A GROWTH MODEL FOR ACADEMIC PROGRAM LIFE CYCLE (APLC): A THEORETICAL AND EMPIRIRCAL ANALYSIS

Edward H. K. Acquah PhD.
Senior Institutional Analyst

Athabasca University
Office of Institutional Studies
1 University Drive
Athabasca, Alberta T9S 3A3
CANADA
Phone (780) 675-6341
Fax (780) 675-6110
E-mail: edwarda@athabascau.ca

The 50th Forum of the Association for Institutional Research (AIR)

Chicago, Illinois State USA, May 29- June 2, 2010

Track Number: Track 4: Institutional Management and Planning

Presentation Format and Length: Scholarly Paper Session (40 minutes)

AV/Computer Requirements: The standard Forum AV setup

Presentation Schedule: Tuesday, June 1, 2010: 9:45-10:25am

Sheraton Chicago Hotels & Towers

Room: Parlour E

Session ID 177

A GROWTH MODEL FOR ACADEMIC PROGRAM LIFE CYCLE (APLC): A THEORETICAL AND EMPIRIRCAL ANALYSIS

Abstract

Academic program life cycle concept states each program's life flows through several stages: introduction, growth, maturity, and decline. A mixed-influence diffusion growth model is fitted to enrolment data on academic programs to analyze the factors determining progress of academic programs through their life cycles. The regression analysis yield reasonable parameter estimates, including magnitude of enrolment peaks and duration of stages and describes growth patterns of academic programs very well. The results indicate that key factors accounting for progress of academic programs through life cycle stages are external information and word-of-mouth communication (social and behavioural factors as well as economic factors). The model's application for analyzing market dynamics and long-range forecasting is demonstrated.

Introduction:

Recent challenges and competition in the higher education sector have created a situation where postsecondary institutions are viewed as producers and their academic programs are viewed as products; and students are perceived as end-users or customers in the education marketplace. In the past, postsecondary institutions sprang up on the assumption that: "if you build, they will come." This assumption is no longer sustainable. In recent years, it has been claimed that colleges and universities have been characterized by the "market ethos", which is said to involve the transformation of educational values into business values (Karabel, 2005; Tuchman, 2009). Colleges and universities see the purpose of education in more practical terms, such as preparing students for jobs (workforce development) (Tuchman, 2009). More importantly, according to Tuchman (2009), colleges and universities perceive knowledge and job preparation as commodities whose transmission is purchased by student customers (and their parents), when they pay tuition, room, board, and other fees.

According to this perception, education has become a market transaction in which potential buyers (students and their parents) must be actively sought after and motivated with incentives to buy into an institution's market offerings. Like businesses, academic institutions require innovative marketing strategies in order to survive and grow in the highly competitive postsecondary market. These marketing strategies depend on the stage of each academic program in its life cycle. The academic program life cycle (APLC) is a powerful marketing tool. Effective program marketing requires that deans, directors and program managers understand how to introduce new academic programs, how to manage them during their lives, and when to withdraw or eliminate those academic programs that no longer enjoy a meaningful market demand.

Research Objective:

An open university has been offering various quality academic and professional certificate and degree programs through open and distance learning (ODL) in Canada and the rest of the world for more than twenty years. However no attempt has been made to study the life cycles of the ODL academic programs offered. There has been a rapid growth in ODL programs both as a result of increasing number of ODL institutions worldwide and the incursion of traditional postsecondary institutions into the ODL sub-market with new ODL academic program offerings, creating additional competitive pressures. In the ensuing competition, each institution is trying to secure a sustainable share of the ODL sub-market. The ODL University would therefore need to implement innovative marketing strategies in order to achieve its market share objectives and keep ahead of the emerging competition in the ODL sub-market. The sure way to do this is to examine the life cycles of its academic programs (product life cycles).

Product Life Cycles (PLC) have been used as a basis for product planning and control in marketing (Schultz & Roa, 1986). In the same way, the PLC concept can be used as a basis for planning and control of academic programs in academe. PLC studies have been done for a wide variety of products (Cox, 1967; Polli & Cook, 1969). On the other hand, the PLC studies have rarely been done for academic programs. This study attempts to make up for this apparent neglect by offering a framework for PLC analysis of academic programs. Specifically, the study employs economic and marketing concepts and tools to analyze the growth of online and distance learning (ODL) academic programs during their life cycle (APLC) in order to determine the underlying forces of the diffusion (growth) of these academic programs. The knowledge and insights that would emerge from these analyses are important for enrolment planning, formulation and implementation of enrolment marketing strategies, and forecasting of enrolments at the program level.

Literature Review

For many years, the PLC concept has been applied only in business to determine the stages durable and non-durable consumer products go through in their life cycles and to forecast the duration, peaks and growth rates over the life cycle stages (Schultz & Rao, 1986; Cox, 1967; Polli & Cook, 1969; Brinbaum, 1998; Modis, 1994; Shewchuk, 1992; Shane & Ulrich, 2004). Academic programs of study offered by academic institutions have been neglected by PLC researchers. Recently, however, Institutional Researchers have begun to apply the PLC concepts and tools to the analysis of academic programs life cycles (Lakatos, 2009; Mukerji & Tripathi, 2004). However, to date much of what has been done is mainly introductory and less academic.

In business, all products have life processes and in academia, all academic programs are also deemed to possess life cycles. The life cycle of a product is a depiction of its sales history from its market inception to its withdrawal from the market. The life cycles of products are in effect sales volume curves. According to the PLC concept, all products begin life with first sale of the product, rise to a peak and then decline until their usefulness to buyers and their contributions to profits are insufficient to justify their presence in the market (Kotler, 2000). The intuitive logic of the PLC concept is that each product's life typically flows through distinct stages of growth: development, introduction, growth, maturity, and decline.

On the other hand, the life cycle of an academic program (APLC) is a depiction of its enrolment history from its introduction to its withdrawal from an institution's portfolios of programs. The life cycles of academic programs are in effect enrolment/registration volume curves. According to the APLC concept, all academic programs begin life with first set of enrolments/registrations, rise to a peak and then decline, or until they are revised and renewed, replaced or withdrawn. Thus an academic program might typically diffuse over its life through several distinct stages, which include introduction, growth, maturity, and decline; and/or a second growth, maturity and decline.

A new academic program diffuses or attempts to gain a foothold in the market with slow enrolments and/or registrations (Introductory Stage) initially because the program might be relatively new and untried or untested. Time is needed for the program to gain acceptance. If the program gains market acceptance, it should, at some point in time, launch into a period of comparatively rapid growth (Growth Stage). This growth stage is exemplified as enrolments/registrations increasing at an increasing rate or by an upward-rising steep curve. The slope of the enrolment curve is steepest during this stage but as the program approaches the end of the growth stage, enrolments begin to level off.

A change in the growth rate heralds this change which is indicated by enrolments increasing at a decreasing rate. When the enrolment growth rate has peaked, the program passes into the maturity stage (Maturity Stage). The volume of enrolments peaks and there is little or no growth at all. Enrolments in the academic program then begin to decline after some time. When the rate of decline begins to accelerate, the decline stage is underway (Decline Stage). This might culminate in the disappearance of the academic program from the market and from the academic institution's portfolio of programs, or the program might require revision and renewal, or replacement altogether.

