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Comparative Evaluation and Outcrop of Metropolitan Population of two highly dense country India and China

Dr. Sarjerao Krushnat Powar
Assistant Professor, Smt. Kasturbai Walchand College of Arts and Science, Sangli,

ABSTRACT
The world urban population is expected to be double by 2050, increasing from 3.6 billion in 2011 to 6.3 billion in 2050 (UN, 2011). The urban population of India and China increasing exponentially over period of time the growth of urban population of India is slower than China after 1981 census. The urban population is projected with the help of past data. There are two types of approaches for calculating projections, viz macro and micro approach (Goldstain and Arriaga, 1975). The data collected for this study is from various censuses for India and data for China is collected from website www.tradingeconomics.com. The urban population of India and China is projected from 1991–2051 by using Ratio Method, URGD Method and Logistic Growth Curve Method. The analysis of the study reveals that the projected urban population of India is over estimated by Ratio Method and under estimated by URGD Method and logistic Growth Curve Method. In case of China projected urban population is under estimated for all the methods. And also shows that the URGD Method for China and Logistic Growth Curve Method for India gives reasonable projected of urban population.
Keywords: Urbanization, estimation and projection, UN Methods and Logistic Growth Curve Method

I. INTRODUCTION

The world urban population is expected to double by 2050, increasing from 3.6 billion in 2011 to 6.3 billion in 2050 [1]. This mainly become rapid change in the nature of human activities and rapid development in the human research in science, technology and management.

Historically, the process of rapid urbanization started in more development regions. In 1920, just under 30 per cent of the their population was urban and by 1950, more than half of the population living in urban areas, in 2011 high level of urbanization is recorded in Australia, New Zealand and Northern America.

The United Nation has initiated the projection of urban population in 1978; later on it has gained increasing importance in the characterization of urban development process [2]. Initially it starts with only percentage of urban, afterwards the use of geometric growth rate [3]. The demo-economic model for urban-rural areas with rural to urban migration was studied by [4]. Shenghe Liu et al. [5] have studied Linear Regression Model and S-Curve Regression Model for projection of Chain's Urbanization level. Mark R. Montogomery [6] proposed econometric models of to predict City population growth rate using total, urban and rural. [7, 8] proposed to a model to project the world proportion of urban population and compared to his estimates.

There are two types of approaches for calculating projections of the urban and rural population can be distinguished. The Macro-approach makes use of existing national population projection and derives projection of urban and rural populations from these. The micro-approach projects the population of various urban and rural units independently. The results of these units can be summed to obtain the projections of total and urban populations [9].

The projection of total, urban and rural population generally depending on the past growth rate and this growth rate is depending upon various factors such as fertility, mortality, migration, economic and industrial development and many other factors. Hence the projection of urban and total population is a complex phenomenon.

In this paper an attempt is made to project the total, urban and rural population of India and China from 1991–2051, using the various methods viz. Ratio method, URGD method and Logistic growth curve method. The paper has divided into four sections. In first section Introduction of urban population projections, the second section deals with methods and materials used to project the urban population, the third section explains about the Analysis and Interpretation of projected urban population and last section gives the summary and conclusions.

II. METHODS AND MATERIALS

The present analysis is carried out by using the [10] data on total and urban population and Chinese total and urban population from website

[11] for 1971–2001. The different methods have been used for projecting total, urban and rural populations viz Ratio method, URGD method and Logistic Growth Curve method.

Ratio Method

The Ratio Method assumes that projection of the population as a whole are available together with data specifying the urban/rural population from consecutive censuses. Projection of urban and rural populations is obtained by redistributing the projected total population among urban and rural areas [9]. The projection procedure is as follows:

a) Ratio of urban population to total population is calculated for each census.
b) Past trend of these ratios are analysed and extrapolated to those dates in future for which national population projection are available. The extrapolation is done by using the logistic growth curve method.
c) And finally the projected ratios are multiplied by projected total population and the products are the projection of urban population.

The ratio method is easy to compute and understand. It requires limited data and less time to calculate.
The projection is requiring the ratio of urban population to total population for past censuses. The ratio of urban and total population extrapolated by using the logistic growth curve method and also the urban population is projected by using the same model.

The United Nations Method

The projection method elaborated by United Nations can be considered a special case of Ratio method. To calculate projections with this method the proportion of urban population relative to the projected total population is treated as a logistic function. The United Nations method is based on the data for consecutive population census which identify urban and rural areas together with projection of the total population. These assumptions of projection seem to be focus directly on the process of urbanization. The UN model is based on the observed difference between the exponential growth rates of urban and rural population which is calculated from the past data. Therefore, this method is called as Urban-Rural Growth-Difference (URGD) method.

