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India's population challenge: Understanding the trends of population structure

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***Abstract*---**India stands at a critical juncture in its demographic journey. With over 1.4 billion people, it is not just the most populous nation in the world but also one of the most demographically diverse. The structure of its population, comprising the young dependent population, the working-age group, and the elderly, holds profound implications for the country's socioeconomic development, employment landscape, and healthcare systems. This study explores long-term trends in India's total population, working-age population (15-64), old-age population (65 & above), young dependents (0-14), urban & rural population, life expectancy at birth, population density, sex ratio, fertility rate, birth rate, and death rate to understand the evolving demographic landscape. The study utilizes data for all 22 variables from the World Bank Development Indicators covering the period from 1975 to 2022. To examine the trends, along with line diagram and CAGR (Compound Annual Growth Rate), 11 different regression models, including linear, logarithmic, log-linear, power, exponential, compound, quadratic, cubic, logistic, and inverse, etc., are applied. By mapping the trends, the study underscores the urgent need for age-sensitive strategies to effectively manage India's population challenges and maximise its demographic potential.

***Keywords*---**CAGR, India, Old-age Population, Working-age Population.

1. Introduction

India, now the most populous nation in the world (DESA, 2023), faces both unprecedented opportunities and formidable challenges in managing its demographic transformation. With a population exceeding 1.4 billion (DESA, 2023), India's demographic profile has evolved significantly over the decades, driven by a complex interplay of declining fertility rates (Office of the Registrar General & Census Commissioner, 2020), rising life expectancy (World Bank,

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2022), increased urbanisation (DESA, 2018), and changing socioeconomic patterns. These shifts are reshaping the age structure of the population and generating profound implications for policy, planning, and development. Understanding the underlying trends in population structure, particularly the relative shares of the working-age population, the young dependents, and the elderly, as well as the trends in population density, sex ratio, urban population, rural population, fertility rate, birth rate, death rate, etc., is essential to addressing India's socioeconomic aspirations and sustainable development goals (SDGs).

Historically, India has been characterised by a youthful population structure. For many decades, a large proportion of the population was composed of children and adolescents (Dyson et al., 2005), while the elderly constituted a much smaller segment. This youth-dominated age structure placed significant demands on public expenditure, particularly in education, child nutrition, maternal health, and basic services. However, the beginning of the demographic transition in the late 20th century brought noticeable changes. With a steady decline in birth rates (Office of the Registrar General & Census Commissioner, 2020) and improving health infrastructure (Kumar, 2023; EY India, 2024), the share of the working-age population (15–64 years) began to increase (The Economic Times, 2024; HRWorld, 2024), paving the way for a demographic dividend (Mukherjee et al., 2019). This demographic advantage, characterised by a lower dependency ratio (World Economics, n.d.) and a rising share of the productive age population (The Economic Times, 2024), provided India with a unique window to accelerate economic growth and human capital formation.

The demographic dividend, often referred to as the "golden period" or "demographic bonus" as here an economy moves from the second stage (high fertility-low mortality) to the third stage (low fertility-low mortality) of the demographic transition (Jain et al., 2025), represents a situation when the working-age group outnumbers the dependent populations (both young and old) (Abhishek & Adabar, 2022). In India, this phase peaked during the early 2000s, in 2005-2006 (Madiwalappagol, 2023), and continues to present opportunities, particularly if the labour force is well-educated, skilled, and adequately employed. Though there is a positive impact of demographic dividend on economic growth in India (Jain et al., 2025), but the dividend is not automatic; it must be capitalised through proactive investments in education, skill development, health, and employment generation (Jafrin et al., 2024). Thus, the demographic dividend is both a promise and a responsibility. If well-managed, it can fuel economic progress; if neglected, it can exacerbate unemployment, social inequality, and political unrest.

Yet, even as India attempts to harness the benefits of its growing workforce, another structural shift is underway. The share of the elderly population (aged 65 years and above) is gradually rising, a trend that will accelerate in the coming decades. Improved longevity, better medical care, and a declining birth rate are contributing to the ageing of India's population. Currently, India's old-age dependency ratio remains modest, but it is projected to double by 2050. The bulge of the working population is expected to last till 2055 (Thakur, 2019). As per the Economic Survey 2018-19, India is expected to experience the peak of its demographic dividend around the year 2041, and at that time, the working-age population (20-59 years) will constitute approximately 59% of the total population. Hence, this demographic ageing, if not planned for adequately, can become a burden on public resources and the working population. This is because while ageing is a natural outcome of demographic transition, it also raises critical concerns about social security, old-age care, pension coverage, healthcare financing, and intergenerational equity.

On the other end of the spectrum lies the young dependent population (those aged 0–14 years), which continues to be a substantial demographic segment. Although birth rates are steadily decreasing, significant regional and socio-economic differences continue to result in high dependency burdens in several parts of the country. This creates dual challenges: ensuring quality education, nutrition, and healthcare for the young, while simultaneously preparing for an ageing population. Balancing the needs of the young and the old within a resource-constrained economy is a complex policy task that requires forward-looking governance and inclusive planning.

Against this backdrop, trend analysis of India's population structure offers crucial insights into the past, present, and future trajectory of demographic change. By tracking changes in the absolute numbers of total population, working-age population, young dependents, and the elderly over time, researchers and policymakers can better understand the timing and pace of demographic shifts in India. This study, therefore, aims to conduct a detailed and comparative trend analysis of India's different demographic variables by presenting visual trends and analytical commentary to provide a comprehensive overview of India's population structure. This is because India's population challenge is not merely a matter of size; it is a question of structure and preparedness. As the country straddles between youth potential and the onset of ageing, a deep understanding of its demographic evolution becomes vital. Only thoroughly informed, data-driven, and age-sensitive policies can enable India to translate its demographic changes into developmental progress. The coming decades will test the country's ability to manage this transition wisely. This study is a modest contribution toward that understanding. To the best of my knowledge, it is the first of its kind to employ rigorous statistical techniques while incorporating 22 variables for the analysis.

2. Data & Methods

2.1 Data

This study aims to conduct a detailed and comparative trend analysis of various core components of India's demographic structure, including the total population, working-age population, old-age population, young dependent population, urban population, rural population, life expectancy at birth, population density, sex ratio, fertility rate, birth rate, and death rate. Therefore, the study has used time-series data sourced from the World Bank Development Indicators for the period 1975 to 2022. The period of study is selected based on data availability. The description of the variables is presented in Table 1.

Table 1: Description of the Variables

Variable	Description
Total Population	All Indian residents, regardless of legal status or citizenship
Total Male Population	All Indian male residents
Total Female Population	All Indian female residents
Total Population Ages 0-14	All Indian residents between the ages of 0-14
Total Male Population Ages 0-14	All male Indian residents between the ages of 0-14
Total Female Population Ages 0-14	All female Indian residents between the ages of 0-14
Total Population Ages 15-64	All Indian residents between the ages of 15-64
Total Male Population Ages 15-64	All male Indian residents between the ages of 15-64
Total Female Population Ages 15-64	All female Indian residents between the ages of 15-64
Total Population Ages 65 & Above	All Indian residents aged 65 & above
Total Male Population Ages 65 & Above	All male Indian residents aged 65 & above
Total Female Population Ages 65 & Above	All female Indian residents aged of 65 & above
Life Expectancy at Birth	Number of years a newborn infant would live
Life Expectancy at Birth (Male)	Number of years a newborn male infant would live
Life Expectancy at Birth (Female)	Number of years a newborn female infant would live
Urban Population	Number of people living in urban areas
Rural Population	Number of people living in rural areas
Population Density	Midyear population divided by land area in km^2
Sex Ratio	Sex ratio at birth (male births per female births)
Fertility Rate	Births per woman
Birth Rate	Number of live births occurring during the year, per 1,000 population estimated at midyear
Death Rate	Number of deaths occurring during the year, per 1,000 population estimated at midyear

Source: Author's Own

2.2 Methods

Initially, the study employs simple line graphs to graphically visualize the variables against time **(**see, Appendix**)** and uses descriptive statistics to have a brief numerical overview of the demographic variables. Then, the Compound Annual Growth Rate (CAGR) is calculated to reflect the average annual rate of change in the variables over time.

$$\boldsymbol{CAGR} = \left(\frac{Final\ Value}{Begining\ Value}\right)^{\frac{1}{t}} - 1 \ldots\ldots\ldots\ldots \mathbf{(}1\mathbf{)}$$

Where t = Time in Years.

Subsequently, the study employs eleven different regression models, such as linear, logarithmic, log-linear, inverse, quadratic, cubic, hyperbolic, power, etc., using time (T) as the independent variable. The model-wise regression equations are as follows. After running the eleven different regressions, the best-fitted model for each variable will be selected on the basis of goodness of fit **(**R^2**)** **(**Padhy & Sahu, 2024**)**.

Linear-Linear: $Y_t = \beta_0 + \beta_1 T$ ....**(**2**)**

Log-Linear (Growth): $LnY_t = \beta_0 + \beta_1 T$ ....**(**3**)**

Logarithmic: $LnY_t = \beta_0 + \beta_1 LnT$ ....**(**4**)**

Quadratic: $Y_t = \beta_0 + \beta_1 T + \beta_2 T^2$.......................(5)
Cubic: $Y_t = \beta_0 + \beta_1 T + \beta_2 T^2 + \beta_3 T^3$.................(6)
Compound: $Y_t = \beta_0 \beta_1^T$.....................................(7)
Power: $Y_t = \beta_0 T^{\beta 1}$...(8)
Exponential: $Y_t = \beta_0 e^{\beta 1 T}$..................................(9)
Logistic: $Y_t = \frac{1}{1-e^{-(\beta 0+\beta 1 T)}}$ .... (10)
S-Curve: $Y_t = \frac{A}{1+Be^{CT}}$ ....(11)
Inverse: $Y_t = \beta_0 + \frac{\beta_1}{T}$ ....(12)

Where, Y_t = Dependent variable at time 't', β_0 = Intercept and β_i = Slope coefficients (i = 1, 2 & 3) in all the equations. In equation 11, A = asymptotic maximum (similar to L in logit), B = a shape parameter that adjusts the curve's position on the y-axis, C = growth rate parameter and e = Euler's constant (2.71828). Note that the equations exclude the error term (μ_t).

3. Results & Discussion

3.1 Descriptive Analysis

India's demographic profile in Table 2 highlights that the average total population stands at over 1.02 billion, with a slightly higher male population (530 million) compared to females (495 million) for the sample period. The child population averages about 346.5 million, comprising 180.6 million males and 165.9 million females, and is left-skewed, suggesting a declining trend, likely due to falling birth and fertility rates. The working-age population forms the largest demographic group, with a mean of 630 million, and is slightly right-skewed, indicating a gradual increase over time, a hallmark of India's ongoing demographic dividend. Meanwhile, the elderly population, though smaller at around 49 million, shows positive skewness, reflecting a rising trend in ageing, especially among females, owing to higher life expectancy.

Life Expectancy at Birth (LEB) averages around 61.9 years, with females living longer (62.8 years) than males (61 years), as shown in the table. These values are slightly left-skewed, implying consistent improvements in health outcomes over time. The urban population averages around 296 million and is right-skewed, highlighting increased urbanization, while the rural population, averaging over 729 million, is left-skewed, reflecting a gradual shift from rural to urban areas. The population density averages around 345 people per sq. km, showing a nearly symmetrical distribution, consistent with national population growth. The sex ratio hovers around 1.081, indicating a persistently male-dominated population, though the variation remains minimal over time.

The average birth rate is nearly 28 births per 1000, and the fertility rate stands at 3.46, both showing signs of a decline, as indicated by their skewness. On the other hand, the death rate, with a mean of 9.69, is positively skewed, reflecting steady improvements in healthcare and a declining mortality trend. Most variables demonstrate platykurtic distributions (kurtosis < 3), indicating moderate variability without significant outliers.

Table 2: Descriptive Statistics

Variables	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
Ages 0-14 (Total)	346532985.5	366423866.5	389736560	248577214	45206731.34	-0.857751	2.320970
Ages 0-14 (Male)	180644851.2	191156493.5	204250499	128314870	24337799.13	-0.837794	2.290923
Ages 0-14 (Female)	165888134.3	175267373.5	185486061	120262344	20871712.12	-0.880601	2.356228
Ages 15-64 (Total)	629940555.7	612291174.5	966626467	339212605	195247140.6	0.179388	1.737552
Ages 15-64 (Male)	326274827.8	317073728	500684854	175655122	101057938.2	0.181412	1.737860
Ages 15-64 (Female)	303665727.9	295217446.5	465941614	163557483	94189450.13	0.177206	1.737233
Ages 65 & Above (Total)	49197592.1	44606592.5	95489097	23519716	20375492.77	0.690772	2.437971
Ages 65 & Above (Male)	23302585.56	20982061	45281873	11772323	9401027.467	0.777203	2.586628
Ages 65 & Above (Female)	25895006.54	23624530.5	50207224	11747394	10982138.43	0.617573	2.319322
Total Population	1025671133	1028445452	1425423212	611309535	254118888.6	-0.029437	1.706691
Male Population	530222264.6	531886681	735531456	315742315	131228786.5	-0.034441	1.702404
Female Population	495448868.8	496558770.5	689891756	295567220	122891307.8	-0.024049	1.711366
LEB (Total)	61.88660417	62.068	71.698	50.761	6.058661199	-0.159716	1.870322
LEB (Male)	61.03179167	61.1785	70.237	51.211	5.449493972	-0.09776	1.868639
LEB (Female)	62.8151875	63.0035	73.271	50.281	6.714163165	-0.212343	1.88188
Urban Population	296435570.9	281254251.5	511327815	130404550	113473343.3	0.294706	1.883578
Rural Population	729235562.5	747191200	914095397	480904985	142303327.7	-0.253957	1.682907
Population Density	344.9732891	345.9064007	479.42553	205.60728	85.4701141	-0.029437	1.706691
Sex Ratio	1.081083333	1.084	1.096	1.059	0.011999704	-0.287631	1.49818
Birth Rate	27.79870833	27.9645	38.362	16.336	7.150282351	-0.08551	1.651629
Death Rate	9.688791667	9.081	15.528	6.576	2.710966719	0.637424	2.181821
Fertility Rate	3.460770833	3.4145	5.195	1.994	0.981853896	0.114472	1.744412

Source: Author's Compilation

3.2 Trend Analysis Using CAGR

The CAGR analysis from 1975 to 2022 in Table 3 reveals significant demographic transitions in India. The total population grew at a rate of 1.78% annually, with male and female populations growing at nearly the same pace. Notably, the 0–14 age group registered a relatively modest CAGR of 0.79%, suggesting a slowing pace of child population growth, aligned with declining birth and fertility rates. Within this group, male children (0.82%) slightly outpaced female children (0.77%) in growth, reflecting historical gender disparities. In contrast, the working-age group grew much faster at 2.21%, with negligible gender differences, highlighting the expansion of India's labour force and the ongoing demographic dividend. The elderly population saw the highest growth rates, especially among females (3.07%), compared to males (2.85%), signalling the onset of population ageing, particularly due to improvements in female longevity. The life expectancy indicators further support this trend. Overall life expectancy grew at 0.72% per annum, with female life expectancy (0.79%) increasing more rapidly than male life expectancy (0.66%), which indicates that females live longer in India than males.