The diffusion of an academic program, sequence and duration, shape of the curve and magnitude of enrolments at each transition of the APLC (diffusion) are influenced by myriad of forces. The determinants of the rate of program diffusion at the introduction stage include perceived advantage of the program relative to the best available alternative and awareness of the program and its benefits to prospective students (Zaltman & Stiff, 1973). The impact of government educational policies can be especially dramatic during the growth stage. Expansion from demographic changes, changes in social and economic trends and student learning (student experience with the program) can impact enrolments in the program at the growth stage as well as the transition to maturity. On the other hand, unfavourable demographic changes such as relocation and/or out- migration can accelerate the onset of decline.

Although the APLC and the PLC appear simplistic, these concepts have descriptive value when used as a systematic framework for explaining market dynamics (Day, 1981). The PLC has been used by researchers as a forecasting model in marketing (Bass, 1969, 1980). The PLC has also been used: to model the factors which determine the progress of a product through the stages of the life cycle (Mahajan & Muller, 1979); to establish the life cycle position of the product; and as a tool to formulate competitive strategies (Day, 1981).

Contrary to the initial notion that a product ultimately declines and has to be removed from the market, recent developments, however, have shown that the growth/and or maturity of a product or academic program can be extended over its life cycle by adaptation and improvements (Hopkins, 1977). Most academic programs are revised regularly and improved/renewed to make them more acceptable to labour market demand. This implies that the APLC does not generally follow the hypothesized stages of the classical bell-shaped life cycle curve as shown in Fig 1(introduction, growth, maturity, and decline).

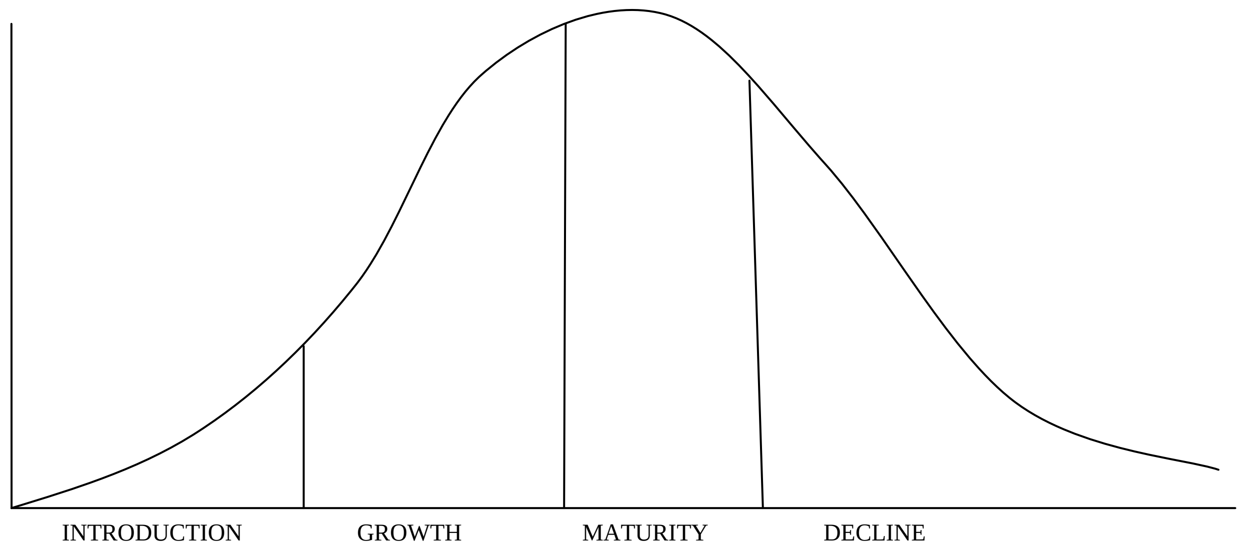


Fig 1 Stages of the Classical Product Life Cycle (Bell Shaped Pattern of Enrolments)

As shown in Fig 1, product sales grow slowly in the introduction stage; grow rapidly in the growth stage; are approximately constant in the maturity stage, and drop off in the decline stage.

In addition to the classical bell-shaped PLC curve, empirical research has identified other shapes of the PLC (Rink & Swan, 1979; Tellis & Crawford, 1981; Cox, 1967). In their studies, Rink and Swan (1979) identified at least 12 patterns including such shapes as the cycle-recycle curve (Fig 2); stable maturity curve (Fig 3), and growth-decline-plateau. As will be shown below, many academic programs do not necessarily follow the classical bell-shaped curve but rather the cycle-recycle pattern or some other variants.

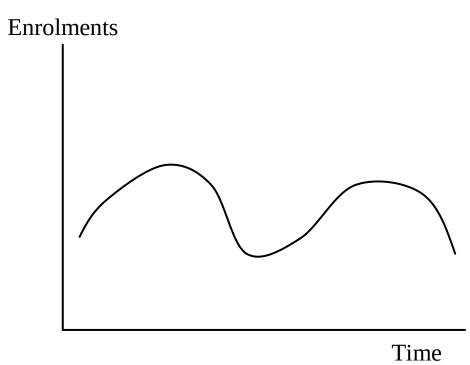


Fig 2: Cycle-Recycle APLC (Growth-Re-Growth)

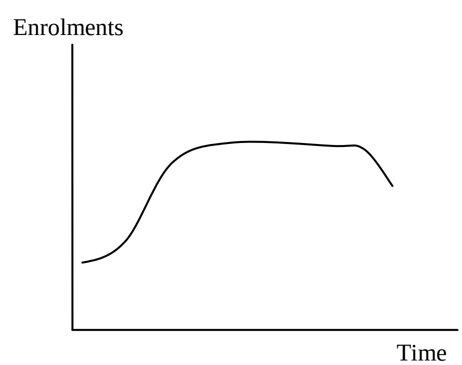


Fig 3: Stable Maturity APLC

Theoretical Framework

Roger's theory of diffusion of innovations (1960) leads to a curve shape that is similar to the classical PLC curve shape. The theory has therefore been acclaimed to provide a theoretical basis for the PLC curve. The focus of this study is the application of a diffusion growth model (Bass, 1981; Acquah, 1994) to the analysis of academic program life cycles.

Growth models have been used in marketing for new products which indicate exponential growth to some asymptote (Haines, 1964; Bass, 1969, 1981; Fourt & Woodlock, 1960). The growth model suggested here is based on the theory of diffusion which postulates that enrolments in a new academic program grow to a peak and then level off to some magnitude higher or lower than the peak. Diffusion is characterized as a process by which innovations or new academic programs are adopted over time by members of a social system who are linked by channels of communication (Rogers, 1962). The important elements in this definition are: the innovation (academic program) which diffuses over time; members of a social system; adoption decisions; and communication channels. It is the characterization of these elements and the assumptions made about them that determines the nature of the diffusion model. Quantitatively, diffusion is aggregate adoption over time.

Much of the researches on diffusion of innovations have dealt with information variables and the capacity of formal and informal sources of information to influence prospective adopters (students) to try an academic program (Day, 1981). The theory suggests that potential adopters (students) are influenced by external and internal information in their adoption (enrolment) decisions:

External Information consists of all the information about an external academic institution and its offerings and these may include: view-book; campus visit; catalogue; College Comparison Guides; high school visit by faculty members; mailing from the honours program; high school visit from the admissions officer; athletic staff; home/hotel visit.

