Construction of appropriate model for Enrolment Projection of India

Vishal D. Pajankar[1]

[1]National Council of Educational Research and Training, New Delhi INDIA
vdp1234@rediffmail.com[1]

Abstract: There are different models used for enrolment projection in the education system. Of them ARIMA, double exponential, logistic curve method, reconstructive cohort, and regression model, method are commonly used. Every model has its suitability under certain conditions and with prior assumptions. In India, no attempt was made to estimate enrolment except in 1996. The logistic curve method was adopted to estimate enrolment between 1996 – 2001. In the present situation, an attempt has been made to estimate school enrolment for the next years. The present paper discusses fitting the best model for estimating enrolment for the next few years.

1.   Introduction

Every country has a unique school education system. India also has its school education system. It has four-layer systems. From grade 1 to grade 5 is called as a primary stage, grade 6 to grade 9 is called as an upper primary stage, grade 9 and 10 is called as a secondary stage and grade 11 and 12 is called as a higher (or senior) secondary stage. All states and Union Territories of the country have adopted the same pattern of school education system. The country has a defined entry age in the school system that is 6 years of age. Once a child completes 6 years of age then s/he will be eligible to get enrolled in the school system at grade 1. Accordingly, the stage-wise age group is also defined by the Government of India, children in the age group of 6 to 10+ years, are supposed to be in the primary stage, children in the age group of 11 to 13+ years, are supposed to be in the upper primary stage, children in the age group of 14 to 15+ years, are supposed to be in secondary stage and children in the age group of 16 to 17+ years, are in higher (or senior) secondary stage. However, there are some exceptions in entry age of a child in the system.

Once the child gets enrolled in the school system, the flow of s/he movement is depends on her/his academic performance. Though, after the implementation of the Right To Education Act 2009, the country has adopted the No Detention Policy in the country at the Elementary stage that is in primary and upper primary stages (from grade 1 to 8). But 100% transition of the children from grade i to grade i+1 ($1 \le i \le 7$) is not happened. Always, there will be a number of dropouts or repeaters remain in the system. The education flow model of children transitions from grade i to grade i+1 ($1 \le i \le 9$), repetition, and moving out from the systems is very well explained in [1] and [2]. The model in figure1 demonstrates the implications for enrolment at future dates with explicit assumptions about the continuation of past and current trends. The flow model can also be used to reconstruct the flows of a chart of education systems. The flow model is used to explain the behavioral relationship which determines in part the parameters playing such an important role in the model. Such as repetition rates, dropout, promotions, new entrants in the system at any class. Sometimes dropout occurs due to the influence of social factors forced to leave the systems against their wishes or individuals' perceptions of their short-term and long-term employment and earning prospects.

In some cases, dropouts for a school may be transferred to another school, district, or administrative area without informing the parent-school or without issuing school leaving certificate document or any other legal document. In such a situation, he/she may be treated as a new entrant for the new school. From the above-given base model of the flow of students in the system, let us elaborate in detail the fundamental concepts involved in the Transaction Model.
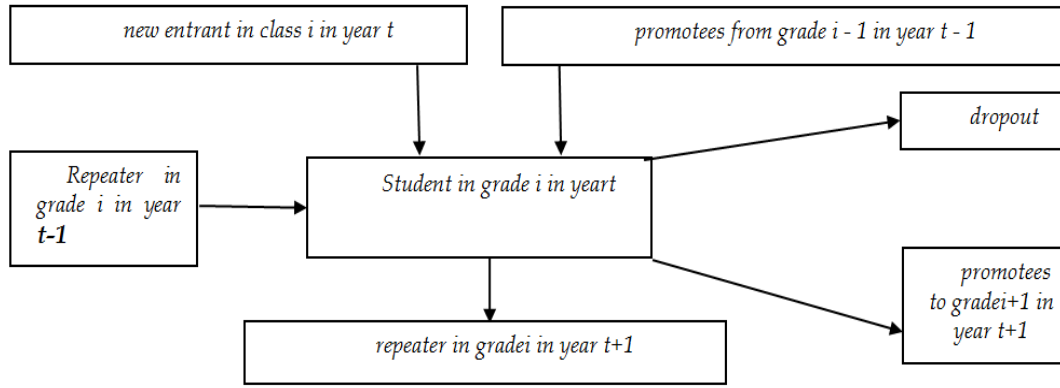
Figure 1. Base Model of student's flow in the school system [1]

2.   Literature Review

While fitting the appropriate model of enrolment projection, several researchers have used different models according to their suitability and availability of resources. A structural model for projecting public school enrolment by grade, progrmme, and district used in [3]. The advantage of specifying a structural model is that many of the standard approaches to forecasting enrolment emerge as special cases of its reduced form equations explained in [3]. The National Center for Educational Statistics (NCES) 2025 used double exponential smoothing and multiple linear regression method for projection of education statistics to 2025 [4]. NCERT used the logistic curve method to project the enrolment of 1997 – 2001. They used prior data collected under the third, fourth, fifth, and sixth All India School Education Survey[1] conducted during 1973, 1978, 1986, and 1993 respectively. The achievement of the study was that the error between actual data and projected data was in-between 2% to 5% only, which is statistically acceptable [5]. Cohort method for projection is explained by [6] and [7]. [7] studied the cohort-survival ratio method in the projection of school attendance and [7] explained reconstructive cohort methods with other aspects such as basic concepts, educational planning, methods of analyzing and projecting school enrolment, flow methods, RCM, projection of teachers' supply and demand, etc.