The urban population expanded sharply at 2.89%, while the rural population grew more slowly at 1.35%, indicating a clear urbanization trend over the decades. Similarly, population density rose at a CAGR of 1.77%, consistent with overall population growth and urban expansion. Meanwhile, the sex ratio improved marginally at 0.03%, implying a slight narrowing of the gender gap, though deeper socio-cultural factors still influence gender balance.

The fertility rate fell sharply at -1.98% per year, and the birth rate declined at -1.76%, confirming India's progress through the demographic transition marked by smaller family sizes and reduced reproductive behaviour. Additionally, the death rate decreased by -1.77% annually, reflecting significant strides in healthcare, nutrition, and public health. These declining rates point to a better quality of life and longer lifespans. Altogether, the CAGR results show that while India’s population continues to grow, the structure and characteristics of the population have shifted, with ageing, urbanization, and gender health improvements shaping the future socioeconomic planning landscape.

Table 3: CAGR Results

Variables	CAGR (in %)
Ages 0-14 (Total)	0.793571
Ages 0-14 (Male)	0.816320
Ages 0-14 (Female)	0.769405
Ages 15-64 (Total)	2.205607
Ages 15-64 (Male)	2.206180
Ages 15-64 (Female)	2.204991
Ages 65 & Above (Total)	2.962134
Ages 65 & Above (Male)	2.846329
Ages 65 & Above (Female)	3.072350
Total Population	1.779439
Male Population	1.777417
Female Population	1.781597
LEB (Total)	0.722041
LEB (Male)	0.660339
LEB (Female)	0.787538
Urban Population	2.887505
Rural Population	1.347044
Population Density	1.770439
Sex Ratio	0.031246
Birth Rate	-1.975137
Death Rate	-1.762810
Fertility Rate	-1.774112

Source: Author’s Compilation

3.3 Trend Analysis of Young Dependents

The regression Estimation for Ages 0–14 (Total) in Table 4 shows that the Cubic regression model demonstrates the highest R^2 value of 0.999, indicating an almost perfect fit. This suggests that the total population aged 0–14 follows a cubic (non-linear) trend over time rather than a simple linear or exponential path. The cubic regression equation can be written as:

$\text{Ages 0-14 (Total)}_t = 238294459.877 + 6200047.464.T + 12313.829.T^2 - 1853.993.T^3 + \mu_t$ ..(13)

The positive linear coefficient (β_1 = 6200047.464) suggests that the child population initially increased over time, indicating a period of demographic expansion. This growth was further accelerated by the positive quadratic coefficient (β_2 = 12313.83), which amplified the rate of increase during the early years. However, the presence of a negative cubic coefficient (β_3 = -1853.99) marks a turning point, implying that the upward trend eventually reversed, leading to a gradual decline in the 0–14 age group in the later years, reflecting the long-term impact of falling birth and fertility rates. This can also be seen in Figure 1. Simply, the cubic behaviour reflects a demographic transition where the child population first rises with population growth, peaks, and then declines may be due to falling fertility and birth rates, as confirmed by the negative CAGRs in those variables, in Table 3.

Table 4: Regression Estimation for Ages 0-14 (Total)

	Model Summary			**Parameter Estimates**			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.765	149.966	.000	277326453.315	2824756.417		
Logarithmic	.888	364.069	.000	205698854.572	48054665.074		
Inverse	.482	42.878	.000	364710421.240	-195684369.637		
Quadratic	.991	2538.647	.000	226711639.443	8898534.081	-123954.646	
Cubic	**.999**	11033.550	.000	238294459.877	6200047.464	12313.829	-1853.993
Compound	.754	140.734	.000	277633742.819	1.009		
Power	.906	444.131	.000	221084100.968	.150		
S	.519	49.647	.000	19.713	-.628		
Growth	.754	140.734	.000	19.442	.009		
Exponential	.754	140.734	.000	277633742.819	.009		
Logistic	.754	140.734	.000	3.602E-09	.991		

Source: Author's Compilation

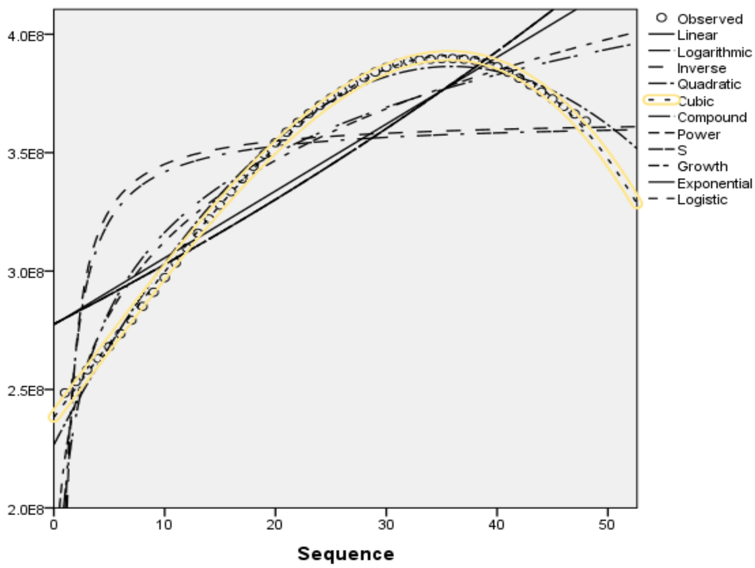

Figure 1: Curve Estimation Plot for Ages 0-14 (Total)

Based on the regression estimations presented in Table 5 (Ages 0–14 Male) and Table 6 (Ages 0–14 Female), the Cubic regression model exhibits the highest R^2 values in both cases, 0.999 for males and 0.998 for females, indicating that the child population for both genders follows a non-linear cubic trend over the period from 1975 to 2022.

In Table 5, the positive linear (β_1) and quadratic (β_2) terms suggest an early and accelerating increase in the male child population. However, the negative cubic coefficient (β_3 = -1,082.17) indicates a subsequent reversal and decline in growth, likely due to reduced birth rates and fertility decline. This captures the demographic transition affecting male children specifically. On the other hand, in Table 6, the positive linear coefficient (β_1) also indicates an initial increase in the female child population. However, the slightly negative quadratic (β_2) and negative cubic coefficient (β_3 = -771.82) together suggest that although the growth continued briefly, it slowed down earlier and more gradually compared to males, followed by a steady decline.

Therefore, Tables 5 and 6 confirm that the male and female child populations followed a cubic growth pattern, characterized by an initial rise followed by a downturn, as also shown in Figures 2 and 3, respectively. This reflects broader demographic changes such as declining fertility rates, improved family planning, and shifting socio-economic priorities. The trend is evident in both genders but appears slightly more abrupt among males and gradually tapering among females, as seen from the respective cubic coefficients.

Table 5: Regression Estimation for Ages 0-14 (Male)

	Model Summary			**Parameter Estimates**			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.769	153.298	.000	143290943.655	1524649.288		
Logarithmic	.886	359.030	.000	104884065.880	25850687.899		
Inverse	.478	42.137	.000	190386733.156	-104873649.800		
Quadratic	.990	2260.165	.000	116344571.564	4758213.939	-65991.115	
Cubic	**.999**	13433.737	.000	123105418.356	3183117.900	13548.259	-1082.168
Compound	.757	143.687	.000	143510449.950	1.009		
Power	.906	442.589	.000	113465171.060	.155		
S	.516	49.022	.000	19.062	-.648		
Growth	.757	143.687	.000	18.782	.009		
Exponential	.757	143.687	.000	143510449.950	.009		
Logistic	.757	143.687	.000	6.968E-09	.991		

Source: Author's Compilation

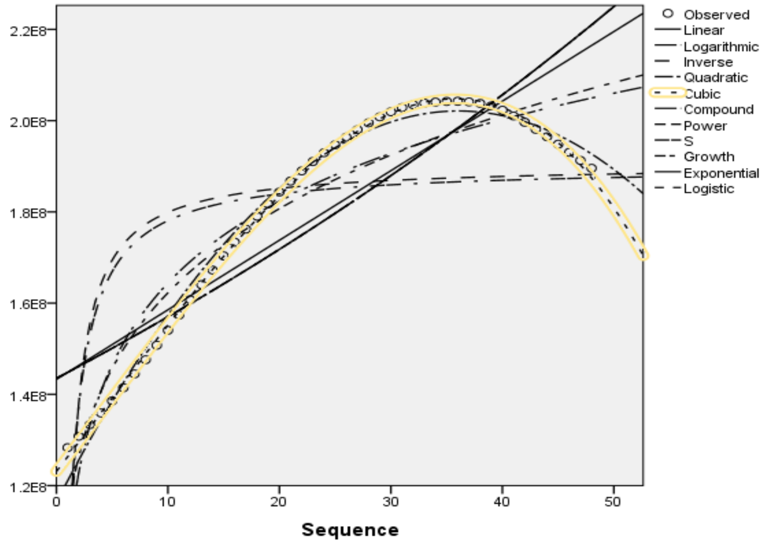

Figure 2: Curve Estimation Plot for Ages 0-14 (Male)

Table 6: Regression Estimation for Ages 0-14 (Female)

	Model Summary			Parameter Estimates			
Equation	R^2	**F**	**Sig.**	β_0	β_1	β_2	β_3
Linear	.760	146.065	.000	134035509.395	1300107.140		
Logarithmic	.889	369.223	.000	100814788.251	22203977.333		
Inverse	.487	43.740	.000	174323688.140	-90810720.205		
Quadratic	.992	2893.396	.000	110367067.596	4140320.156	-57963.531	
Cubic	**.998**	8858.081	.000	115189041.102	3016929.610	-1234.431	-771.824
Compound	.749	137.287	.000	134126179.462	1.008		
Power	.906	445.289	.000	107636580.853	.145		
S	.523	50.385	.000	18.975	-.607		
Growth	.749	137.287	.000	18.714	.008		
Exponential	.749	137.287	.000	134126179.462	.008		
Logistic	.749	137.287	.000	7.456E-09	.992		

Source: Author's Compilation

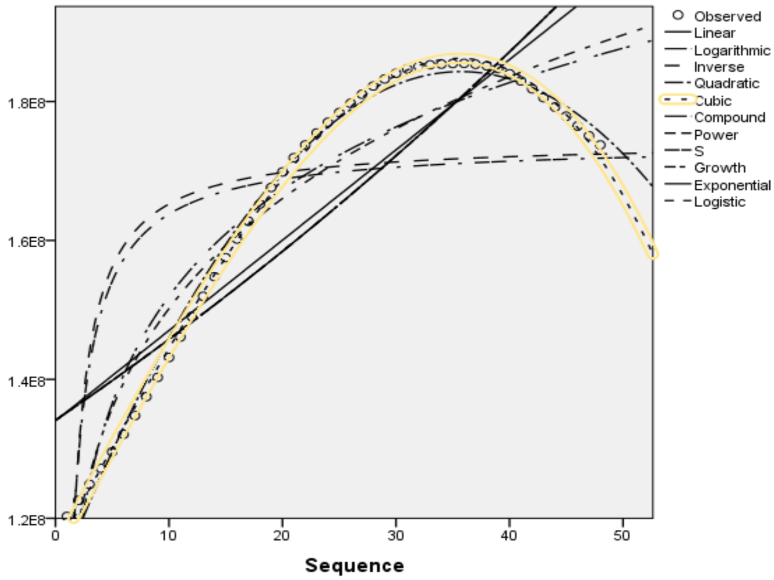

Figure 3: Curve Estimation Plot for Ages 0-14 (Female)

3.4 Trend Analysis of Old Age Population

According to Table 7, the Cubic regression model exhibits the highest R^2 value of 0.999, indicating an almost perfect fit and confirming that the growth of the elderly population in India follows a non-linear cubic trend. This model captures the complex pattern of change more accurately than other functional forms like linear (R^2 = 0.940) or exponential (R^2 = 0.996), even though they also show strong fits.

The positive linear coefficient (β_1) indicates an initial rise in the elderly population. However, the negative quadratic term (β_2 = -19,106.558) suggests a temporary slowing in the rate of increase, followed by a resurgence of growth as indicated by the positive cubic coefficient (β_3 = 632.620). This combination suggests a trend where the elderly population initially increases gradually, experiences a slight deceleration, and then accelerates more rapidly in recent years, as illustrated in Figure 4, reflecting longer life expectancy, reduced mortality, and improved healthcare outcomes. Thus, the cubic model not only demonstrates statistical superiority but also mirrors the demographic reality of ageing in India, which necessitates the need for robust policy planning to manage the challenges of an ageing society.

Table 7: Regression Estimation for Ages 65 & Above (Total)

	Model Summary			Parameter Estimates			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.940	720.485	.000	14627000.443	1411044.558		
Logarithmic	.657	88.056	.000	-5401560.316	18630029.278		
Inverse	.220	12.939	.001	54724338.218	-59496721.432		
Quadratic	.994	3923.048	.000	25811662.588	68885.100	27391.009	
Cubic	**.999**	10253.334	.000	21859369.333	989663.465	-19106.558	632.620
Compound	.996	11321.552	.000	22287935.376	1.029		

Equation	Model Summary			Parameter Estimates			
	R^2	F	Sig.	β_0	β_1	β_2	β_3
Power	.796	179.823	.000	13658341.743	.409		
S	.314	21.044	.000	17.762	-1.420		
Growth	.996	11321.552	.000	16.920	.029		
Exponential	.996	11321.552	.000	22287935.376	.029		
Logistic	.996	11321.552	.000	4.487E-08	.971		

Source: Author's Compilation

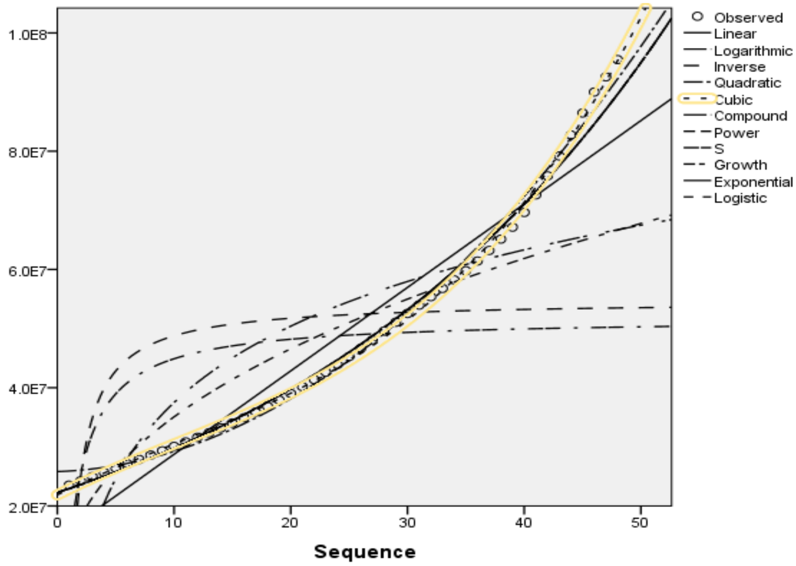

Figure 4: Curve Estimation Plot for Ages 65 & Above (Total)

In Tables 8 and 9, the Cubic regression model emerges as the best-fitting model for both male and female elderly populations with extremely high R^2 values of 0.998 and 0.999, respectively. Though in Table 9, growth, exponential and logistic regression also have the same R^2 values, but their F-statistic is less than that of the cubic model. Thus, the cubic model is chosen as the best-fitted model **(**Padhy & Sahu, 2024**)**. This indicates that the growth in the elderly population for both genders follows a non-linear cubic trend, as shown in Figures 5 and 6. The cubic patterns for both genders reflect the impact of long-term demographic transition: declining fertility, extended longevity, and improved healthcare. Thus, the results confirm that India's elderly population is expanding rapidly, reflecting higher life expectancy and better survival rates.