Internal Information/word-of-mouth information about an academic institution and/or program circulating within a social system and may include information from: parents; friends; current students; high school teacher; high school guidance counsellor; and alumni. For example, newspapers and magazines such as US News & World Report and MACLEAN'S Magazine, publish annual rankings of academic institutions. Although those rankings have neither a solid theoretical or methodological basis, administrators care about those rankings because potential students and parents consult them to plan college applications (Monks & Ehrenberg, 1999; Stevens, 2007).

The Analytical Framework

The Basic Growth Model: These considerations suggest the formulation of a basic diffusion growth model which is explicitly based on the external and internal sources of information about the new academic program (innovation), but also implicitly takes into account the other diffusion elements such as the members of the potential social system (potential students). Assuming that both external and internal information are effective in generating new student enrolments in an academic program then, the number of new enrolments in a time, Δt, is given by the following equation:

$$\Delta A(t)=k_1 (M^* - A(t)\Delta t) + k_2 A(t) [M^* - A(t)\Delta t] \qquad (1)$$

Where:
$\Delta A(t)$ = new enrolments in an academic program in year t;

A (t) = the cumulative number of previous enrolments in an academic program in year t;

k_1 = parameter measuring the effectiveness (influence) of external information in generating New enrolments;

k_2 = parameter measuring the effectiveness (influence) of internal information (word-of-mouth) in generating new enrolments in an academic program;

M^* = the ceiling number of potential adopters (potential students) of an academic program in the social system;

$[M^*-A(t)]$ = the remaining number of potential adopters (potential students) of an innovation (academic program) in year t

Using differential notations:

$$dA(t) = k_1 (M^* - A(t))\, dt + k_2 A(t) (M^* - A(t))\, dt \qquad (2)$$

$$dA(t)/dt = k_1 (M^* - A(t)) + k_2 A(t) (M^* - A(t))$$

$$= (k_1 + k_2 A(t)) (M^* - A(t)) \qquad (3)$$

Where, $dA(t)/dt$ = instantaneous rate of diffusion (growth) of the new academic program at time t, best shown as an S-shaped curve (Fig 4).

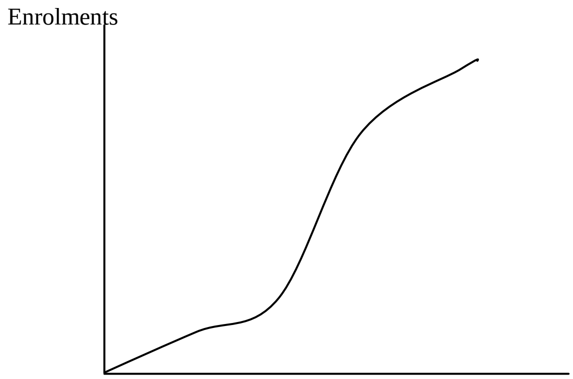


Fig 4: The S-Shaped Cumulative Enrolments Curve

This model is known as the Basic Mixed-Influence Diffusion Growth Model (Acquah, 1994). It is similar to the new product growth model for consumer durables introduced by Bass (1969) and extended by Mahajan and Schoeman (1977). In his new growth model, Bass (1969) classified the population of potential adopters (potential students) as innovators and imitators and included "coefficient of innovation", (k_1), and "coefficient of imitation", (k_2), to capture their role in the diffusion growth process.

According to Bass (1969) innovators (innovating students) are progressive members of the potential adopters in the social system, which are venturesome, daring and less risk averse and whose decisions to enroll in an academic program are based mainly on information from the academic institution. On the other hand, imitators base their decision to enroll in an academic program not only on external information but, more importantly, also on word-of-mouth communication such as information from current students, alumni, relatives, parents and friends.
Equation (3) can be modified and re-specified as:

Since: $dA(t)/dt = a_t$,

$$a_t = dA(t)/dt = (k_1 + k_2 A(t))\,[M^* - A(t)] \quad (4)$$

Expanding this product we have:

$$a_t = k_1M^* + (k_2 - k_1)A_t - (k_2/M^*)A_t^2 \qquad (5)$$

Equation (5) states that new enrolments in an academic program is a function of the number of potential adopters in the social system, M*, external influence, (k_1), and internal influence, (k_2). For successful academic programs, the coefficient of internal influence, k_2, will ordinarily be much larger than the coefficient of external influence, k_1, and enrolment will attain its maximum value at about the time that cumulative enrolments is approximately one-half of M* (Bass, 1969). A modified form of this equation has been used to study the diffusion of administrative policies among American States (Mahajan, Kumnar & Haynes, 1977; Walker, 1969; Cry, 1983; Cray, 1973); new products (Bass, 1969; Robinson & Lakhani, 1975; Mahajan & Petersen, 1979) and diffusion of cocoa spraying chemicals and hybrid cocoa seeds (Akinola, 1984; Acquah, 1994).

As specified in equation (5), the model can be used to show that the maximum number of enrolments in an academic program as a function of time (see appendix 1) coincides with the maximum number of enrolments as a function of the total number of potential enrolments. First, differentiate equation (5) with respect to A_t and set it equal to zero:

$$\frac{da_t}{dA_t} = (k_2M^* - k_1) - 2k_2A_t = 0$$

$$2k_2A_t = (k_2M^* - k_1)$$

$$A_t = \frac{(k_2M^* - k_1)}{2k_2} \qquad (6)$$

This equation states that the maximum number of program enrolments (A_t) is a function of the number of potential students (M*).

The Discrete Analogue:

In estimating the parameters k_1, k_2, and M* in the basic model in equation (5), we use the following analogue suggested by Bass (1969) and Mahajan (1977):

$$a_t = \beta_0 + \beta_1 A_{t-1} + \beta_2 A^2_{t-1} + \varepsilon_t \tag{7}$$

where:

t = 2, 3, 4,…….T.

a_t = new enrolments in an academic program at time t

ε_t= stochastic error term

$A_{t-1} = \sum_{t-1}^{T-1} a_t$ = cumulative program enrolments through time t-1

Since $\beta_0 = k_1M^*$, then $k_1 = \beta_0/M^*$ from Eq. (5) and Eq. (7)

$\beta_1 = k_2 - k_1$

Since $\beta_2 = -k_2/M^*$, then $k_2=-\beta_2M^*$

$$\beta_1 = -\beta_2M^* - \beta_0/M^* \tag{8}$$

Transferring terms and re-arranging, Eq. (8) becomes:

$$\beta_2M^* + \beta_1 + \beta_0/M^* = 0 \tag{9}$$

Multiplying M* through Eq. (9), we have:

$$\beta_2M^{*2} + \beta_1M^* + \beta_0 = 0 \tag{10}$$

or

$$M^* = \frac{(-\beta_1 \pm \sqrt{\beta_1^2 - 4\beta_0\beta_2})}{2\beta_2} \tag{11}$$

and the parameters k_1, k_2, and M* are identified.

This model, along with others (Bass, 1969; Acquah, 1994; Wind, 1981) assumes: an s-shaped diffusion curve; homogenous potential adopters (potential students) of the program; no consideration of economic decision variables; and constrained long-run growth given the fixed number of potential adopters in the social system (M*).

Regression Analysis

The model was tested by developing regression estimates for the parameters using time series enrolment data for academic programs at an online and distance learning (ODL) University in Canada. Students rarely repeat enrolment in an academic program of studies, which means that the enrolment data are unique headcount and do not include repeat enrolments. There is no problem of "repeat sales" encountered in growth models for consumer products (Bass, 1969). The model was estimated for various academic programs using STATA statistical software (Baum, 2006). The regression results and parameter estimates for the basic growth model are shown in Tables 1 and Table 2.