The United Nations method has applied in two alternative ways, and which one is adopted will depend on the length of the projection intervals. If the length of each interval is only one year, the method of annual rates may be applied; projections for longer intervals can be interpolated for each calendar year. In the case of longer intervals, the method of instantaneous rates of growth may be used [9].

Instantaneous Growth Rate Method

Here the instantaneous Growth Rate method is illustrated by denoting the total population of an area at time ‘t’ by T(t) and urban population and rural population as U(t) and R(t), respectively.
T(t) = U(t) + R(t) (2.2.1.1)
Let us further assume that the function is not only continuous but also differentiable in the considered time period. The time t = o is chosen at the beginning of the projection period. Thus, Instantaneous rates of increment in the Urban and rural population exist. In this case, the United Nations method was assumed that the k difference between these two instantaneous growth rate is constant, i.e., independent of time. Thus, the following equation is,

$$\frac{1}{U}\frac{dU(t)}{dt} - \frac{1}{R}\frac{dR(t)}{dt} = k \qquad (2.2.1.2)$$

where, k is a constant. by integrating from Eq. (2.2.1.2) we get,

$$\left.\begin{array}{l} \ln U(t) - \ln R(t) = kt + c \ or \\ U(t) = R(t)e^{kt+c} \end{array}\right\} \qquad (2.2.1.3)$$

where, c- arbitrary constant, Thus, we can fix its value in such a way that the Eq. (2.2.1.2) is satisfied by the proportion of urban and rural population at the beginning of the projection period when t = 0, i.e. at the time of the last census. Thus,

$$\frac{U(0)}{R(0)} = e^{c} \quad \text{or} \quad c = \ln\left[\frac{U(0)}{R(0)}\right] \qquad (2.2.1.4)$$

Putting Eq. (2.2.1.3) in Eq. (2.2.1.1), we find,

$$T(t) = R(t)\, e^{kt + c} + R(t) \qquad (2.2.1.5)$$

By using this equation we have to get following equations for U(t) and R(t),

$$R(T) = \frac{T(t)}{1 + e^{kt+c}} = \frac{T(t)}{1 + [U(0)/R(0)]e^{kt}} \quad (2.2.1.6)$$

$$U(t) = \frac{T(t)}{1 + [U(0)/R(0)]e^{kt}} \cdot \frac{U(0)}{R(0)} . e^{kt} \quad (2.2.1.7)$$

The above equations indicate that the proportion of projected rural population tends to zero, while the projected urban population tends to 1 as time increases.
There are several steps involved in this projection technique: First, the value of k is estimated by using the past census results.

From Eq. (2.2.1.3), we have,

$$\frac{U^{-1}}{R^{-1}} = \frac{U^{0}}{R^{0}} e^{-nk} \qquad (2.2.1.8)$$

where, U^{-1} is the urban population for the first census, R^{-1} is the rural population for the first census, U^{0} is the urban population for the second census, R^{0} is the rural population for the second census, n is the length of time interval.
Above equation may be written as,

$$k = -\frac{1}{n}\ln\left[\frac{U^{-1}/R^{-1}}{U^{0}/R^{0}}\right] = \frac{1}{n}\ln\left[\frac{R^{-1}U^{0}}{R^{0}U^{-1}}\right] \qquad (2.2.1.9)$$

Second, projections of the urban and rural populations, starting from the relevant data of the second census, and using projections of the total population, are made by using formulas (2.2.1.6) and (2.2.1.7).

Annual Growth Rate Method

The annual growth rates method calculates approximately urban and rural population at yearly intervals by using the past data. Annual exponential growth rate is calculated to past urban and rural population. These growth rates are denoted by u and r, respectively, and their difference d is obtained as,

$$d = u - r \qquad (2.2.2.1)$$

Here we assume that the exponential growth rates are constant and independent of time, the projection is begin at time t = 0, the urban and rural population at that time is U(0) and R(0), respectively one year later the urban and rural population is given by,

$$\left.\begin{aligned} U(1) &= U(0).(1+u) = U(0).(1+r+d);\\ R(1) &= R(0).(1+r) \end{aligned}\right\} \qquad (2.2.2.2)$$

And thus;

$$\begin{aligned} T(1) &= U(0).(1+r+d) = R(0).(1+r)\\ &= [U(0) + (R(0)].(1+r) + U(0).d\\ &= T(0).(1+r) + U(0).d \end{aligned} \qquad (2.2.2.3)$$