Table 8: Regression Estimation for Ages 65 & Above (Male)

Equation	Model Summary			Parameter Estimates			
	R^2	F	Sig.	β_0	β_1	β_2	β_3
Linear	.926	571.647	.000	7475273.806	646012.725		
Logarithmic	.636	80.315	.000	-1482324.673	8456973.833		
Inverse	.209	12.162	.001	25791243.205	-26790984.692		
Quadratic	.992	2774.701	.000	13182618.094	-38868.590	13977.170	
Cubic	**.998**	8244.337	.000	10974367.946	475594.490	-12002.244	353.461
Compound	.991	4816.407	.000	10978902.369	1.028		

Equation	Model Summary			Parameter Estimates			
	R^2	F	Sig.	β_0	β_1	β_2	β_3
Power	.773	156.959	.000	6977347.668	.386		
S	.298	19.484	.000	17.011	-1.322		
Growth	.991	4816.407	.000	16.211	.028		
Exponential	.991	4816.407	.000	10978902.369	.028		
Logistic	.991	4816.407	.000	9.108E-08	.973		

Source: Author's Compilation

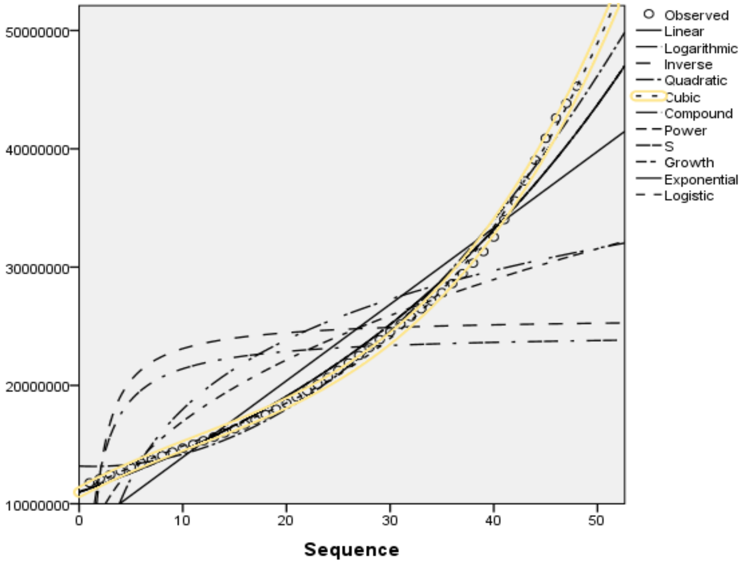

Figure 5: Curve Estimation Plot for Ages 65 & Above (Male)

Table 9: Regression Estimation for Ages 65 & Above (Female)

Equation	Model Summary			Parameter Estimates			
	R^2	F	Sig.	β_0	β_1	β_2	β_3
Linear	.951	895.331	.000	7151726.590	765031.835		
Logarithmic	.674	95.192	.000	-3919235.514	10173055.400		
Inverse	.228	13.613	.001	28933094.943	-32705735.999		
Quadratic	.996	5559.016	.000	12629044.714	107753.660	13413.840	
Cubic	**.999**	12561.704	.000	10885001.806	514068.898	-7104.312	279.159
Compound	.999	32811.487	.000	11308357.761	1.031		
Power	.815	202.511	.000	6697728.966	.432		
S	.328	22.449	.000	17.123	-1.513		
Growth	.999	32811.487	.000	16.241	.030		
Exponential	.999	32811.487	.000	11308357.761	.030		
Logistic	.999	32811.487	.000	8.843E-08	.970		

Source: Author's Compilation

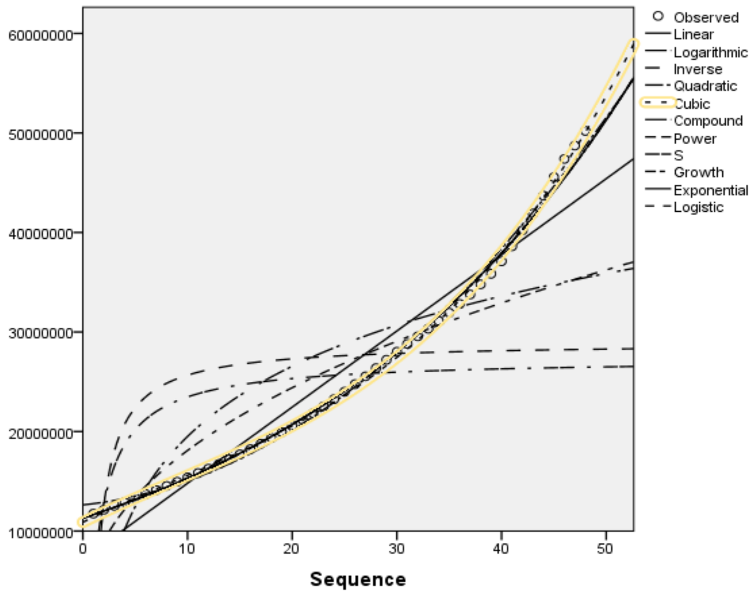

Figure 6: Curve Estimation Plot for Ages 65 & Above (Female)

3.5 Trend Analysis of Working Population

As per Table 10 the Cubic regression model provides the best fit for the working-age population in India, with an R^2 value of 1.000, indicating a perfect statistical fit. The positive linear coefficient (β_1) reflects a steady increase in the working-age population, while the positive quadratic term (β_2) accelerates this growth further. However, the negative cubic coefficient (β_3 = -2,578.166) signals a potential deceleration or plateauing of growth in later years. This dynamic suggests that while the working-age population grew significantly during the observed period, likely due to declining mortality and a demographic shift, it may begin to stabilize or slowdown in the coming years. Hence, strategic investment in education, skills, and employment opportunities will be crucial to maximize the benefits of this trend and to prepare for the inevitable ageing of the current workforce.

Table 10: Regression Estimation for Ages 15-64 (Total)

	Model Summary			**Parameter Estimates**			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.994	7791.715	.000	289262212.168	13905238.512		
Logarithmic	.772	155.698	.000	62766027.690	193528243.464		
Inverse	.287	18.536	.000	690516873.010	-652118299.240		
Quadratic	.999	24885.386	.000	321669649.968	10016345.976	79365.154	
Cubic	**1.000**	112618.098	.000	337776742.538	6263825.250	268860.361	-2578.166
Compound	.996	10385.544	.000	342032025.382	1.023		
Power	.858	278.660	.000	223952996.205	.336		
S	.364	26.310	.000	20.324	-1.209		
Growth	.996	10385.544	.000	19.650	.023		
Exponential	.996	10385.544	.000	342032025.382	.023		
Logistic	.996	10385.544	.000	2.924E-09	.977		

Source: Author's Compilation

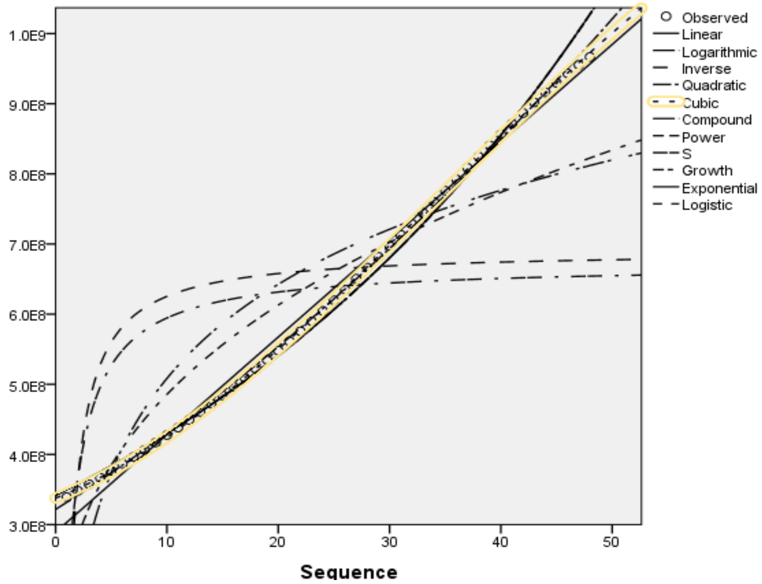

Figure 7: Curve Estimation Plot for Ages 15-64 (Total)

Tables 11 and 12 also yield similar results for the male and female working population, and the graphical plots of the three tables are shown in Figures 7, 8 and 9, respectively.

Table 11: Regression Estimation for Ages 15-64 (Male)

	Model Summary			Parameter Estimates			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.994	7626.504	.000	149954383.518	7196752.828		
Logarithmic	.772	155.356	.000	32784557.547	100143172.284		
Inverse	.287	18.533	.000	357626599.999	-337509199.645		
Quadratic	.999	24561.403	.000	166920382.592	5160832.939	41549.385	
Cubic	**1.000**	101359.933	.000	175243454.470	3221780.339	139467.878	-1332.224
Compound	.996	10625.359	.000	177276954.007	1.023		
Power	.858	278.153	.000	116148887.328	.336		
S	.364	26.330	.000	19.666	-1.208		
Growth	.996	10625.359	.000	18.993	.023		
Exponential	.996	10625.359	.000	177276954.007	.023		
Logistic	.996	10625.359	.000	5.641E-09	.977		

Source: Author's Compilation

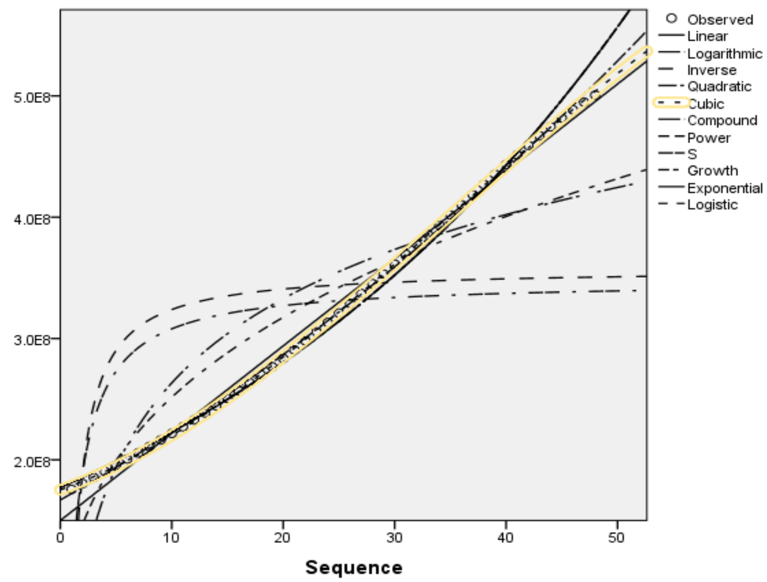

Figure 8: Curve Estimation Plot for Ages 15-64 (Male)

Table 12: Regression Estimation for Ages 15-64 (Female)

	Model Summary			**Parameter Estimates**			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.994	7969.779	.000	139307828.469	6708485.691		
Logarithmic	.772	156.062	.000	29981470.007	93385071.220		
Inverse	.287	18.540	.000	332890272.988	-314609099.577		
Quadratic	.999	25135.497	.000	154749267.590	4855512.996	37815.769	
Cubic	**1.000**	123762.442	.000	162533288.199	3042044.890	129392.482	-1245.942
Compound	.995	10120.436	.000	164754883.792	1.023		
Power	.859	279.188	.000	107804062.800	.337		
S	.364	26.288	.000	19.594	-1.210		
Growth	.995	10120.436	.000	18.920	.023		
Exponential	.995	10120.436	.000	164754883.792	.023		
Logistic	.995	10120.436	.000	6.070E-09	.977		

Source: Author’s Compilation

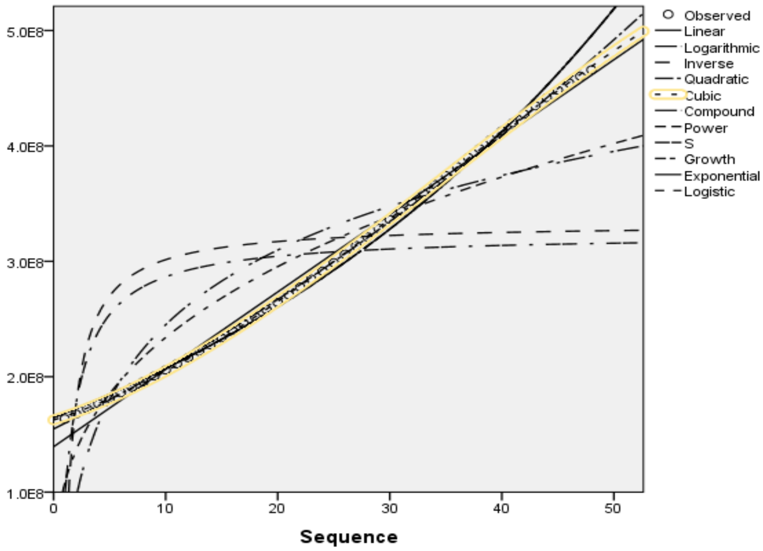

Figure 9: Curve Estimation Plot for Ages 15-64 (Female)

3.6 Trend Analysis of Total Population

Table 13 also highlights that the Cubic regression model offers the best fit with an R^2 value of 1.000, signifying an almost perfect explanation of the variation in India's total population between the sample period. The positive linear (β_1) and quadratic (β_2) coefficients show that India's total population experienced strong and accelerating growth over the decades. However, the negative cubic term (β_3 = -3,799.539) introduces a curvature that implies a moderation or slowdown in the growth rate in the later years. This pattern is consistent with India's demographic transition, where initial high fertility and declining mortality led to rapid growth, which is now stabilizing due to declining fertility rates, urbanization, and changes in reproductive behaviour. So, the findings underscore the importance of proactive policy planning in education, employment, housing, and social infrastructure to accommodate current population levels while preparing for a future where population growth may plateau or decline.