The data appear to be in good agreement with the model. The coefficient of determination R^2 values and the adjusted coefficient of determination (adjusted-R^2) indicate that the model provides a reasonably very strong fit to the data and describes the growth rate behaviour of academic programs very well (Howell, 2002). The large F-values (significant far beyond 0.01, that is $p<0.01$) implies that it is a very strong model. The estimated multiple correlation coefficients, R, indicate that the dependent variables are strongly correlated with the independent variables of social and behavioural influences as a whole (Table 1).

Furthermore, the parameter estimates seem reasonable for the model. Almost all the model effects were statistically significant at 0.05 levels as indicated by their t-values (Table 2, in parentheses) and p-values (probability of significance) and are consistent with a priori expectations. One of the conditions for the model to make sense is that the regression estimates for the parameter c must be negative, which is reflected by the estimated results of β_2 in Table 2. In addition, the estimated results for M*, the ceiling number of potential students in the social system, appear quite plausible.

The estimates for the basic model's parameters (k_1, k_2, M*) were based on the estimated regression coefficients as was shown above. According to the literature (Kmenta, 1971), if the estimates of the restricted parameters (original model) are linear functions of the estimates of he unrestricted coefficients (regression model), then all the desirable properties of the latter carry over to the former. In this case, the variances of the restricted parameters could be determined from the variances and co-variances of the regression coefficients. This means that if the t-values of the estimated regression coefficients indicate statistical significance, then the associated restricted model's parameters estimates are also statistically significant. In this case, almost all the parameter estimates of the restricted model were found to be statistically significant (Table 2).

Performance of the Model

An important way to assess the performance of the model is its ability to generate time paths in historical simulation or ex-post forecast approximating the actual time paths of the dependent variable (Hallam, 1990). The methods used to assess the forecasting or predictive accuracy of models span charts to spectral analysis.

An important result from the regression is the implied estimate of the total number of enrolments expected annually over the life of an academic program (Bass, 1969). Fig 5, 6, 7, 8 and 9 chart the actual enrolments and the enrolments predicted by the regression equation for five of the academic programs studied in this paper. For every academic program studied, the model describes the general trend of the time path of a program's life cycle very well (Table 3). In addition, the model's estimates indicate a very good fit with respect to both the magnitude and the timing of peaks for some of the academic programs.

Table 3 shows a comparison of the model's predicted enrolment peaks and time of peaks with the actual enrolment peaks and time of peaks. For example, the actual enrolment peak of program C was 827 in time 20 compared to the predicted peak of 847 in time 20; the actual enrolment peak of program D was 686 in time 18 compared to the predicted peak of 680 in time 18; the actual enrolment peak of program E was 213 in time 12 compared to the predicted peak of 222 in time 12; the actual enrolment peak of program F was 267 in time 16 compared to the predicted peak of 262 in time 17; and the actual enrolment peak of program H was 27 in time 8 compared to the predicted peak of 26 in time 8.

Another test of the model's long-range forecasting accuracy is the correlation between the actual enrolments and the enrolments predicted by the model for each of the academic programs for each year indicated in the long-range intervals shown in Table 4. For all of the academic programs, there is a strong correlation between the actual enrolments and the enrolments predicted by the model (($|R|>=0.6$) over the long-range. The correlation values range from 0.677 to 0.997 and all the tests are statistically significant at the 5 percent level ($p<0.05$).

A stronger test of the model's forecasting accuracy is what is known as cross-validation (Maddala, 1988). In this procedure, the sample is split into two periods (N: n_1, n_2): the first sub-sample (n_1) is used to estimate the parameters of the model and the estimated parameters are then used to predict the dependent variable in the first period (with-in sample prediction) and in the second period (out-of-sample prediction). The correlations between these predicted enrolments and their respective actual enrolments are computed and compared. The out-of-sample correlation ($R\text{-}_{o\text{-}s}$) is usually smaller than the with-in-sample correlation ($R_{\text{-}w\text{-}s}$) for a satisfactory forecasting performance. The cross-validation test was performed for all the academic programs studied in this paper and the results are shown in Table 5. With the exception of the Academic Program A, the out-of-sample correlation coefficients($R\text{-}_{o\text{-}s}$) are smaller than the with-in-sample correlation coefficients ($R_{\text{-}w\text{-}s}$), indicating that the model is able to accurately forecast academic program enrolments (life cycles) over the long-range.

The results of all the tests above seem to indicate that the basic model developed and applied in this paper seem to fit the enrolment data on academic programs studied here very well. It is therefore important to note that the mixed influence diffusion (growth) model can be used to study the life cycle of academic programs. It is also possible to use the knowledge gained for purposes of long-range forecasting of enrolments for academic programs.

Applying the Model for Long-Range Forecasting

Recall the basic growth model:

$$a_t = k_1M^* + (k_2 - k_1)\,A_{t-1} - (k_2/M^*)A_{t-1}^{\,2}$$

The last predicted enrolment for Program B was 244 in 2008/09 fiscal year. <u>All things remaining the same</u> in the 2009/10 fiscal year, the predicted enrolment for Program B would be 244:

$$a_{09/10} = a_{08/09} + 0 = 244$$

But in economics, nothing remains constant, so the enrolment forecast for the 2009/10 fiscal year would be:

$$a_{09/10} = 244 + (k_2 - k_1)(a_{08/09}) + k_2/M^*(a_{08/09})^2$$

$$a_{10/11} = 244 + (k_2 - k_1)(a_{08/09} + a_{09/10}) + k_2/M^*(a_{08/09} + a_{09/10})^2$$

$$a_{11/12} = 244 + (k_2 - k_1)(a_{08/09} + a_{09/10} + a_{10/11}) + k_2/M^*(a_{08/09} + a_{09/10} + a_{10/11})^2$$

$$a_{12/13} = 244 + (k_2 - k_1)(a_{08/09} + a_{09/10} + a_{10/11} + a_{11/12}) + k_2/M^*(a_{08/09} + a_{09/10} + a_{10/11} + a_{11/12})^2$$

$$a_{13/14} = 244 + (k_2 - k_1)(a_{08/09} + a_{09/10} + a_{10/11} + a_{11/12} + a_{12/13}) + k_2/M^*(a_{08/09} + a_{09/10} + a_{10/11} + a_{11/12} + a_{12/13})^2$$

The enrolment forecasts obtained are presented in Table 6 below.

Summary and Conclusion

The mixed influence diffusion (growth) model developed in this paper to study the life cycle of academic programs is characterized by an s-shaped growth curve; an assumption about the homogeneity of prospective program students; the influence of behavioural and social factors on prospective students' decision to enrol in academic programs, and no explicit consideration of economic factors such as income, tuition, financial assistance and advertising. Even in spite of all these limitations, the model yielded reasonable empirical parameter estimates and the timing of enrolments in academic programs. The ability of the model to forecast program enrolments (enrolment demand growth) was demonstrated by using the parameter estimates to generate plausible long-range enrolment forecast for one of the academic programs studied in this paper.

We may now claim to know something about the phenomenon the paper set out to explore: all the information which emanates from an academic institution and all the information which circulates within a potential social system are the main social and behavioural forces influencing the decision to enrol in an academic program at a particular institution. These external and internal influences have been the basic underlying forces in the enrolment decisions of potential students, but the roles of these forces have rarely been formally recognized, empirically studied and delineated. The mixed influence diffusion model has put the role of external and internal influences in the enrolment decisions into theoretical and empirical perspectives. The doors are now open for Institutional Researchers to apply the growth model to study the life cycles of academic programs in their institutions.