A simple and computational formula can be derived from Eqs. (2.2.2.2) and (2.2.2.3); from the first equation we have,

$$\frac{U(1)}{U(0)} = (1+r+d) \qquad (2.2.2.4)$$

While the second equation follows,

$$T(1) = U(0).d + T(0).(1+r) \qquad (2.2.2.5)$$

Eq. (2.2.2.5) can also be written as,

$$\frac{T(1) - U(0).d}{T(0)} = (1+r) \qquad (2.2.2.6)$$

Putting Eq. (2.2.2.6) in Eq. (2.2.2.4), we get,

$$\frac{U(1)}{U(0)} = \frac{T(1) - U(0).d}{T(0)} + d \qquad (2.2.2.7)$$

Finally,

$$U(1) = \frac{T(1) - U(0).d}{T(0)}.U(0) \qquad (2.2.2.8)$$

And from this

$$R(1) = T(1) - U(1) \qquad (2.2.2.9)$$

By using the Eqs. (2.2.2.8) and (2.2.2.9) we will project the urban and rural population. The total population is already projected by other method.

Logistics Growth Curve

All observers of the nature agree that population do not grow without limit. Question is what limits them? It may be shortage of essential resources or internal competition. Whatever the cause, populations instead of increasing indefinitely, often trend to reach a plateau. This frequently observed pattern can be modelled using a variety of equations. The most popular among those is the logistic equation.

How can the equation for exponential growth be modified so that it generates a plateau? Instead of assuming that the per capita instantaneous growth rate 'r' is constant, we let it depend on the population size, thus

$$\frac{1}{N(t)}\frac{dN(t)}{dt} = f(N(t)) \qquad (2.3.1)$$

The simplest form of f(N(t)) is linear. Remember that per capita growth rate decreases as population size increase. Hence we have

$$\frac{1}{N(t)}\frac{dN(t)}{dt} = r - c\,N(t). \qquad (2.3.2)$$

When N(t) is close to zero, we can ignore the term $(N(t))^2$ and hence behaviour of the model is like the exponential model. However, as N(t) increases, the per capita growth rate fall down and reaches zero at $N(t) = \frac{r}{c}$. This constant $(\frac{r}{c})$ is often called the 'carrying capacity' of the experiment and is denoted by k. Substituting back c = r/k we get,

$$\frac{dN(t)}{dt} = \frac{r(K - N(t))}{K} \qquad (2.3.3)$$

To solve his differential equation we separate the variable, thus

$$\frac{1}{N(t)(K - N(t))} K\,dN(t) = r\,dt \qquad (2.3.4)$$

This can be using partial function as,

$$\left[\frac{1}{N(t)} + \frac{1}{K - N(t)}\right] dN(t) = r\,d\,t \qquad (2.3.5)$$

This, on integrating, gives

$$\ln\left[\frac{N(t)}{K - N(t)}\right] = rt + d \qquad (2.3.6)$$

Here the constant of integration d is clearly equal to $\ln\left[\frac{N(0)}{K - N(0)}\right]$. Hence we get,

$$\left[\frac{N(t)}{K - N(t)}\right] = [e^{rt}]\left[\frac{N(0)}{K - N(0)}\right] \qquad (2.3.7)$$

The above equation can be written as,

$$N(t) = \frac{K}{1 + qe^{-rt}} \qquad (2.3.8)$$

$$\text{where, } q = \left[\frac{(K - N(0))}{N(0)}\right] \qquad (2.3.9)$$

This is the equation of logistic growth. Note that as t →∞, N(t) → K. The population does not grow without limit. The curve represented by this equation is called sigma modal because it is shaped like the letter S stretched at both ends.

ANALYSIS AND INTERPRITAION

Ratio Method

By using the extrapolated ratio of urban to total and rural to total population and projected total population, the urban and rural population is projected for next 50 years for India and China (Table 1). The projected urban population of India for 2051 is 2.86 times that of 1991 census, this value is higher than China (2.61), which may be true because China is already adopted one child policy whereas India is not at all implemented such kind of policies.

Table 1: *Projection of Urban population of India and China by Ratio Method from 2011–2051.*

Year	Total population		Urban Population		Rural Population	
	India	**China**	**India**	**China**	**India**	**China**
1991	844324222	1150780000	208242633	324519960	636081589	886951579.9
2001	1030000000	1271850000	287107421	467023320	741502907	949241833.3
2011	1196614390	1444962260	368162800	440467588	828451590	1045853148
2021	1337093915	1573839468	443330454	539022082	893763461	1106217084
2031	1446314301	1686057253	507298497	642137427	939015805	1152306770
2041	1526524148	1780809261	558193308	746391598	968330840	1184789456
2051	1582995328	1858757928	596713870	848606121	986281458	1205181422

In summary the projected growth of urban population of India is more than that of China. The data revels that the urban population is increasing from 2011 to 2051 and doubling time is 50 years for both the countries, this indicates that urban population is increasing solely but better growth is conserved than rural population.