Table 13: Regression Estimation for Total Population

	Model Summary			**Parameter Estimates**			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.999	40459.522	.000	581215665.902	18141039.486		
Logarithmic	.824	215.134	.000	263063322.046	260212937.775		
Inverse	.328	22.475	.000	1109951632.423	-907299390.052		
Quadratic	.999	22522.807	.000	574192952.231	18983765.127	-17198.482	
Cubic	**1.000**	2171896.436	.000	597930572.032	13453536.136	262067.633	-3799.539
Compound	.986	3185.726	.000	632958291.716	1.019		
Power	.887	360.574	.000	442907959.054	.276		
S	.394	29.880	.000	20.811	-1.015		
Growth	.986	3185.726	.000	20.266	.018		
Exponential	.986	3185.726	.000	632958291.716	.018		
Logistic	.986	3185.726	.000	1.580E-09	.982		

Source: Author's Compilation

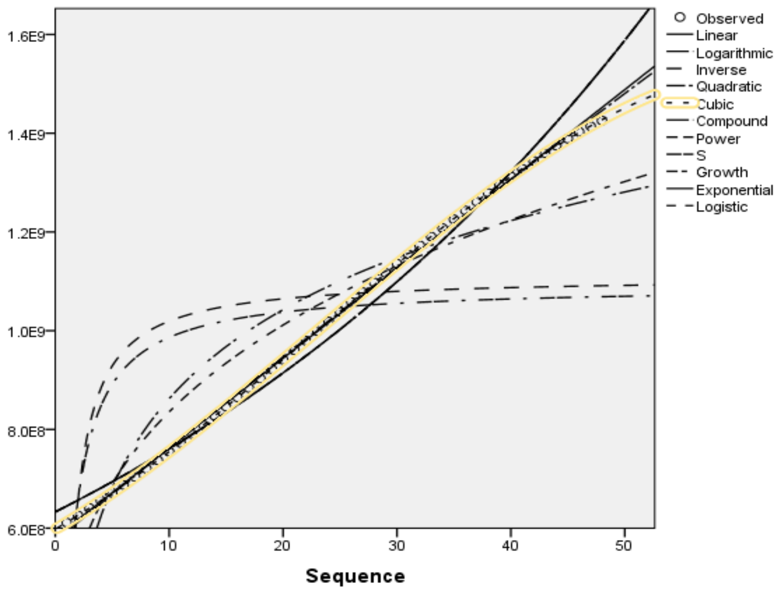

Figure 10: Curve Estimation Plot for Total Population

Tables 14 and 15 also produce similar results for the total male and female populations, and the graphical plots corresponding to the three tables are displayed in Figures 10, 11, and 12.

Table 14: Regression Estimation for Total Male Population

	Model Summary			**Parameter Estimates**			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.999	35483.295	.000	300720601.207	9367414.831		
Logarithmic	.825	216.506	.000	136186299.156	134450833.879		
Inverse	.329	22.566	.000	573804576.315	-469173833.661		
Quadratic	.999	20365.334	.000	296447572.503	9880178.275	-10464.560	
Cubic	**1.000**	1466793.452	.000	309323240.964	6880492.730	141013.892	-2060.931
Compound	.985	3092.560	.000	327342192.928	1.019		
Power	.888	363.055	.000	229009641.829	.276		
S	.395	30.005	.000	20.151	-1.015		
Growth	.985	3092.560	.000	19.607	.018		
Exponential	.985	3092.560	.000	327342192.928	.018		
Logistic	.985	3092.560	.000	3.055E-09	.982		

Source: Author's Compilation

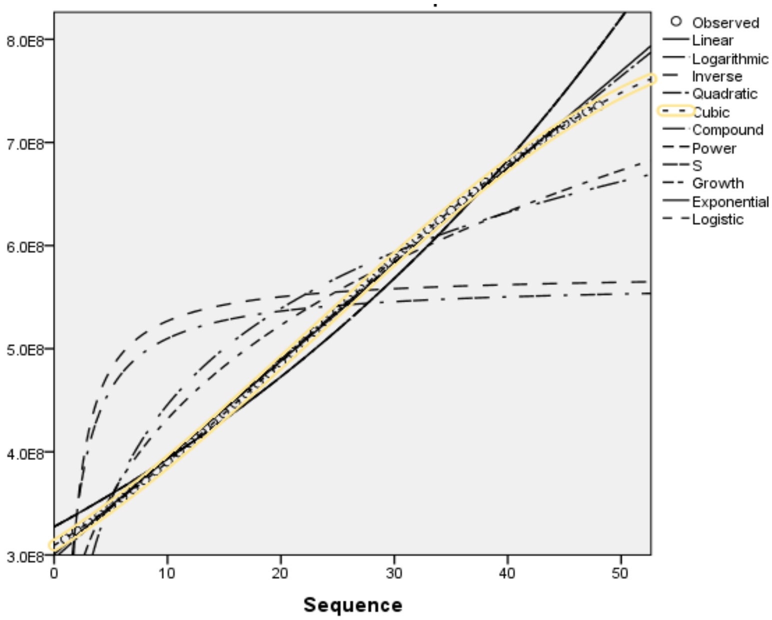

Figure 11: Curve Estimation Plot for Total Male Population

Table 15: Regression Estimation for Total Female Population

	Model Summary			Parameter Estimates			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.999	46636.169	.000	280495064.694	8773624.655		
Logarithmic	.823	213.663	.000	126877022.890	125762103.896		
Inverse	.327	22.377	.000	536147056.108	-438125556.391		
Quadratic	.999	25112.965	.000	277745379.728	9103586.851	-6733.922	
Cubic	**1.000**	1908281.381	.000	288607331.068	6573043.406	121053.740	-1738.608
Compound	.986	3288.314	.000	305616173.861	1.019		
Power	.886	357.914	.000	213898357.784	.276		
S	.393	29.745	.000	20.083	-1.014		
Growth	.986	3288.314	.000	19.538	.018		
Exponential	.986	3288.314	.000	305616173.861	.018		
Logistic	.986	3288.314	.000	3.272E-09	.982		

Source: Author’s Compilation

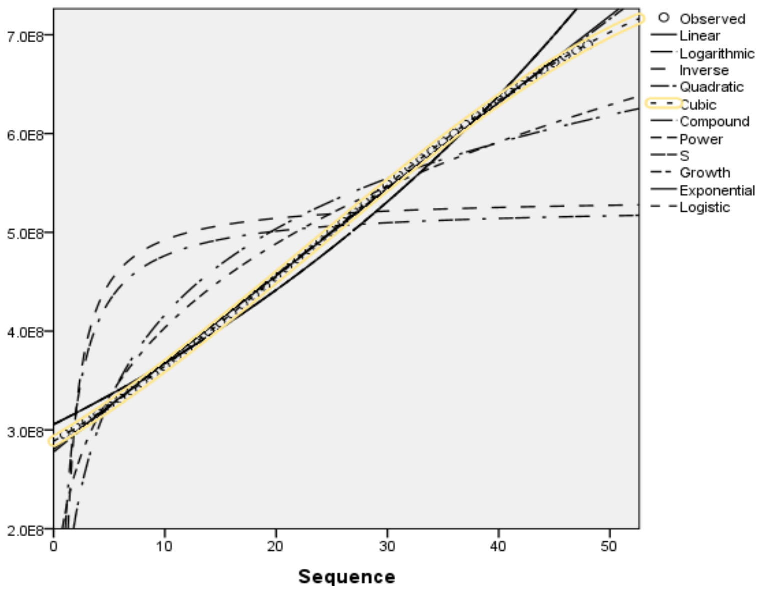

Figure 12: Curve Estimation Plot for Total Female Population

3.7 Trend Analysis of Urban & Rural Population

In Table 16, the Cubic regression model provides the best statistical fit with an R^2 value of 1.000, indicating a nearly perfect explanation of the changes in India's urban population from 1975 to 2022. Although the quadratic model also yields a perfect R^2 of 1.000, the higher F-statistic in the cubic model (269,695.716 vs. 229,721.056) confirms its superior explanatory power **(**Padhy & Sahu, 2024**)**.

The positive linear coefficient (β_1) indicates a consistent year-on-year increase in urban population, while the positive quadratic term (β_2) shows that this growth accelerated over time. The positive cubic coefficient (β_3 = 355.650) further confirms continued acceleration, especially in the recent period, possibly due to rapid industrialization, rural-to-urban migration, infrastructure development, and expansion of metropolitan areas. Unlike many other variables where the cubic term is negative (suggesting tapering), the fully positive nature of all coefficients here indicates sustained and compounding growth in urbanization.

Therefore, there is an ongoing surge in India's urban population, as also displayed in Figure 13, underpinned by socio-economic transformation and migration trends. The model suggests that urban growth is not only continuing but is doing so at an accelerating pace, highlighting the urgent need for investments in urban planning, housing, transportation, water supply, and waste management to ensure sustainable and inclusive urban development.

Table 16: Regression Estimation for Urban Population

	Model Summary			Parameter Estimates			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.988	3749.997	.000	99064076.645	8055979.355		
Logarithmic	.753	139.973	.000	-29050518.052	111060613.526		
Inverse	.277	17.628	.000	331012239.356	-372225966.537		
Quadratic	1.000	229721.056	.000	128367361.565	4539585.165	71763.147	
Cubic	**1.000**	269695.716	.000	126145438.459	5057233.678	45622.875	355.650
Compound	.995	9937.671	.000	136176169.071	1.029		
Power	.872	312.218	.000	79444121.047	.423		
S	.382	28.459	.000	19.575	-1.549		
Growth	.995	9937.671	.000	18.729	.029		
Exponential	.995	9937.671	.000	136176169.071	.029		
Logistic	.995	9937.671	.000	7.343E-09	.972		

Source: Author's Compilation

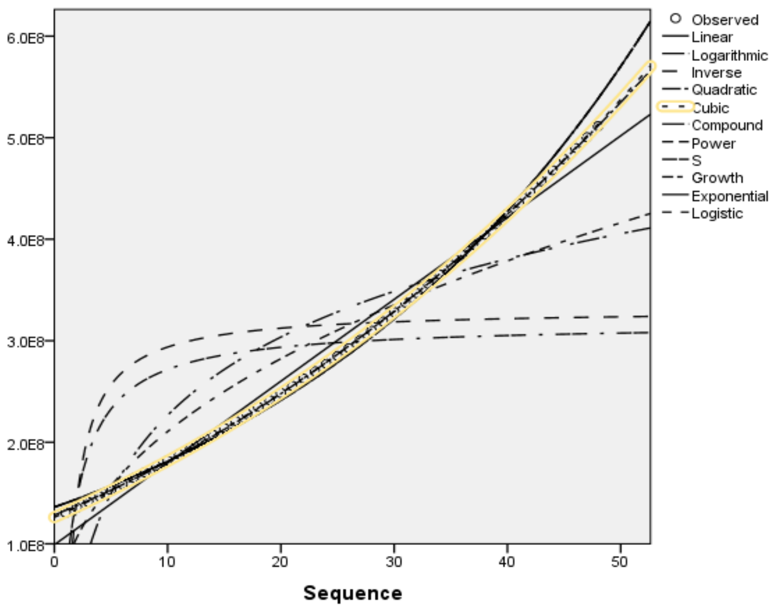

Figure 13: Curve Estimation Plot for Urban Population

As displayed in Table 17, the Cubic regression model again provides the best fit, with an R^2 value of 1.000, indicating a near-perfect explanation of rural population trends in India. This model outperforms all others, including the quadratic (R^2 = 0.996), linear (R^2 = 0.984), and exponential/compound models (R^2 = 0.965). While linear and exponential trends suggest consistent growth or decline, the cubic model captures the non-linear dynamics of rural population change, especially the transition from growth to stagnation or even potential decline, as also reflected in Figure 14. The positive linear (β_1) and quadratic (β_2) terms indicate that the rural population initially increased at an accelerating pace. However, the negative cubic coefficient (β_3 = -4,155.189) suggests a reversal or deceleration in recent decades, reflecting the country's rapid urbanization and demographic transition.

Table 17: Regression Estimation for Rural Population

	Model Summary			Parameter Estimates			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.984	2907.584	.000	482151589.256	10085060.131		
Logarithmic	.863	290.162	.000	292113840.098	149152324.248		
Inverse	.364	26.330	.000	778939393.067	-535073423.515		
Quadratic	.996	5853.870	.000	445825590.666	14444179.962	-88961.629	
Cubic	**1.000**	302617.446	.000	471785133.574	8396302.458	216444.758	-4155.189
Compound	.965	1262.083	.000	502321400.402	1.015		
Power	.904	431.998	.000	374992546.041	.220		
S	.414	32.535	.000	20.464	-.823		
Growth	.965	1262.083	.000	20.035	.014		
Exponential	.965	1262.083	.000	502321400.402	.014		
Logistic	.965	1262.083	.000	1.991E-09	.986		

Source: Author's Compilation

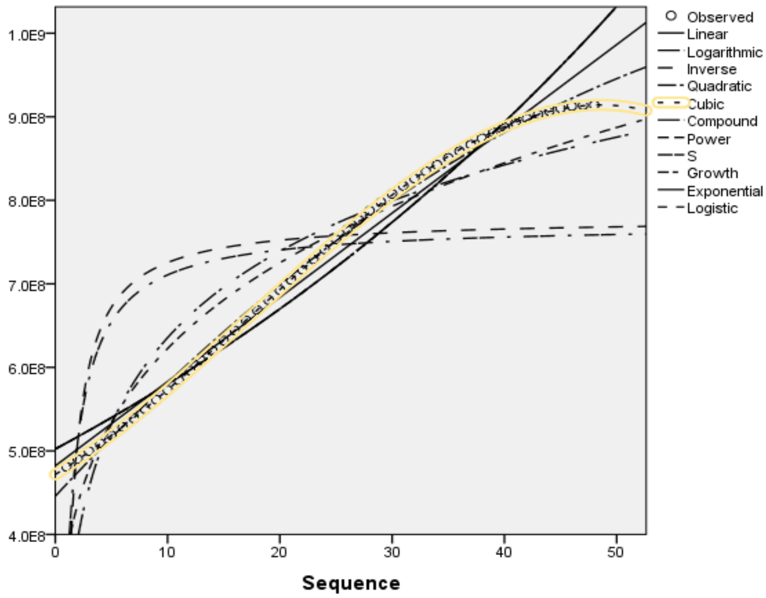

Figure 14: Curve Estimation Plot for Rural Population

3.8 Trend Analysis of Life Expectancy at Birth

The Quadratic model in Table 18 offers the best fit with an R^2 value of 0.991 and a very high F-statistic of 2392.353, making it the most suitable model to explain the changes in LEB, then the Cubic model with the same R^2 value, but with a relatively low F-statistic. The quadratic trend in LEB reflects a period of significant improvement in public health and longevity, followed by a gradual tapering of that progress.