But the purpose of model building is to enhance understanding of the relationship between all the factors, which might potentially impact the growth of academic programs. Thus for future research, a model which integrates both social and economic factors is required.

As a start, the basic mixed influence growth model can be extended into a dynamic model to provide such an integration of social and economic factors with respect to the demand growth for academic programs. It will also be necessary, for purposes of comparison, to show that since the dynamic model incorporates more explanatory factors than the basic model, it performs better than the basic model. Although this type of work is beyond the scope of this paper, the author can say with confidence that this type of research is already under way and the theory and empirical results would be presented at the AIR forum in Ottawa, Canada, in 2011. (Just see the preview: Fig 11a & 11b).

TABLES

Table 1 Growth Model Regression Performance Evaluation

Academic Programs	**Period Covered**	**Regression Statistics**				
		R^2	**Adjusted R^2**	**R**	**F**	***p-value***
A	1979-2009	0.606	0.577	0.778	20.76	0.000
B	1979-2009	0.618	0.589	0.786	21.82	0.000
C	1989-2009	0.900	0.888	0.949	76.69	0.000
D	1991-2009	0.980	0.977	0.990	358.48	0.000
E	1994-2009	0.849	0.823	0.921	33.63	0.000
F	1992-2009	0.994	0.993	0.997	1107.39	0.000
G	1996-2009	0.992	0.990	0.996	609.54	0.000
H	1998-2009	0.537	0.421	0.733	4.64	0.046
J	1977-2009	0.459	0.417	0.677	11.01	0.000
K	1991-2009	0.512	0.447	0.715	7.86	0.005
L	1994-2009	0.561	0.488	0.749	7.66	0.007

Table 2 Growth Model Regression Results for Sample Undergraduate Programs

Academic Programs	**Period Covered**	**Regression Parameter Estimates**			**Model's Parameter Estimates**		
		β_0	**β_1**	**β_2**	**k_1**	**k_2**	**M**
A	1979-2009	170.3854* (3.095)	0.1166* (5.407)	$-0.6690\text{x}10^{-5}$* (4.144)	0.00907	0.12567	18,785
B	1979-2009	107.3771* (4.660)	0.0987* (5.143)	$-0.1152\text{x}10^{-4}$* (3.873)	0.01125	0.10995	9,544
C	1989-2009	166.776* (4.737)	0.0682* (3.074)	$-0.1660\text{x}10^{-5}$** (2.602)	0.00817	0.07637	20,419
D	1991-2009	58.4657* (4.616)	0.1705* (8.840)	$-0.416\text{x}10^{-5}$** (2.810)	0.00142	0.17192	41,326
E	1994-2009	50.5625* (3.584)	0.2700* (6.525)	$-0.1056\text{x}10^{-3}$* (4.737)	0.01851	0.28858	2,732
F	1992-2009	12.7706* (3.973)	0.3042* (24.900)	$-9.9243\text{x}10^{-4}$* (12.287)	0.00383	0.30803	3,332
G	1996-2009	33.9057* (3.499)	0.4391* (21.021)	$-0.8737\text{x}10^{-4}$* (12.130)	0.00664	0.44574	5,101
H	1998-2009	14.3767* (4.930)	0.1751** (2.638)	$-0.6000\text{x}10^{-3}$** (2.118)	0.04009	0.21519	358
J	1977-2009	5.7441 (1.697)	0.2672* (4.627)	$-0.7000\text{x}10^{-3}$* (4.686)	0.01428	0.28148	402
K	1991-2009	34.1369* (5.406)	0.1425* (3.916)	$-0.1622\text{x}10^{-3}$* (3.941)	0.03177	0.17426	1,075
L	1994-2009	128.9881* (5.098)	0.1777* (3.438)	-0.7880x10-4* (3.803)	0.04553	0.22323	2,833

Significant at: **p<0.01*; ***p<0.05*

Table 3 Comparison of Predicted Time and Magnitude of Peak with Actual Values

Academic Programs	Period Covered	Predicted Time Of Peak	Actual Time of Peak	Predicted Magnitude of Peak	Actual Magnitude of Peak
A	1979-2009	23	24	678	892
B	1979-2009	19	16	319	361
C	1989-2009	20	20	847	827
D	1991-2009	18	18	680	686
E	1994-2009	12	12	222	213
F	1992-2009	17	16	262	267
G	1996-2009	12	12	585	602
H	1998-2009	8	8	26	27
J	1977-2009	14	11	30	47
K	1991-2009	10	10	65	72
L	1994-2009	7	4	229	258

Table 4 Long-Term Forecasting Accuracy of the Model for Academic Program Life Cycles

Academic Programs	Period of Forecast	Correlation Between Actual and Predicted Enrolments	
		Correlation R	Significance
A	1979-2009	0.778	0.05
B	1979-2009	0.786	0.05
C	1989-2009	0.945	0.05
D	1991-2009	0.990	0.05
E	1994-2009	0.921	0.05
F	1992-2009	0.997	0.05
G	1996-2009	0.996	0.05
H	1998-2009	0.733	0.05
J	1977-2009	0.677	0.05
K	1991-2009	0.715	0.05
L	1994-2009	0.749	0.05

Table 5 Long-Term Forecasting Accuracy of the Model: Cross-Validation

Academic Programs	Period Covered	With-in-Sample Forecast		Out-of-Sample Forecast	
		Period Covered	R	Period Covered	R
A	1979-2009	1979-1993	0.953	1994-2009	0.993*
B	1979-2009	1979-1993	0.986	1994-2009	0.304
C	1989-2009	1989-1998	0.964	1999-2009	0.945
D	1991-2009	1991-1999	0.977	2000-2009	0.948
E	1994-2009	1994-2001	0.984	2002-2009	0.721
F	1992-2009	1992-2000	0.974	2001-2009	0.556
G	1996-2009	1996-2002	0.967	2003-2009	0.507
H	1998-2009	1998-2003	0.872	2004-2009	0.331
J	1977-2009	1977-1994	0.938	1995-2009	0.409
K	1991-2009	1991-1999	0.763	2000-2009	0.333
L	1994-2009	1994-2001	0.792	2002-2009	0.767

* $R_{\text{-W-S}} < R_{\text{-O-S}}$

Table 6 Forecast of Enrolment Demand for Program B

Fiscal Year	**Forecasted Enrolment**	**Cumulative Enrolment A**	**Cumulative Enrolment Squared A^2**
2008/09	244	343 (Actual)	117,649
2009/10	279	622	386,884
2010/11	310	932	868,624
2011/12	346	1,278	1,633,284
2012/13	389	1,667	2,778,889
2013/14	441	2,108	4,443,664
2014/15	503	2,611	6,817,321

CHARTS

Fig 5: Actual Enrolments and Enrolments Predicted by the Regression Equation (Program C)