Several methods of enrolment projections have been explored. Four methods are identified as an appropriate method in the Indian context namely; auto regression integrated moving average method (ARIMA), double exponential method, logistic curve method, and reconstructive cohort method.

3.   Construction of Projection Model

The projection of enrolment for the coming years is useful for planning and policy decisions for a country. Allocation of infrastructure, the demand of human resources including academics and secretarial staff, provisions for socially disadvantaged groups, etc. are being estimated on the basis for projected figures. Enrolment has three important components that play a vital role in the enrolment projection; namely, promotion rate, repetition rate, and dropout rate. Since enrolment is the function of the population so the population of children also useful in enrolment projection. Change in population proportion directly reflects in the enrolment.

In India, a child who complete 6 years of age, is eligible to get enrolled at grade 1 in a school. It means that in total population, the population of 6-year children is supposed to enroll at grade 1 in a school, so the equation of grade enrolment can be defined as

$$E_i^t = P_{Ag\_6}^t \qquad\qquad (1)$$

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[1] All India School Education Survey is a census survey of all schools in India. It covers all schools including government schools, local body schools, private aided schools and private unaided schools from grade1 to 12 situated in any part of the country. It includes urban are schools, rural schools, tribal area school, forest schools, oriental schools, etc. It collects all information from the schools such as type of school, enrolment, teachers, available infrastructure, incentive schemes, accessibility of schooling facility in rural areas, etc. First survey conducted in year 1957. Till then nine surveys has conducted in the country.

where, $P_{Ag\_6}^t$ is the population of $Ag = 6$ in time t and E_i^t is the enrolment in grade $i = 1$ in time t. But it is not true in a real-life situation. Because a good number of children of under aged children $(i < 6)$ and over-aged children $(i > 6)$ are also get enrolled with children of aged $(i = 6)$ in grade 1. So the equation (1) is redefined as

$$E_{Cl\_1}^t = x_1 P_{Ag\_5}^t + x_2 P_{Ag\_6}^t + x_3 P_{Ag\_7}^t + x_4 P_{Ag\_8}^t + x_5 P_{Ag\_9}^t + x_6 P_{Ag\_10+}^t \qquad (2)$$

where, $P_{Ag\_5}^t$, $P_{Ag\_6}^t$, $P_{Ag\_7}^t$, $P_{Ag\_8}^t$, $P_{Ag\_9}^t$, $P_{Ag\_10+}^t$: *child population in aged i = 5, 6, 7, 8, 9, 10+ years respectively and x_i: coefficient of the child population of aged i (i = 5, 6, 7, 8, 9, 10+) years in grade 1 in time t and*

$$\sum_{i=5}^{10+} x_i = 1 = IR_{Cl\_1}^t \qquad (3)$$

where, $IR_{Cl\_1}^t = E_{Cl\_1}^t * (P_{Ag\_6}^t)^{-1}$, the intake rate of the child. If all new entrants in grade 1, start schooling at the same age then the proportion of this age-group population in time t with the enrolled students in grade 1 in that time can be taken into consideration to estimate the proportion of the population.

While fitting the appropriate model of enrolment projection, several researchers have used different models according to their suitability and availability of resources. As discussed in the literature review, the several methods of enrolment projections have been explored, out of them four methods are identified as an appropriate method in the Indian context namely; auto regression integrated moving average method (ARIMA), double exponential method, logistic curve method, and reconstructive cohort method. A tryout exercise has been conducted with an available enrolment for the year 2012-2015 and to estimate enrolment for the years 2017 and 2018. The finding of the suggestive models is as

- ARIMA method smoothened the data sharply and gave an almost straight uniform line however in actual situation it is not possible
- Double exponential methods produced an increasing linear trend while in decreasing child population rate, linearly increasing enrolment was incorrect.
- The basic assumption for fitting logistic curve was that data should be in an increasing order however there is much noise in the data of enrolment available through UDISE. Even growth in enrolment of two consecutive years was not showing any trend. So the logistic curve was not fitting in the available data. In the study, it was assumed that there is no dropout in the system, hence the dropout rate

Due to these results, it was decided to adopt the reconstructive cohort method for the projection of enrolment and construct the model according to the requirement of the study. Hence, for Reconstructive Cohort Method, some basic requirements are (i) child population at aged 6 years (according to the grade 1 entry policy of India); (ii) apparent Intake Rate for time t; (iii) grade enrolment data for time t; (iv) repetition rate at grade i ($i = 1, 2, ... , 9$) for time t; and (v) promotion rate of class i ($i = 1, 2, ... , 9$) for time t.