Table 18: Regression Estimation for LEB (Total)

Equation	Model Summary			Parameter Estimates			
	R^2	F	Sig.	β_0	β_1	β_2	β_3
Linear	.985	3041.667	.000	51.363	.430		
Logarithmic	.864	292.567	.000	43.265	6.354		
Inverse	.378	27.993	.000	64.044	-23.224		
Quadratic	**.991**	2392.353	.000	50.297	.557	-.003	
Cubic	.991	1593.437	.000	50.549	.499	.000	-4.037E-05
Compound	.979	2132.210	.000	51.857	1.007		
Power	.891	374.336	.000	45.174	.106		
S	.408	31.740	.000	4.157	-.396		
Growth	.979	2132.210	.000	3.948	.007		
Exponential	.979	2132.210	.000	51.857	.007		
Logistic	.979	2132.210	.000	.019	.993		

Source: Author’s Compilation

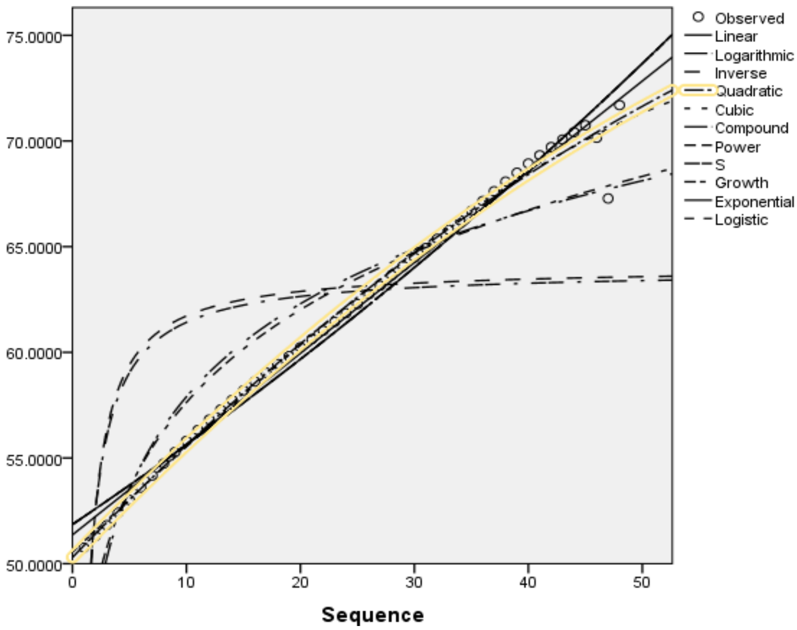

Figure 15: Curve Estimation Plot for LEB (Total)

Tables 19 and 20 also follow the same trend pattern, and the graphical plots of the three tables are shown in Figures 15, 16 and 17, respectively.

Table 19: Regression Estimation for LEB (Male)

Equation	Model Summary			Parameter Estimates			
	R^2	F	Sig.	β_0	β_1	β_2	β_3
Linear	.986	3330.392	.000	51.560	.387		
Logarithmic	.852	264.578	.000	44.402	5.674		
Inverse	.367	26.664	.000	62.943	-20.573		
Quadratic	**.989**	2068.020	.000	50.874	.469	-.002	
Cubic	.989	1367.342	.000	51.072	.423	.001	-3.173E-05

Equation	Model Summary			Parameter Estimates			
	R^2	F	Sig.	β_0	β_1	β_2	β_3
Compound	.983	2627.774	.000	51.985	1.006		
Power	.877	328.371	.000	45.977	.095		
S	.394	29.885	.000	4.140	-.353		
Growth	.983	2627.774	.000	3.951	.006		
Exponential	.983	2627.774	.000	51.985	.006		
Logistic	.983	2627.774	.000	.019	.994		

Source: Author's Compilation

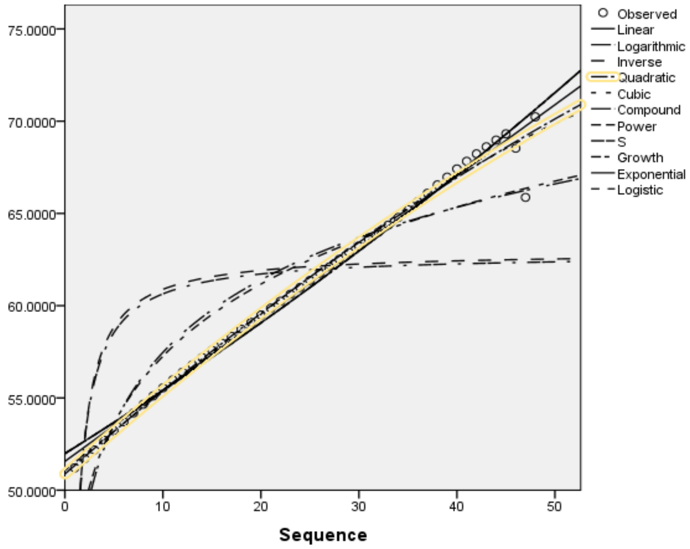

Figure 16: Curve Estimation Plot for LEB (Male)

Table 20: Regression Estimation for LEB (Female)

Equation	Model Summary			Parameter Estimates			
	R^2	F	Sig.	β_0	β_1	β_2	β_3
Linear	.983	2648.813	.000	51.166	.475		
Logarithmic	.874	319.646	.000	42.059	7.082		
Inverse	.388	29.214	.000	65.238	-26.078		
Quadratic	**.992**	2640.287	.000	49.698	.652	-.004	
Cubic	.992	1765.568	.000	49.987	.584	.000	-4.634E-05
Compound	.974	1721.062	.000	51.737	1.008		
Power	.902	422.969	.000	44.351	.117		
S	.422	33.548	.000	4.175	-.441		
Growth	.974	1721.062	.000	3.946	.008		
Exponential	.974	1721.062	.000	51.737	.008		
Logistic	.974	1721.062	.000	.019	.992		

Source: Author's Compilation

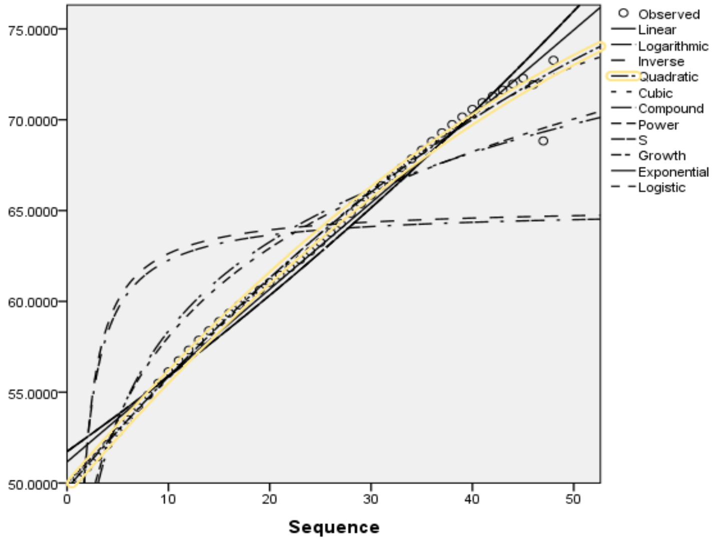

Figure 17: Curve Estimation Plot for LEB (Female)

3.9 Trend Analysis of Fertility, Birth and Death Rate

The Cubic regression model in Table 21 provides the best statistical fit with an R^2 value of 0.999, making it the most appropriate model to explain the decline in fertility rates in India from 1975 to 2022. The negative linear (β_1) and quadratic (β_2) coefficients confirm that fertility rates in India have experienced a steady and accelerating decline, especially during the earlier decades. However, the slightly positive cubic coefficient (β_3 = 1.161E-05) indicates a marginal tapering off or slowing of this decline in the most recent years, which is also shown in Fig.18.

Table 21: Regression Estimation for Fertility Rate

	Model Summary			**Parameter Estimates**			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.996	12222.043	.000	5.176	-.070		
Logarithmic	.849	258.731	.000	6.452	-1.021		
Inverse	.358	25.651	.000	3.121	3.661		
Quadratic	.998	13386.738	.000	5.281	-.083	.000	
Cubic	**.999**	13851.095	.000	5.209	-.066	-.001	1.161E-05
Compound	.992	5980.664	.000	5.552	.979		
Power	.771	154.769	.000	7.815	-.292		
S	.290	18.824	.000	1.108	.990		
Growth	.992	5980.664	.000	1.714	-.021		
Exponential	.992	5980.664	.000	5.552	-.021		
Logistic	.992	5980.664	.000	.180	1.021		

Source: Author's Compilation

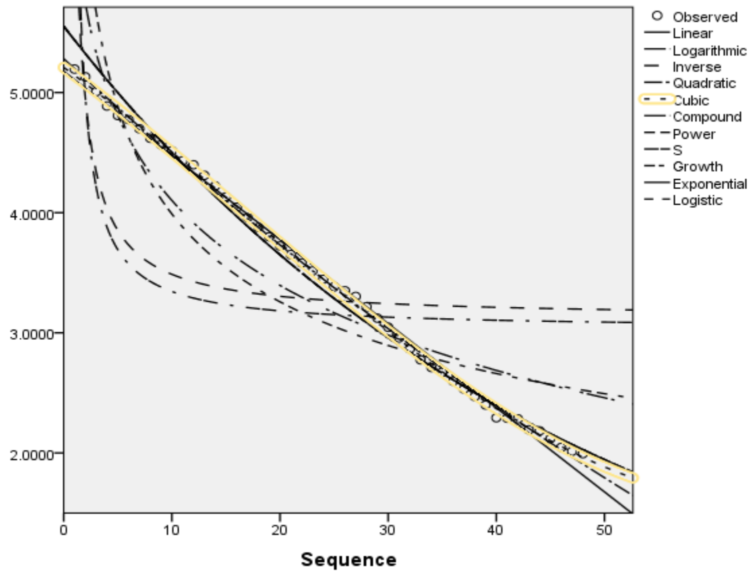

Figure 18: Curve Estimation Plot for Fertility Rate

The Cubic model has the highest R^2 (0.999), as displayed in Table 22. The negative linear and quadratic terms indicate a consistent and sharp decline in birth rates across decades. However, the very small positive cubic term implies a slight flattening of the decline in recent years, hinting that the rate of reduction in fertility is now slowing down, possibly nearing stabilization, which is also graphically represented in Figure 19.

Similarly, the Cubic model is also the best fit for the death rate, with an R^2 of 0.984 (Table 23). Here too, the negative linear coefficient reflects an overall decline in mortality. The positive quadratic and cubic terms, however, suggest that the pace of mortality reduction is slowing, and the curve (Figure 20) may slightly level out.

Table 22: Regression Estimation for Birth Rate

	Model Summary			**Parameter Estimates**			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.994	7663.199	.000	40.274	-.509		
Logarithmic	.781	163.737	.000	48.687	-7.127		
Inverse	.289	18.685	.000	25.574	23.950		
Quadratic	.995	4876.294	.000	39.650	-.434	-.002	
Cubic	**.999**	11265.796	.000	38.433	-.151	-.016	.000
Compound	.977	1993.466	.000	42.980	.981		
Power	.713	114.332	.000	57.371	-.259		
S	.243	14.740	.000	3.213	.835		
Growth	.977	1993.466	.000	3.761	-.019		
Exponential	.977	1993.466	.000	42.980	-.019		
Logistic	.977	1993.466	.000	.023	1.019		

Source: Author’s Compilation

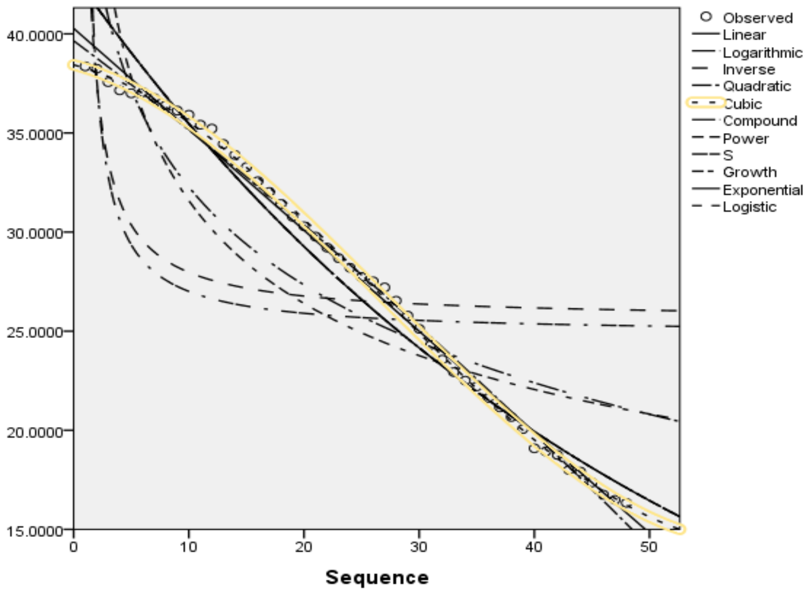

Figure 19: Curve Estimation Plot for Birth Rate

Table 23: Regression Estimation for Death Rate

	Model Summary			**Parameter Estimates**			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.893	385.031	.000	14.173	-.183		
Logarithmic	.920	525.807	.000	18.284	-2.933		
Inverse	.470	40.763	.000	8.613	11.580		
Quadratic	.982	1232.648	.000	16.075	-.411	.005	
Cubic	**.984**	892.582	.000	15.738	-.333	.001	5.401E-05
Compound	.919	522.392	.000	14.688	.982		
Power	.867	299.370	.000	21.430	-.283		
S	.396	30.214	.000	2.136	1.058		
Growth	.919	522.392	.000	2.687	-.018		
Exponential	.919	522.392	.000	14.688	-.018		
Logistic	.919	522.392	.000	.068	1.019		

Source: Author’s Compilation

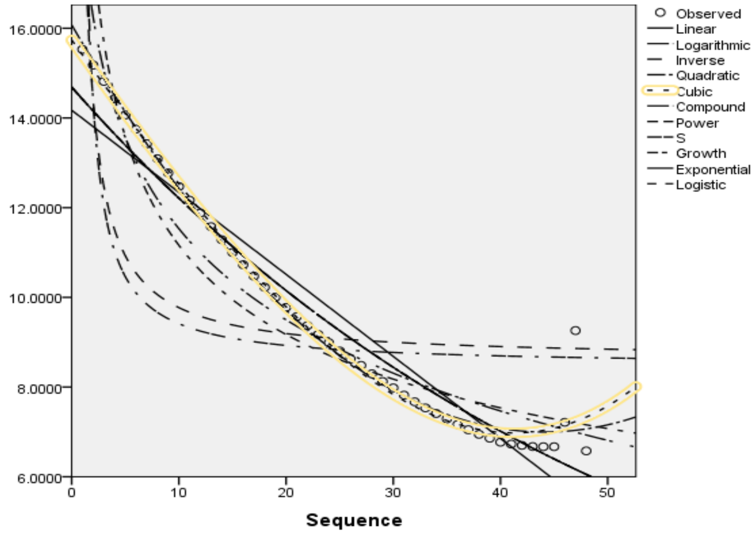

Figure 20: Curve Estimation Plot for Death Rate

3.10 Trend Analysis of Population Density & Sex Ratio

The Cubic regression model is also the most suitable model for explaining the growth pattern in India's population density, as per Table 24. The positive linear (β_1) and quadratic (β_2) coefficients suggest that population density was rising steadily and even accelerating during the earlier years. However, the slightly negative cubic coefficient (β_3 = –0.001) signals a recent deceleration or plateauing of that growth (also shown in Figure 21), possibly due to declining fertility or slowing rural population increase.