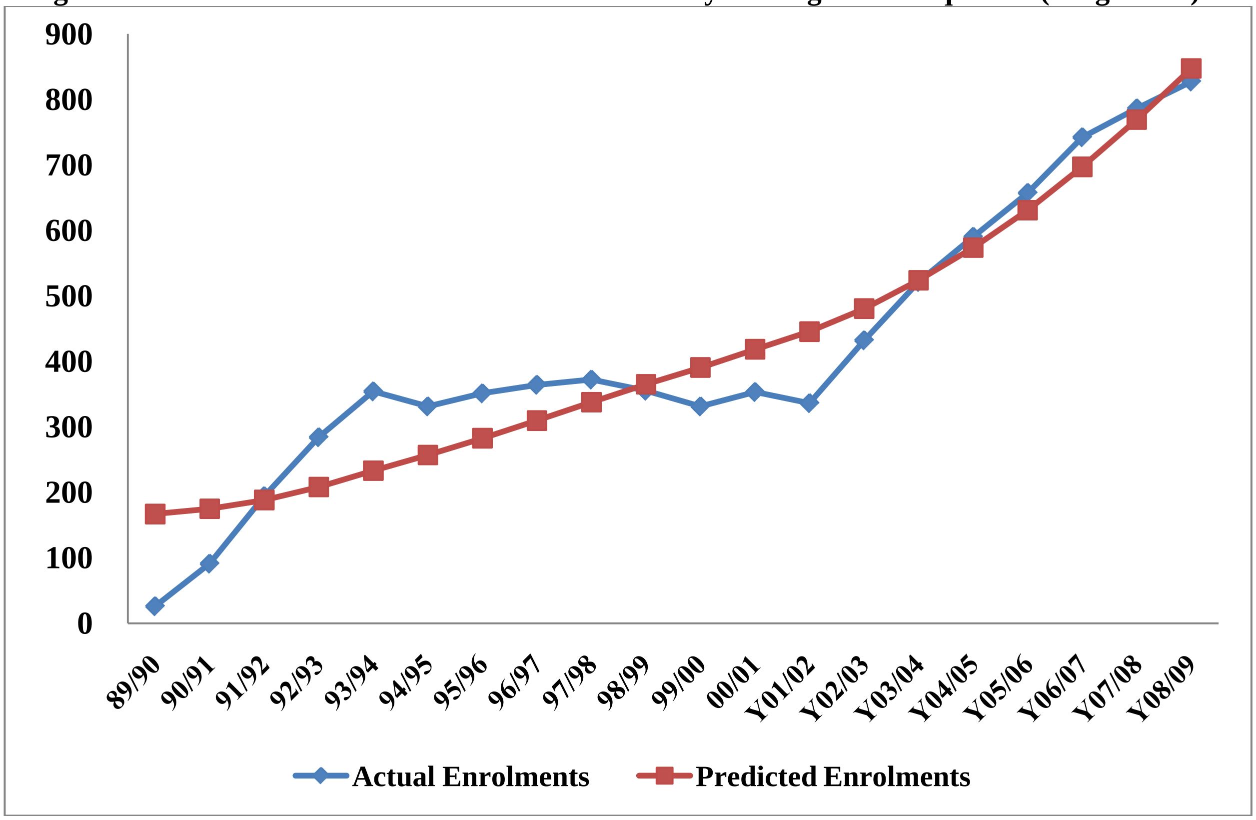


Fig 6: Actual Enrolments and Enrolments Predicted by the Regression Equation (Program D)

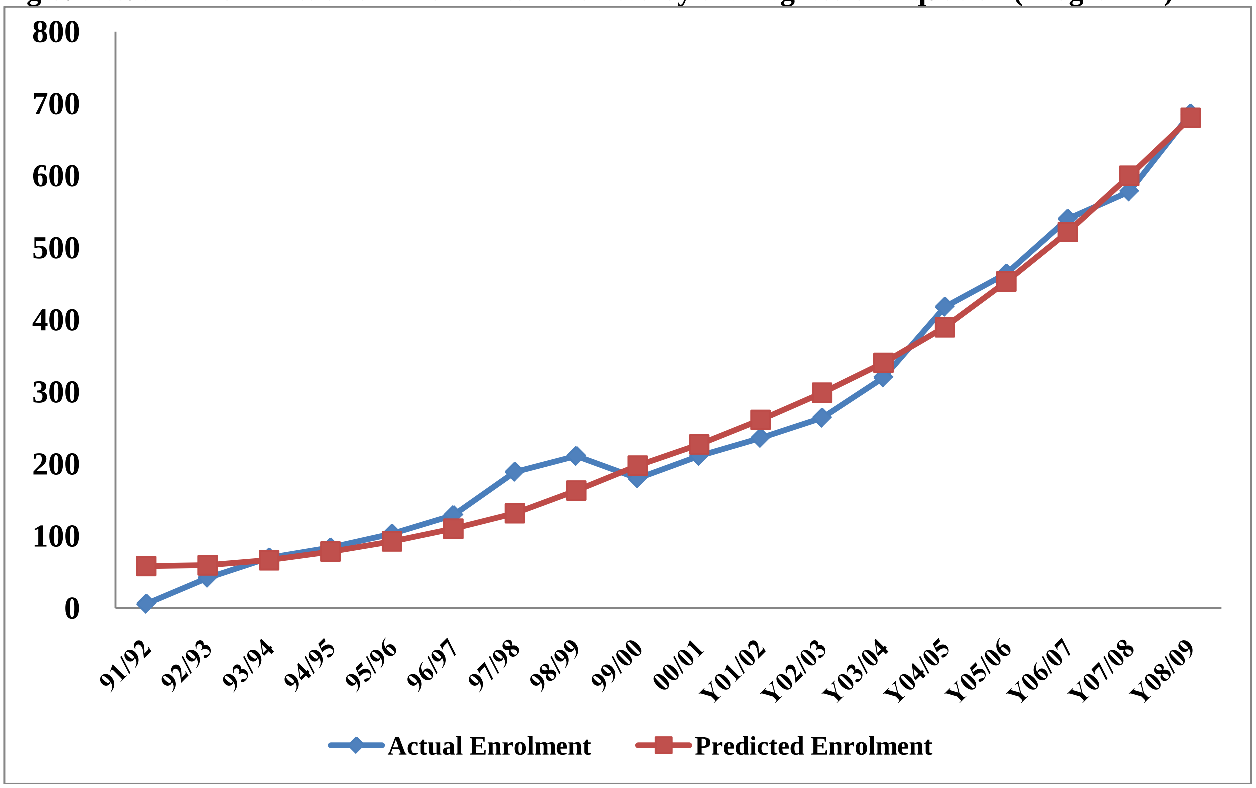


Fig 7: Actual Enrolments and Enrolments Predicted by the Regression Equation (Program E)