The components of the enrolment can be calculated as; the apparent intake rate: $IR_i^t = E_i^t * (P_{Ag\_i}^t)^{-1}$ ($i = 1$); repetition rate, $RR_i^t = R_i^{t+1} * (E_i^t)^{-1}$; and promotion rate, $PR_i^t = (E_{Cl\_(i+1)}^{t+1} - R_{Cl_{i+1}}^{t+1}) * (E_{Cl_i}^t)^{-1}$ where ($2 \le i \le 10$).

Hence the model is constructed in two levels. At the first level, the model is constructed for grade i ($i = 1$)

$$E_i^t = \left(P_{Ag=6}^t * AR_i^t\right) + (E_{i-1}^{t-1} * RR_{i-1}^t) \qquad (3)$$

In the second level, the model is constructed for grade i where ($2 \le i \le 10$) is as

$$E_i^t = (E_{i-1}^{t-1} * PR_{i-1}^t) + (E_i^{t-1} * RR_i^t) - (E_{i-1}^{t-1} * D_{i-1}^t) \qquad (4)$$

In the above model, it is assumed that there is no dropout in the system. So, the dropout will be assumed to *zero,* that is, the dropout rate, $D_{i-1}^t = ZERO$. That's implies

$$E_i^t = (E_{i-1}^{t-1} * PR_{i-1}^t) + (E_i^{t-1} * RR_i^t) \qquad (5)$$

The model is given in (4) and (5) are similar. The only difference is that when there are dropouts in the system, model (4) will be applied and when no dropout in the system then model (5) will be used.

4. Result

The reconstructive cohort method is one of the best methods in the estimation of enrolment for the next n years. Using the model, the enrolment is calculated upto 2025, given in table 1. From the table, it is found that enrolment at primary stage starts decreasing from year 2011 and enrolment at upper primary starts declining after 2016-17. Since, the population is the function of the enrolment. According to the report of RGI Census 2011, the growth rate of child population of India is declining. Change in growth of population is directly implies on the enrolment. As a result, enrolment at primary stage and upper primary is recoded declining.

Table 1. Growth in School Enrolment (2001-02 To 2025-26)
(Figures in Lakhs)

Year	Primary (I-V)			Upper Primary		
	Boys	Girls	All	Boys	Girls	All
2001-02	636	503	1139	261	187	448
2002-03	651	573	1224	263	206	469
2003-04	684	599	1283	273	215	487
2004-05	697	611	1308	285	227	512
2005-06*	705	616	1321	289	233	522
2006-07*	684	634	1319	254	221	475
2007-08*	695	647	1341	270	239	509
2008-09*	694	650	1344	280	254	534
2009-10*	686	644	1330	281	259	540
2010-11*	697	654	1352	299	280	578
2011-12*	708	663	1371	318	301	620
2012-13*	696	652	1348	333	317	649
2013-14*	686	638	1324	341	323	665
2014-15*	676	629	1305	345	327	672
2015-16*	669	622	1291	347	329	676
2016-17*	642	596	1238	340	321	661
2017**	634	587	1222	342	320	661
2018**	630	582	1212	338	314	652
2019**	627	578	1205	333	310	643
2020**	623	571	1194	330	306	636
2021**	623	570	1193	325	302	628
2022**	623	568	1191	322	298	620
2023**	621	565	1186	319	294	613
2024**	617	562	1179	319	294	613
2025**	614	560	1174	319	293	612

5. Conclusion

The reconstructive cohort is one of the best models for the projection of enrolment. The model is chosen out of different available model. It is constructed by considering all possible parameters of the system involved in the transition of a child. The model is then tested with India's enrolment projection by 2025.

According to the [10] and [11], the population of India is increasing from 12,10,855 (2011) to 14,25,908 (2026) (figures in '000 as reported in [11]) however the child population in age group 0-14 years is declining from 3,73,89 (2011) to 3,39,222 (2026) (figures in '000 as reported in [11]). At the same time, the share of children in age group 0-14 years in the population is 30.9% (2011) and which is goes to 23.8% (2026). As a result the count of school going children are decreasing in proportion. From the result of the study presented in the table 1, the enrolment of children is also reported declining at primary stage as well as upper primary stage. As discussed in section [1], the age group of children at primary stage is 6-10+ years and the age group of children at upper primary stage is 11-13+ years, respective declining is reflecting in the outcome of the report.

6. Limitation

- There is much noise in source data so it was difficult to find the trend in the enrolment;
- Promotion rate and repetition rate for three years assumed to be constant and hence estimated accordingly.

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Authors

Dr. Vishal D. Pajankar, Assistant Professor (Statistics) at Educational Survey Division, NCERT, New Delhi has experience of about 17 years of active service. At NCERT, he is involved in large scale surveys such as All India School Education Survey (AISES) and National Achievement Surveys (NAS). In 8th All India School Education survey, he was coordinator of Western region states and also part of national level team. He also coordinated NAS Class V (Cycle 4), core team member of NAS 2017 at Class 3, 5, & 8, and NAS Class X (Cycle 1 and 2). He is also involved in test designing, item development, assessment framework, planning, data quality management, and other related activities. He has visited few countries and credited around 40 research articles and completed 9 research projects.