Table 24: Regression Estimation for Population Density

	Model Summary			**Parameter Estimates**			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.999	40268.561	.000	195.726	6.093		
Logarithmic	.823	214.391	.000	88.950	87.368		
Inverse	.328	22.415	.000	373.281	-304.454		
Quadratic	.999	22165.678	.000	193.461	6.365	-.006	
Cubic	**1.000**	838747.004	.000	201.455	4.502	.088	-.001
Compound	.986	3216.568	.000	213.096	1.019		
Power	.886	357.908	.000	149.265	.275		
S	.393	29.754	.000	5.906	-1.012		
Growth	.986	3216.568	.000	5.362	.018		
Exponential	.986	3216.568	.000	213.096	.018		
Logistic	.986	3216.568	.000	.005	.982		

Source: Author’s Compilation

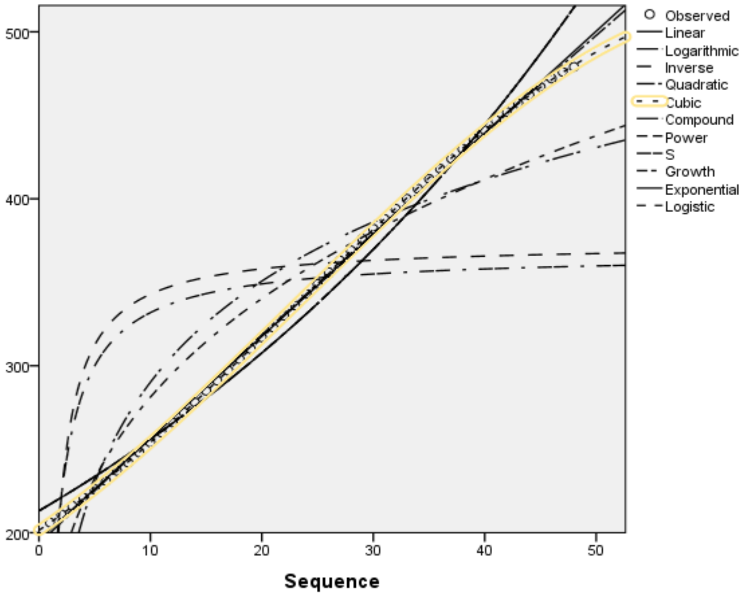

Figure 21: Curve Estimation Plot for Population Density

Table 25 also revealed that the Cubic model provides the best statistical fit, with the highest R^2 value of 0.940. The very small linear and quadratic coefficients close to zero suggest a slow and steady change in the sex ratio across time. The negative cubic coefficient implies that after a modest improvement in the sex ratio in the earlier years, the pace of change has slowed or plateaued in recent times, which is also shown in Figure 22. This reflects how India, over the decades, has made gradual progress in correcting gender imbalances, supported by awareness campaigns, legal reforms (like banning sex-selective abortion), and socio-economic improvements.

Table 25: Regression Estimation for Sex Ratio

	Model Summary			**Parameter Estimates**			
Equation	**R^2**	**F**	**Sig.**	**β_0**	**β_1**	**β_2**	**β_3**
Linear	.517	49.191	.000	1.066	.001		
Logarithmic	.628	77.682	.000	1.050	.011		
Inverse	.335	23.132	.000	1.085	-.043		
Quadratic	.828	108.601	.000	1.050	.003	-3.864E-05	
Cubic	**.940**	228.622	.000	1.062	.000	.000	-1.902E-06
Compound	.519	49.568	.000	1.066	1.001		
Power	.631	78.623	.000	1.050	.010		
S	.337	23.384	.000	.082	-.040		
Growth	.519	49.568	.000	.064	.001		
Exponential	.519	49.568	.000	1.066	.001		
Logistic	.519	49.568	.000	.938	.999		

Source: Author's Compilation

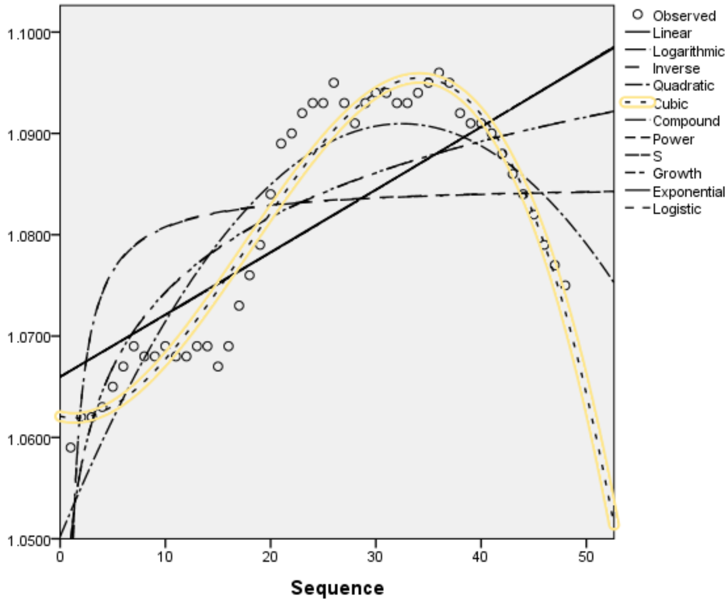

Figure 22: Curve Estimation Plot Sex Ratio

4. Conclusion

This study seeks to undertake an in-depth and comparative examination of 22 key elements of India's demographic structure. By employing CAGR and 11 different regression models and selecting the best-fit model based on the highest R^2 value, the study traces the trajectory of India's demographic shifts from 1975 to 2022, thereby offering insights into the evolving structure of the nation's population and the socio-economic implications therein.

The CAGR analysis found major demographic shifts in India. The total population grew at 1.78% annually, with balanced male and female growth. The child population rose modestly at 0.79%, reflecting declining fertility and birth rates, while the working-age group grew faster at 2.21%, reinforcing India's demographic dividend. The elderly population had the highest growth, especially among females (3.07%), indicating population ageing and rising longevity. Urban population surged at 2.89%, outpacing rural growth (1.35%) and increasing population density (1.77%), showing rapid urbanization. Life expectancy rose (0.72%), with females living longer (0.79%) than males (0.66%). The sex ratio improved slightly (0.03%). Meanwhile, fertility (-1.98%), birth (-1.76%), and death rates (-1.77%) declined steadily, signalling improved health, lower mortality, and advancing demographic transition.

The findings from regression analysis reveal that India's total population has followed a strong cubic growth trajectory, indicating an initially accelerating trend that has begun to decelerate slightly in recent years. This aligns with the demographic transition theory, where populations first experience rapid growth and then gradually stabilize. The working-age population also shows a similar cubic pattern, confirming India's demographic dividend phase. However, the young dependent population, while once rising, now shows signs of decline, particularly visible through the cubic regression estimates for male and female cohorts, with negative cubic coefficients indicating a reversal of growth in later years.

One of the most striking findings is the sharp increase in the elderly population. Both male and female subgroups demonstrate cubic growth trends, suggesting that India is slowly transitioning into an ageing society. This shift has profound implications for healthcare infrastructure, pension systems, and elder care services.

The urban population too follows the cubic growth model, signalling not only consistent growth but also possible signs of urban saturation or restructuring in recent years. This contrasts with the rural population, which, while still growing, is doing so at a decelerating rate. The rural demographic is also best captured by the cubic model, though the coefficients suggest a slowing pace of increase. The analysis of LEB reveals a quadratic relationship, reflecting a period of significant improvement in public health and longevity, followed by a gradual tapering of that progress. In terms of population density, the trend is again best explained by the cubic model, which reveals a recent deceleration in growth, likely due to declining fertility or a slowing increase in rural population. The sex ratio also exhibits the cubic pattern, implying that the pace of growth has slowed in recent times.

5. Policy Implications & Future Research Direction

The rapid growth of the working-age population highlights the urgent need for policies that focus on skill development, job creation, and labour market reforms to harness India's demographic dividend. Simultaneously, the sharp rise in the elderly population, particularly among females, calls for expanded geriatric healthcare, social security measures, and age-sensitive infrastructure. The urban population's faster growth compared to rural areas underscores the need for improved urban planning, including housing, transport, and sanitation, while also revitalizing rural development to reduce migration pressures.

The declining fertility, birth, and death rates suggest progress in public health and reproductive services, but maintaining this momentum requires continuous investment in healthcare access, awareness campaigns, and family planning. The modest improvement in the sex ratio and greater life expectancy among females indicate positive gender trends, yet deeper interventions are needed to eliminate long-standing gender disparities. Future research should explore region-specific trends to better inform state-level interventions and targeted welfare policies.

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Appendix

Figure 23

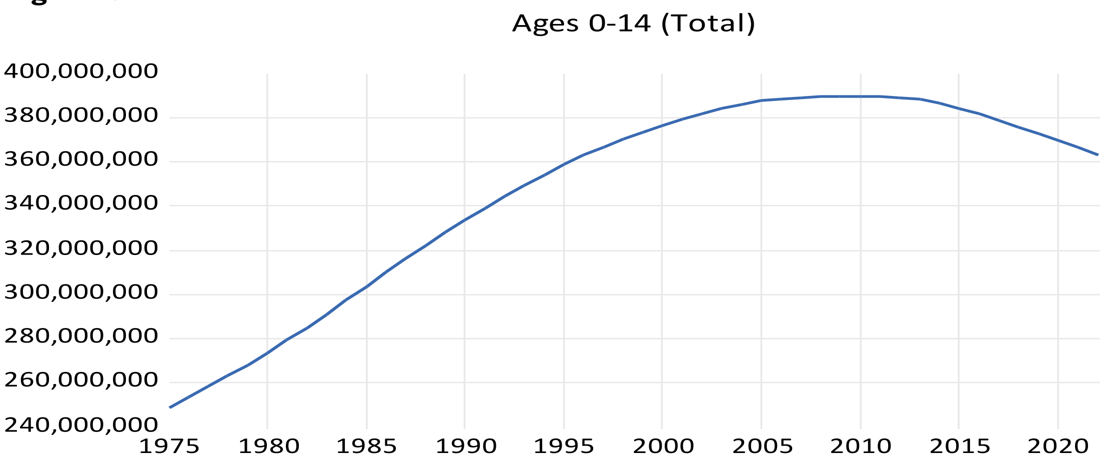
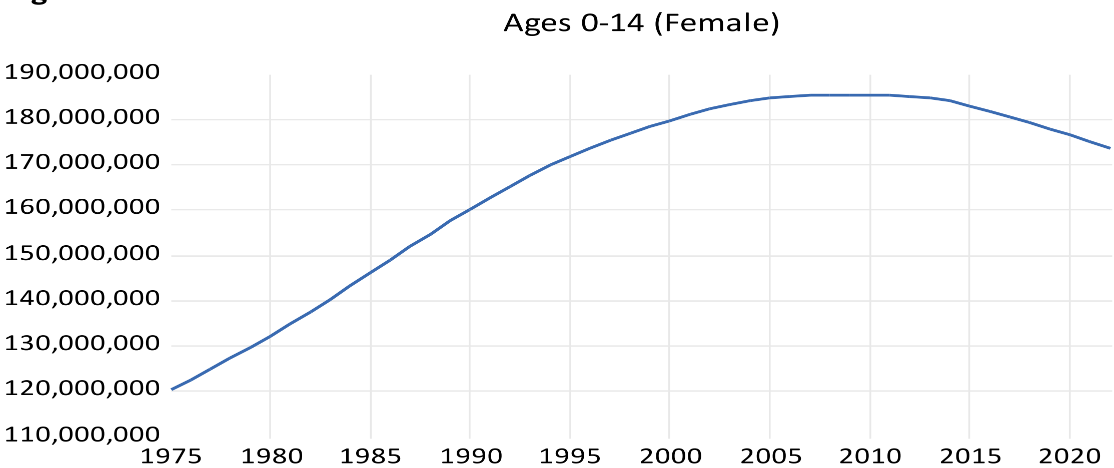


Figure 24



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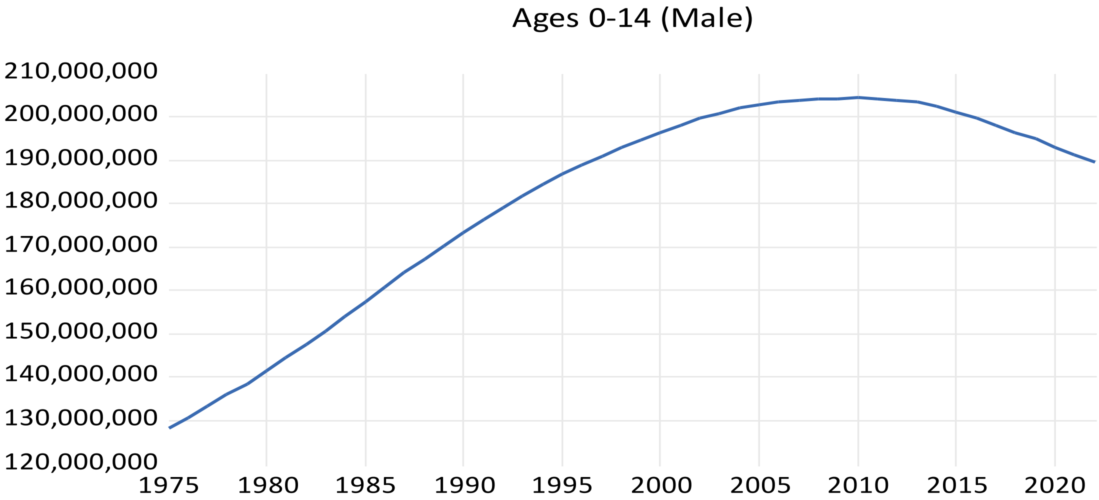

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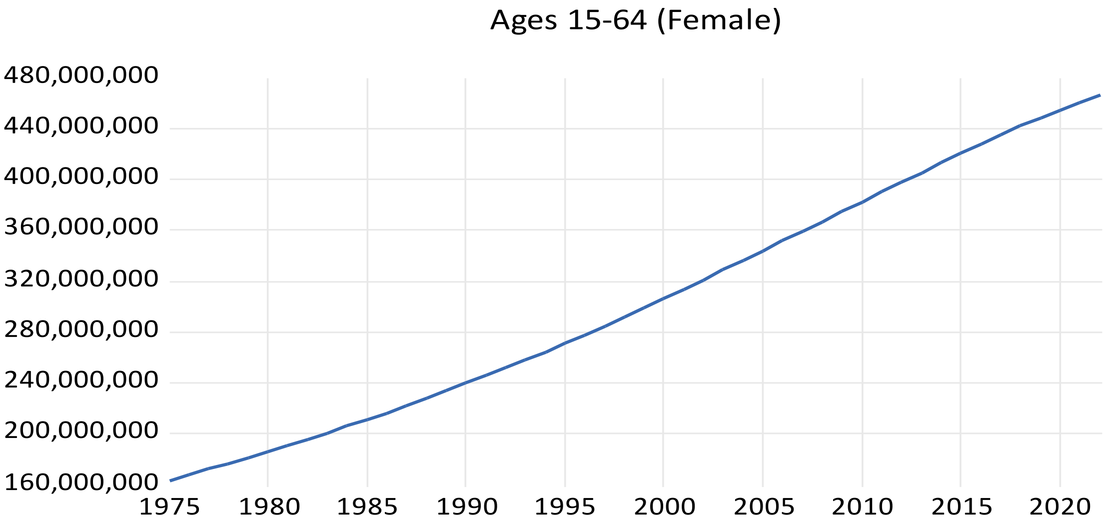