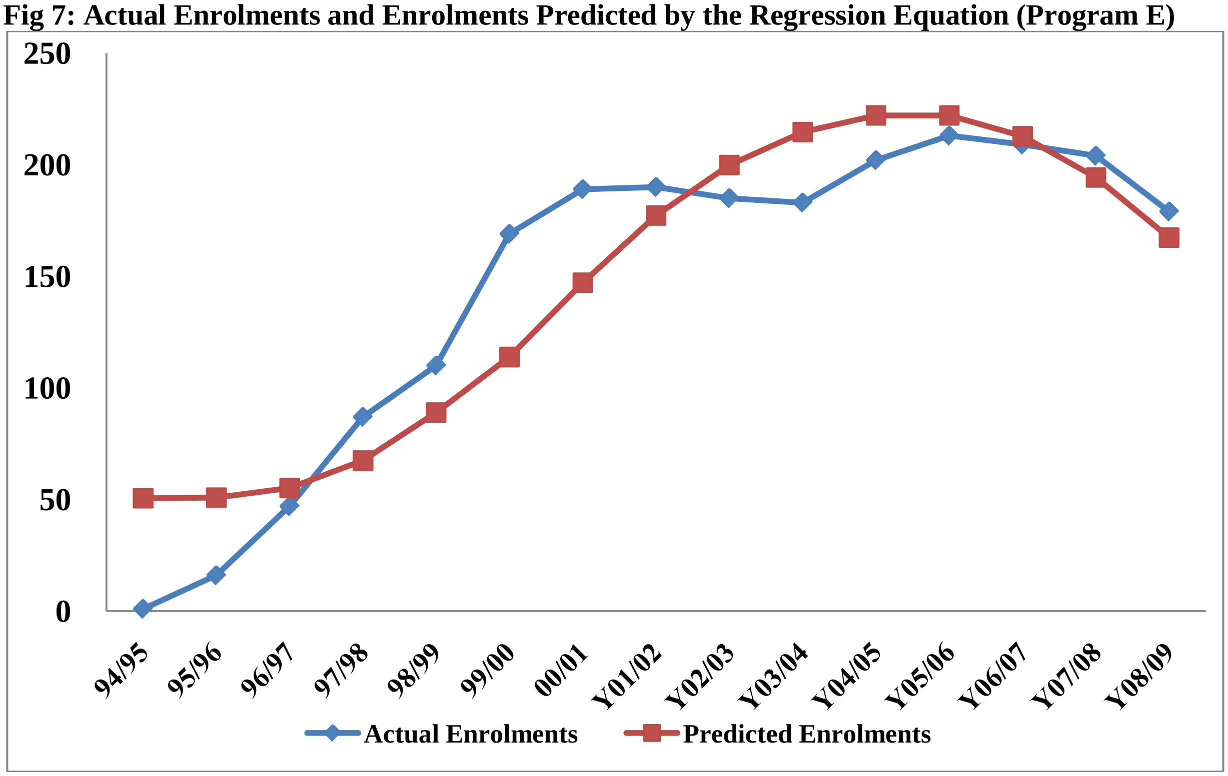


Fig 8: Actual Enrolments and Enrolments Predicted by the Regression Equation (Program F)

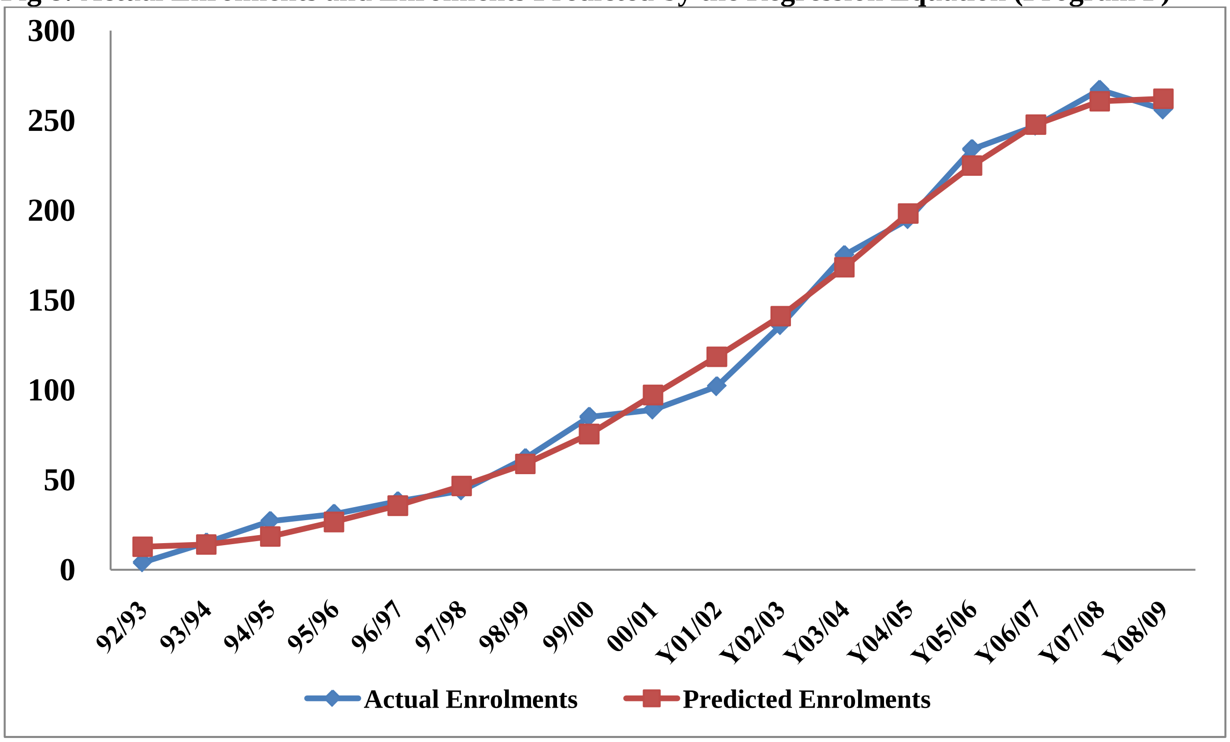


Fig 9: Actual Enrolments and Enrolments Predicted by the Regression Equation (Program G)

