition lasting about 50 years produces an ultimate increase in mean age by 44.75 years over initial base of Bangladesh population-2001 (Table 7 and Figure 2). The projected aging with delay drop of fertility to replacement level is not reliable especially after delayed time at 15 years. Again, according to the Goldstein's approach it can be said that the assumption of the speed of fertility decline between instant and fast may be accepted for projecting aging to the ultimate stationary population. Therefore, a delay drop of fertility decline over a period of 15 years from the base period (2001) may be considered for projecting aging with both the methods presented here. From the analysis, we get a clear picture of future Bangladesh population aging though the magnitude of projected demographic aging measures is different amongst the methods under study.

4 Conclusion

Population aging is usually seen as a cross-sectional process. Its indicators refer to the population observed at certain points in time. Momentum statistics can contribute to understanding of the causes and consequences of aging through focusing on cohort flow and this concept facilitates measurement of the long-run implications for older age groups of changes in the components of population growth. Aging through momentum sheds light on the future process. Population momentum and aging are separate aspects of the same demographic phenomenon i.e., the long term change in vital rates to replacement level. Population aging is a new issue in Bangladesh as its demographic transition has been started recently. This article discusses the role of momentum in structural aging during the demographic transition. From this study, we get a projected picture of aging process though the magnitude of it varies among different approaches of measuring momentum. This paper has shown that the average age of Bangladesh population will increase substantially in the coming decades, and hence, the unavoidable increased aging problems will assume added importance and impact on this agrarian society. It is true that Bangladesh has many years before the problems of aging reach the dimensions which the developed countries are facing at present. So, it is a very crucial time to start thinking on this issue as quick as possible. Since Bangladesh government is trying to achieve its fertility to replacement level hence this analysis will be helpful to make policy regarding with future inevitable aging situation.

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