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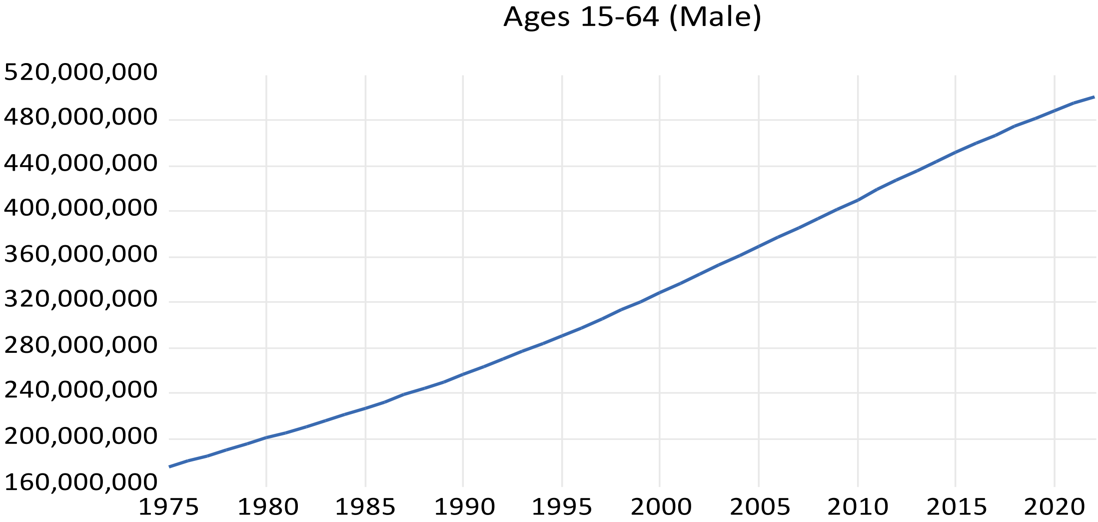

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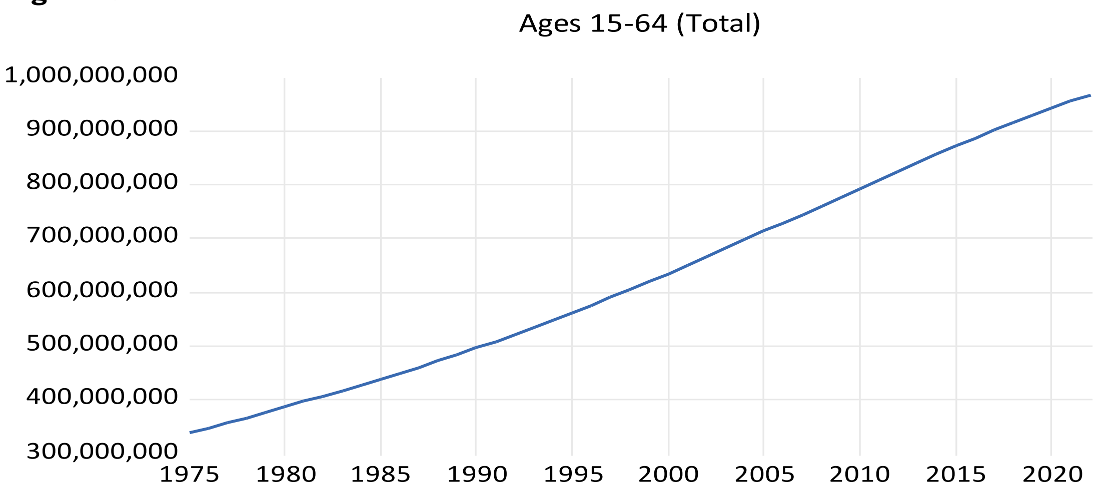

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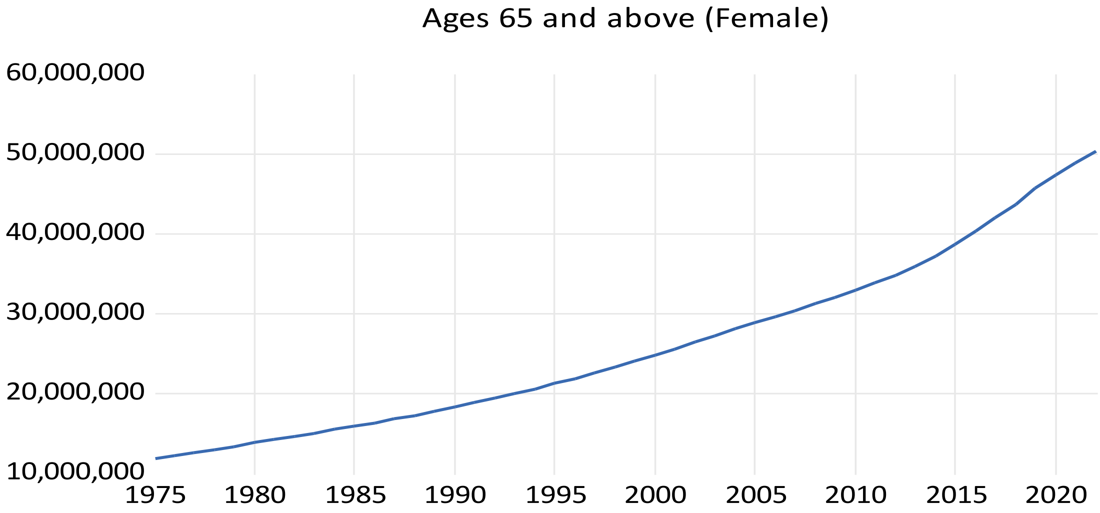

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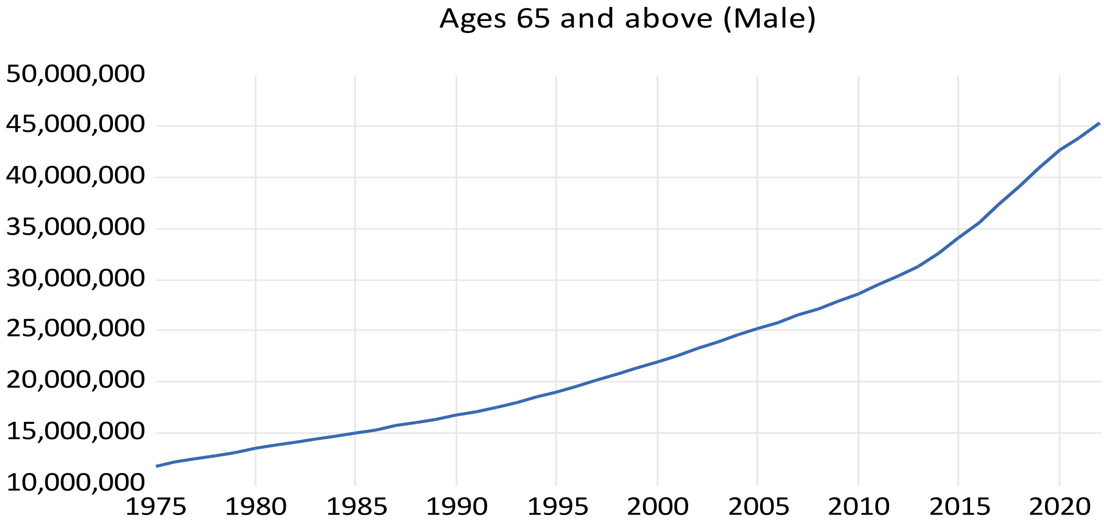

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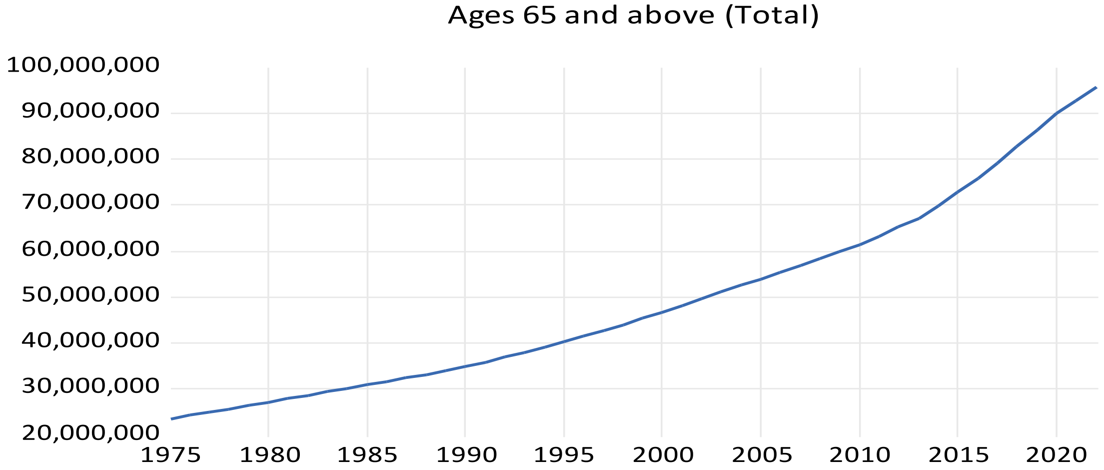

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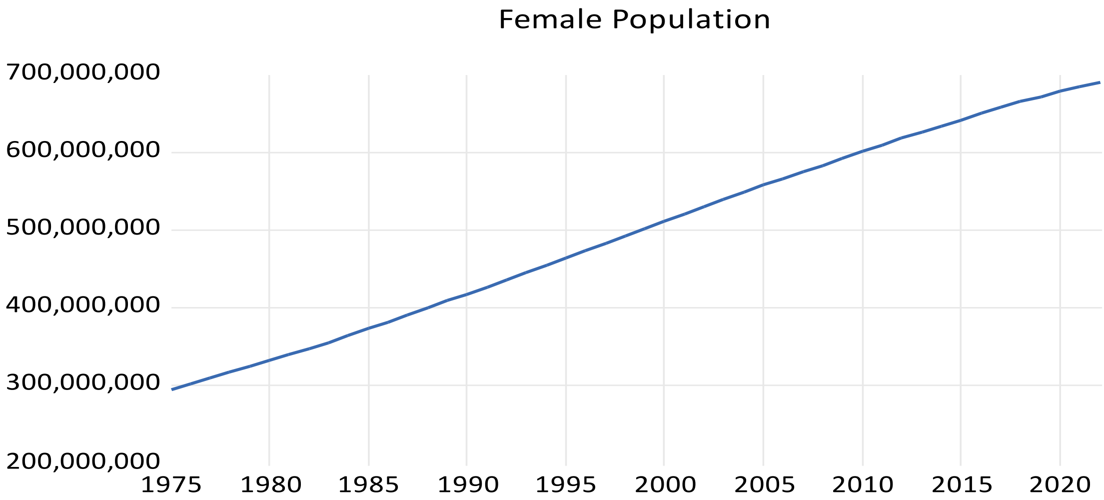

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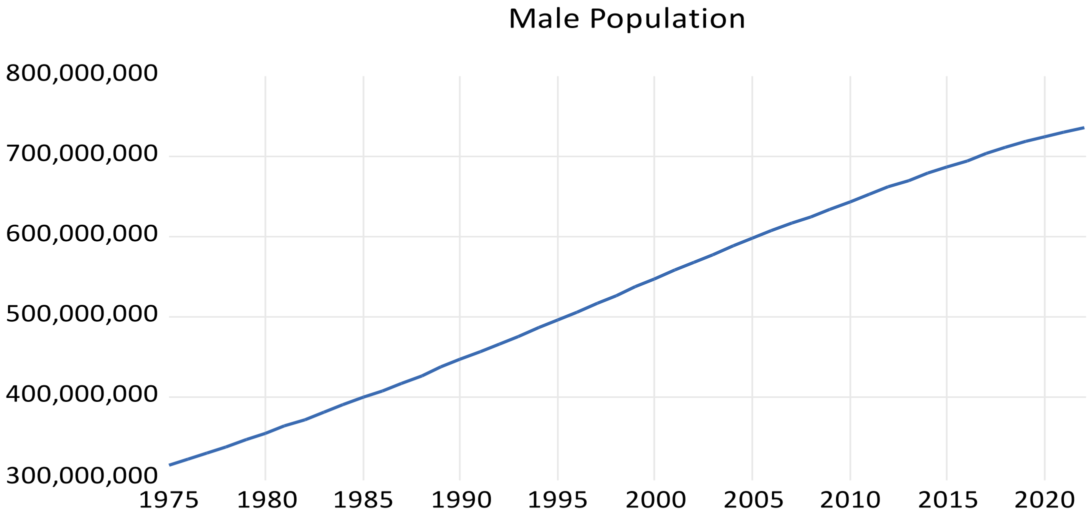

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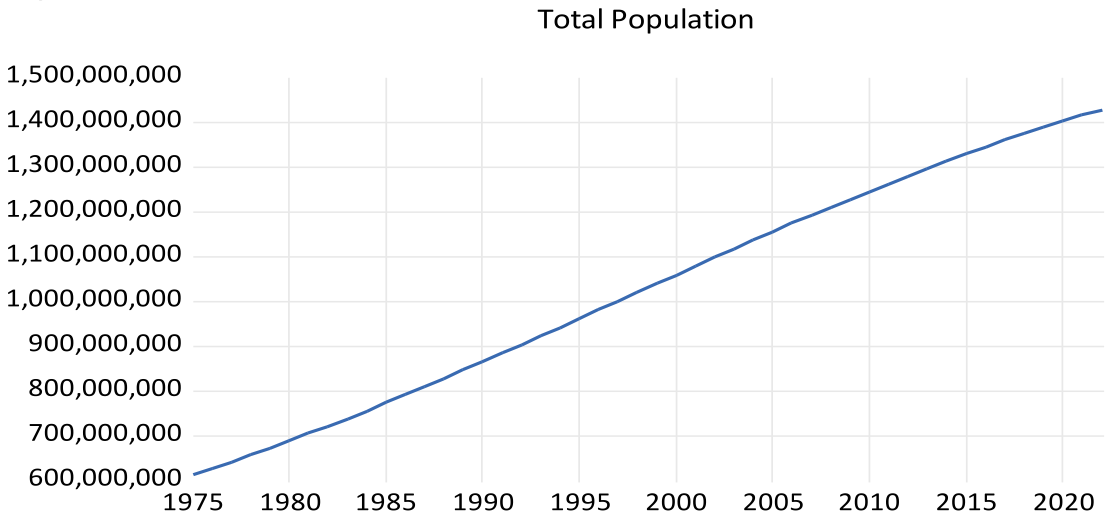

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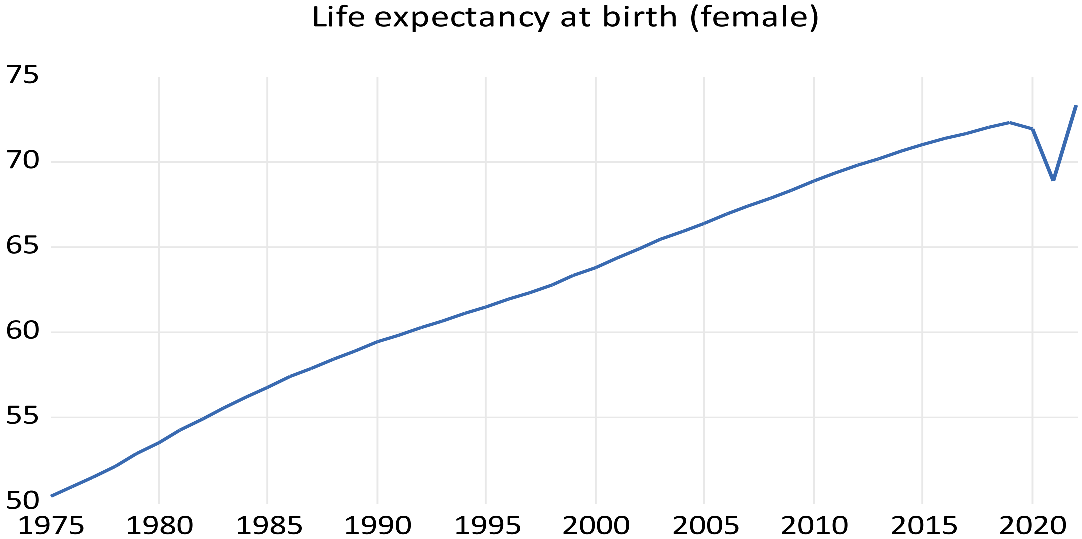