The United Nations Method

Instantaneous Growth Rate Method

The parameters of the projection were calculated from the 1991 and 2001 census by using the Eqs. (2.2.1.4) and (2.2.1.9), the parameters for India are k= 0.0168 and c= -0.9480 and China are k= 0.0189 and c= -1.3689. Here the length of the interval period was taken as 10 years. Putting these parameters and the projected total population in Eqs. (2.2.1.6) and (2.2.1.7), the urban and rural populations were calculated. The analysis explains that the urban and rural population is increasing from 2011–2051 censuses for India and China but doubling time for India is 60 years and that of China is 50 years (Table 2). In this method the projected urban population for India is less than that of China.

Table 2: *Projection of Urban Population of India and India by United Nations Method (Instantaneous Growth Rate) from 2011-2051.*

Year	Total population		Urban Population		Rural Population	
	India	**China**	**India**	**China**	**India**	**China**
1991	844324222	1150780000	208242633	324519960	636081589	825205490
2001	1030000000	1271850000	287107421	467023320	741502907	835055112
2011	1196614390	1444962260	281048757	543612441	930675158	999325758
2021	1337093915	1573839468	318628128	592097620	1059866813	1109185429
2031	1446314301	1686057253	349664237	634315321	1168416127	1210902532
2041	1526524148	1780809261	374394839	669962183	1256851656	1303309080
2051	1582995328	1858757928	393835145	699287423	1328328395	1386264161

Logistic Growth Curve Method

The carrying capacity of the experiment K is fixed for total, urban and rural population by using the past data. The parameters of the Logistic growth curve for projecting the total, urban and rural population were calculated from the 1991 and 2001 censuses by using the Eqs. (2.3.8) and (2.3.9), (Table 3). Putting above parameters in Eq. (2.3.8), we projected the total, urban and rural population, respectively form 2011-2051 censuses for India and China. The projected total, urban and rural population shows increasing trend from 2001–2051 in both the countries. The projected data revels that the urban population doubled in 57 years for India and 50 years for China (Table, 4). Among these methods the ratio method shows the higher growth of urban population and least growth of urban population is observed by URGD method.

Table 3: *Parameters of the Logistic Growth Curve Method for India and China.*

	Parameters					
	Carrying Capacity (k)		q = (K-N(0))/N(0)		Growth Rate (r)	
	India	**China**	**India**	**China**	**India**	**China**
Total Population	1700000000	2133340000	1.0088	1.5363	0.4412	0.2927
Urban Population	520000000	1108365420	1.495	6.5732	0.6133	0.3791
Rural Population	1337029419	1024974580	2.01309431	0.47530846	0.285353429	0.48164767

Table 4: *Projection of Total, Urban Population of India and China by Logistic Growth Curve Method from 2011-2051.*

Year	Total population		Urban Population		Rural Population	
	India	**China**	**India**	**China**	**India**	**China**
1991	844324222	1150780000	208242633	324519960	636081589	826260040
2001	1.03E+09	1271850000	287107421	467023320	741502907	804826680
2011	1196614390	1444962260	361188668	453795611	813814685.1	982938959.1
2021	1337093915	1573839468	419860486	557740161	901381486.7	998592898.9
2031	1446314301	1686057253	460360395	661434999	980709569.3	1008514975
2041	1526524148	1780809261	485735606	757873506	1050189363	1014743618
2051	1582995328	1858757928	500681927	841886268	1109267526	1018630046

III. SUMMARY AND CONCLUSION

The urban population is depending upon various factors such as fertility, mortality, migration, economic and industrial development and many other factors hence the projection of urban and rural population is a complex phenomenon. An attempt is made to estimate for the observed past trend and also to project for the future urban and rural population of India and China for the period 1991–2051 using Ratio Method, URGD method and

Logistic growth curve method. The analysis shows the urban and rural population over estimated by Ratio method and under estimated by URGD and Logistic growth curve method for India from 1991–2001. In case of China estimated and projected urban and rural population is under estimated for all the methods from 1991–2001. And also it shows that the URGD Method for China and Logistic Growth Curve Method for India give reasonable projected urban population.

The projected urban population for China is more than India for URGD method and Logistic growth curve method, but in case of Ratio method opposite trend is observed. It is concluded that the ratio method is more reliable as compared to other two methods. This may be the true fact because China is already strictly implementing family planning programme and one-child policy.

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