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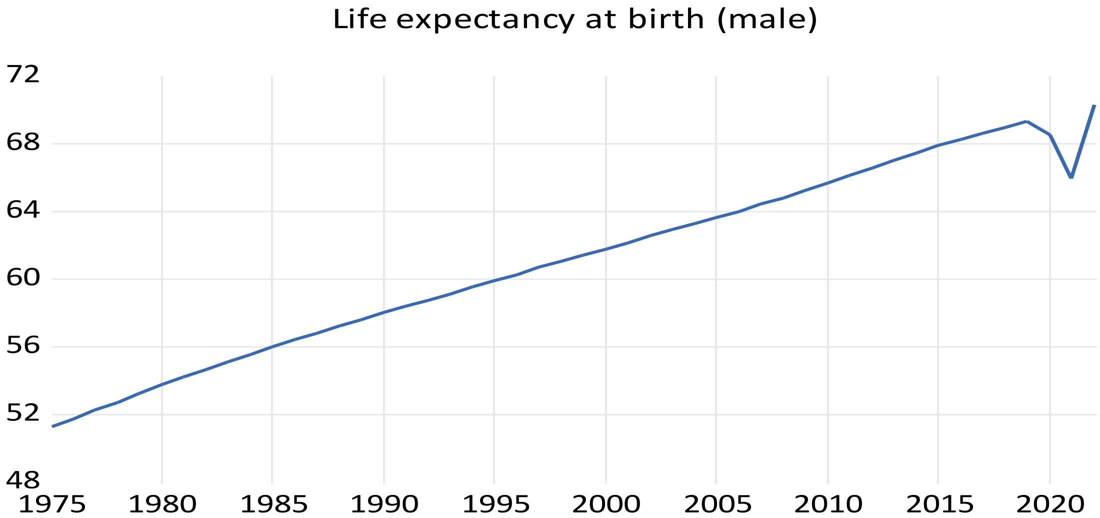

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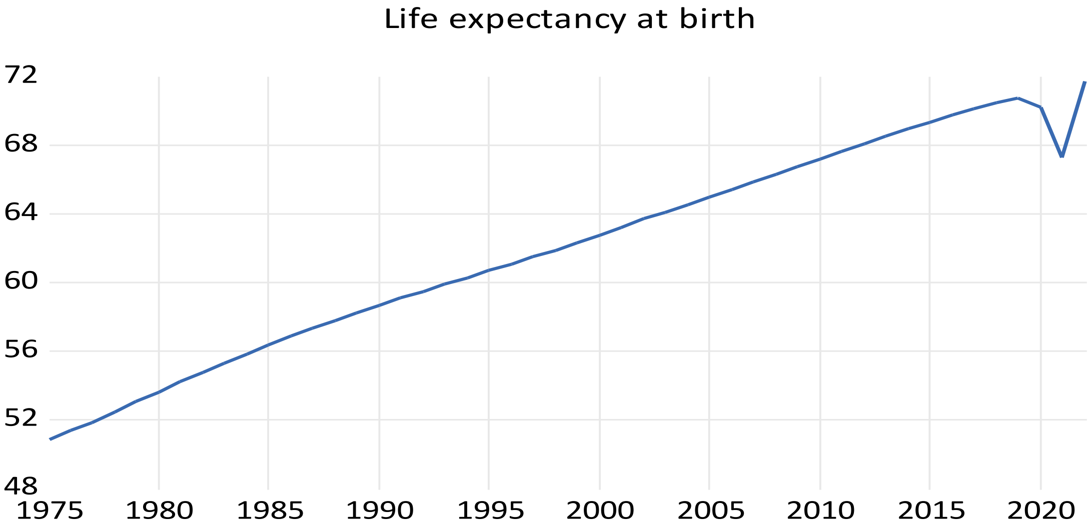

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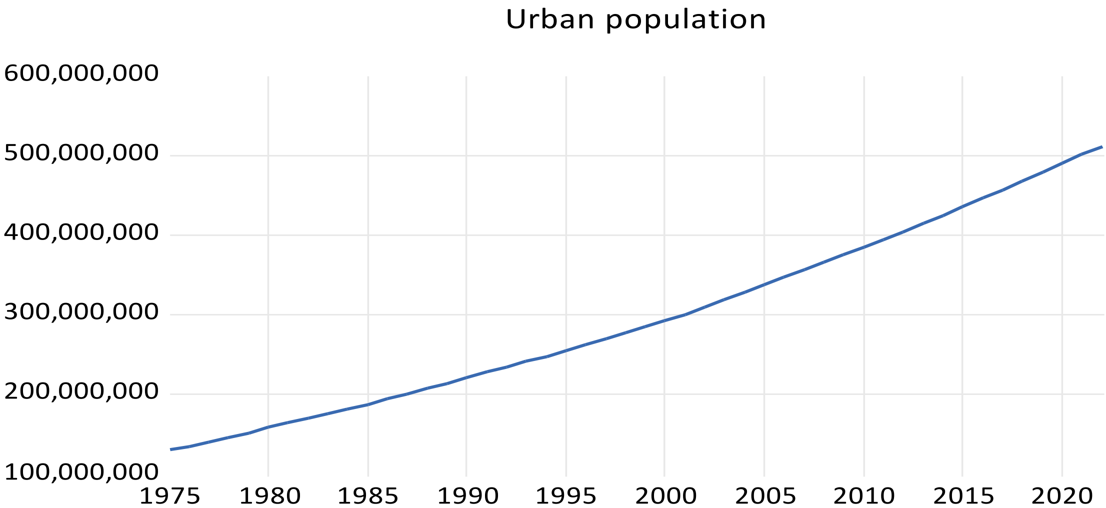

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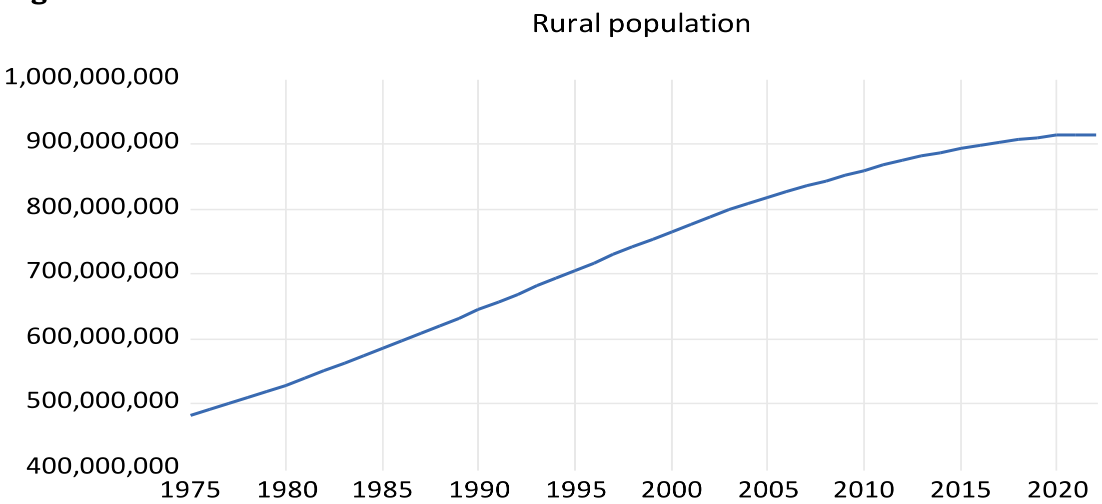

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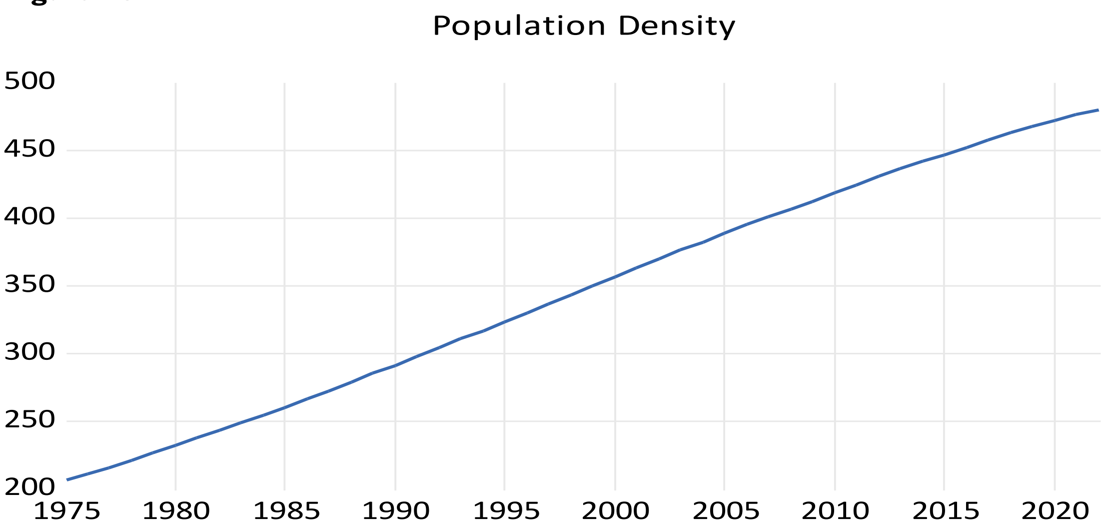

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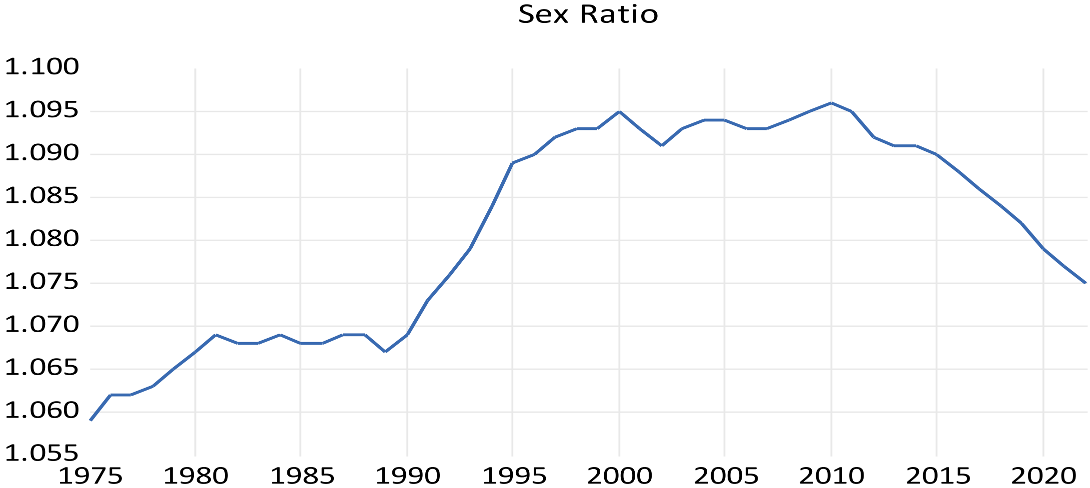

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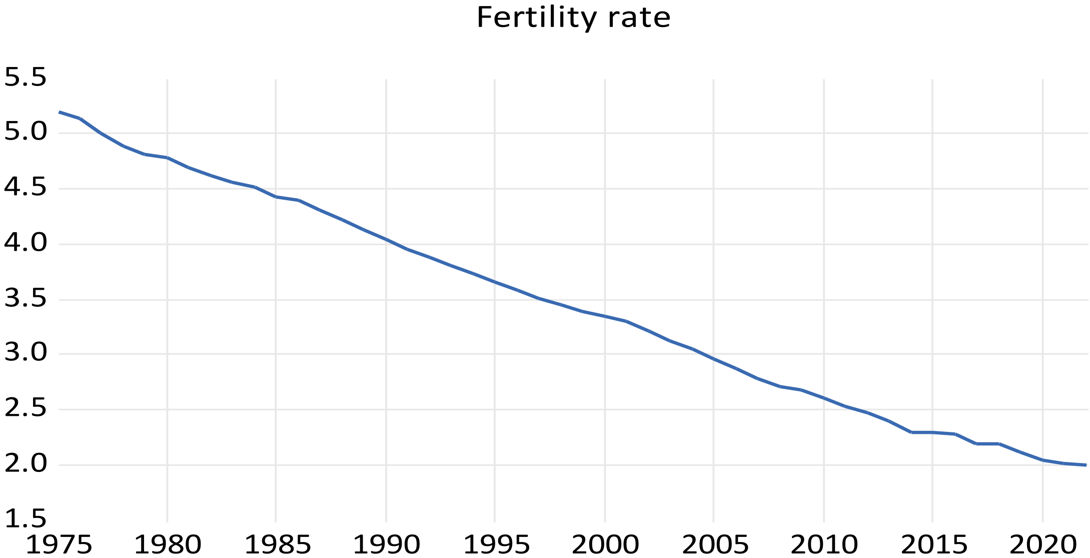

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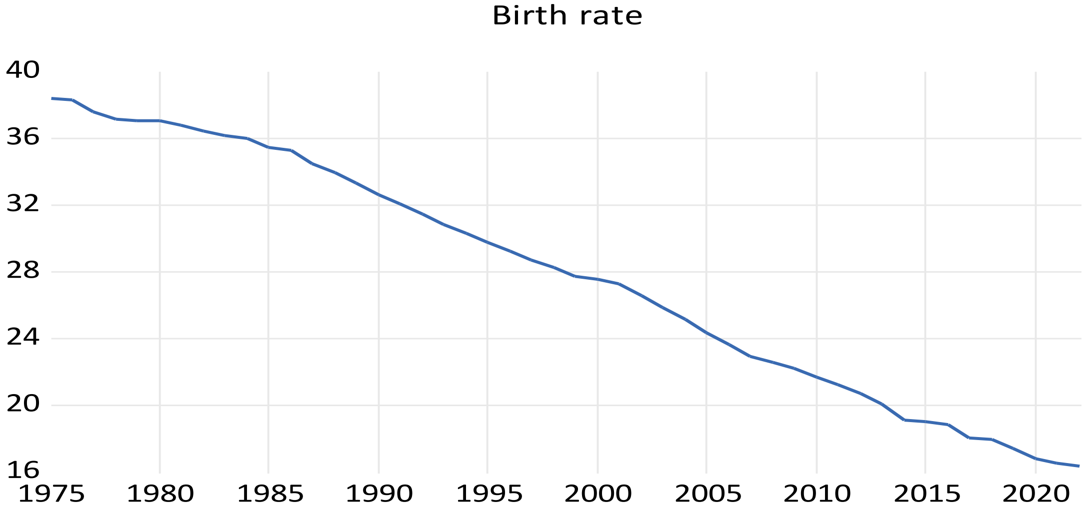

Figure 44