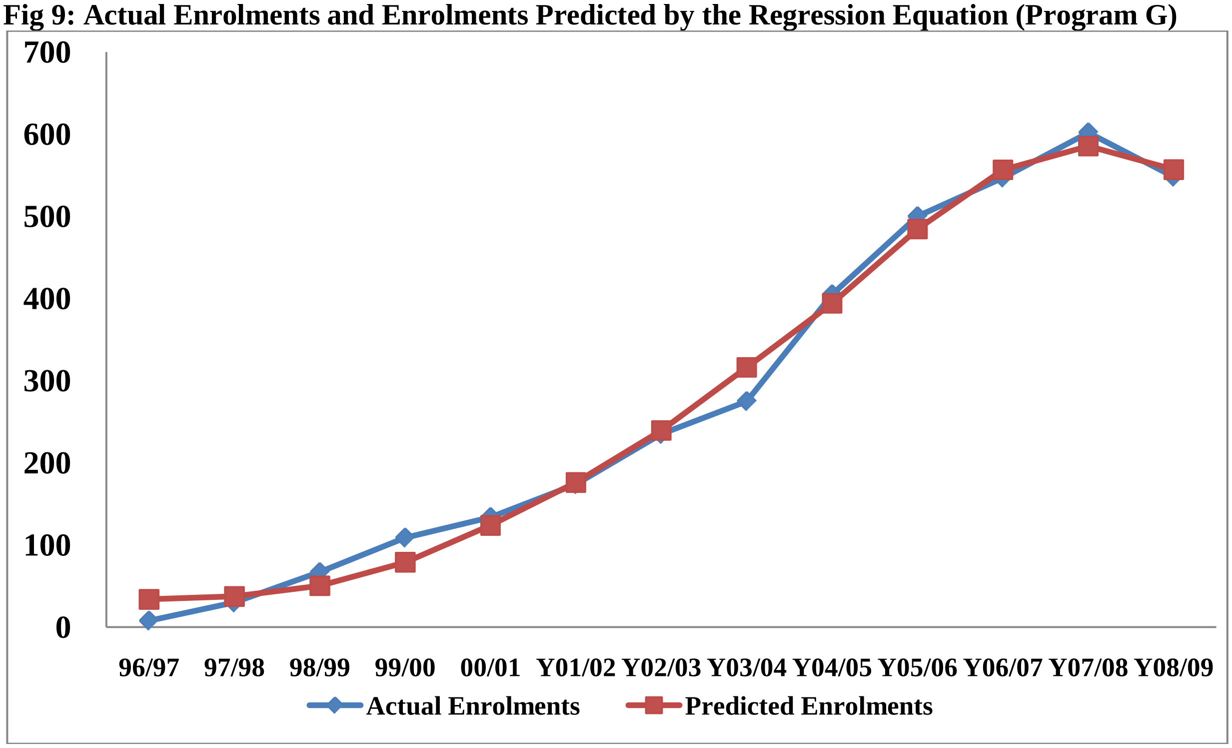
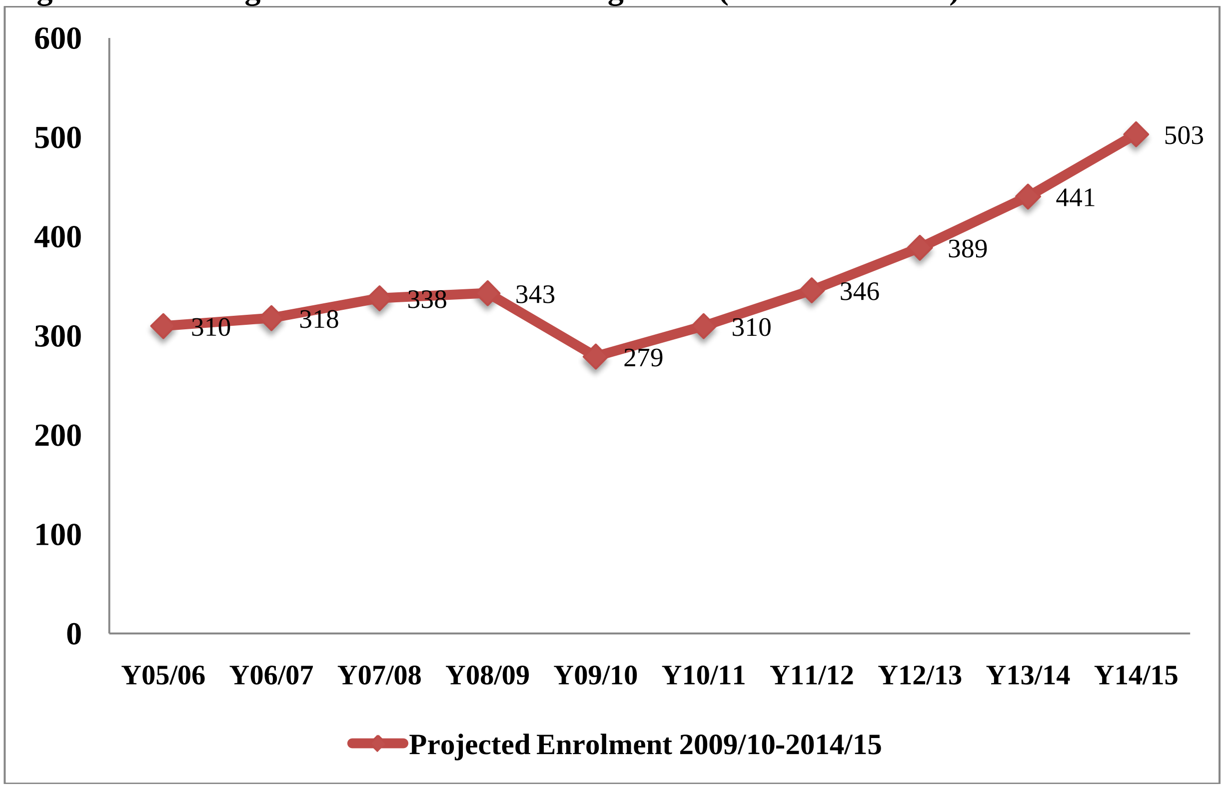


Fig 10 Forecasting Enrolment Demand: Program B (2009/10-2014/15)*



*Note: Actual Enrolments: 2005/06-2008/09

Fig 11a: The Long-range Forecasting Accuracy of the Basic Model for Program B

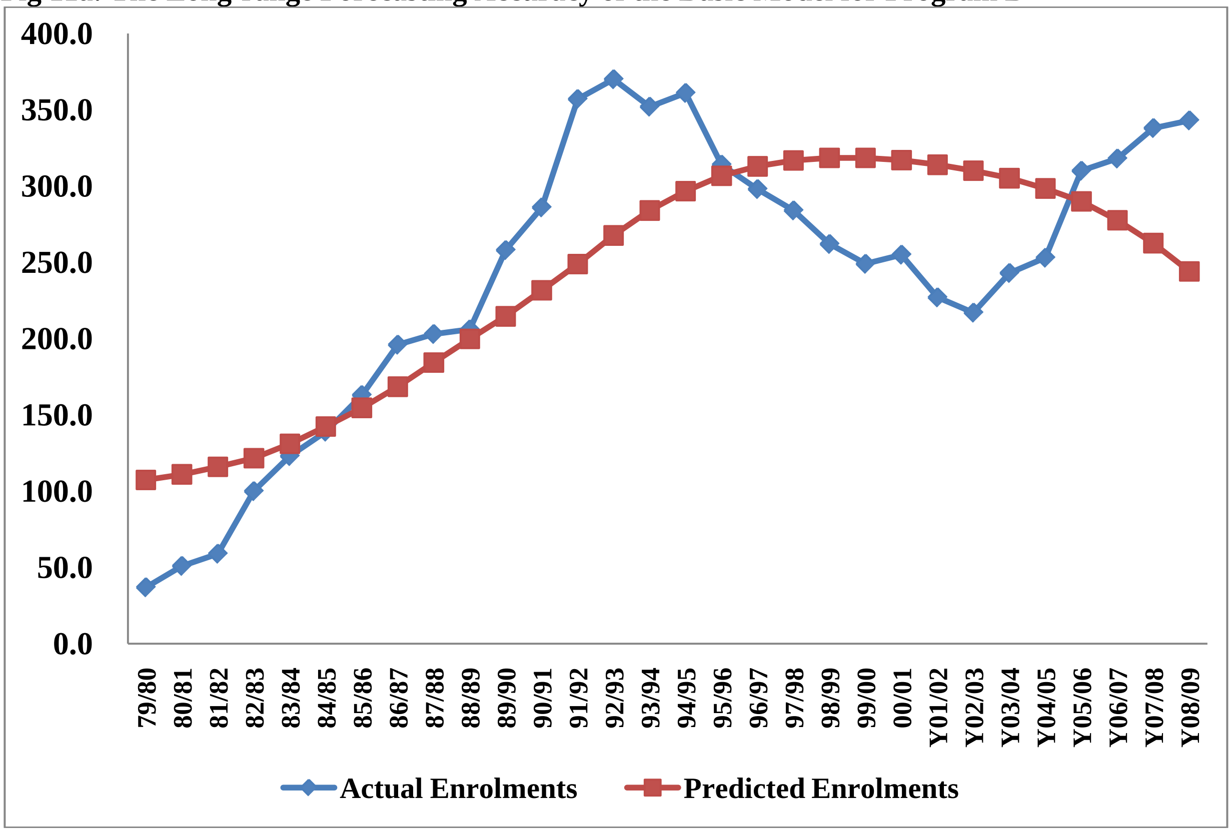
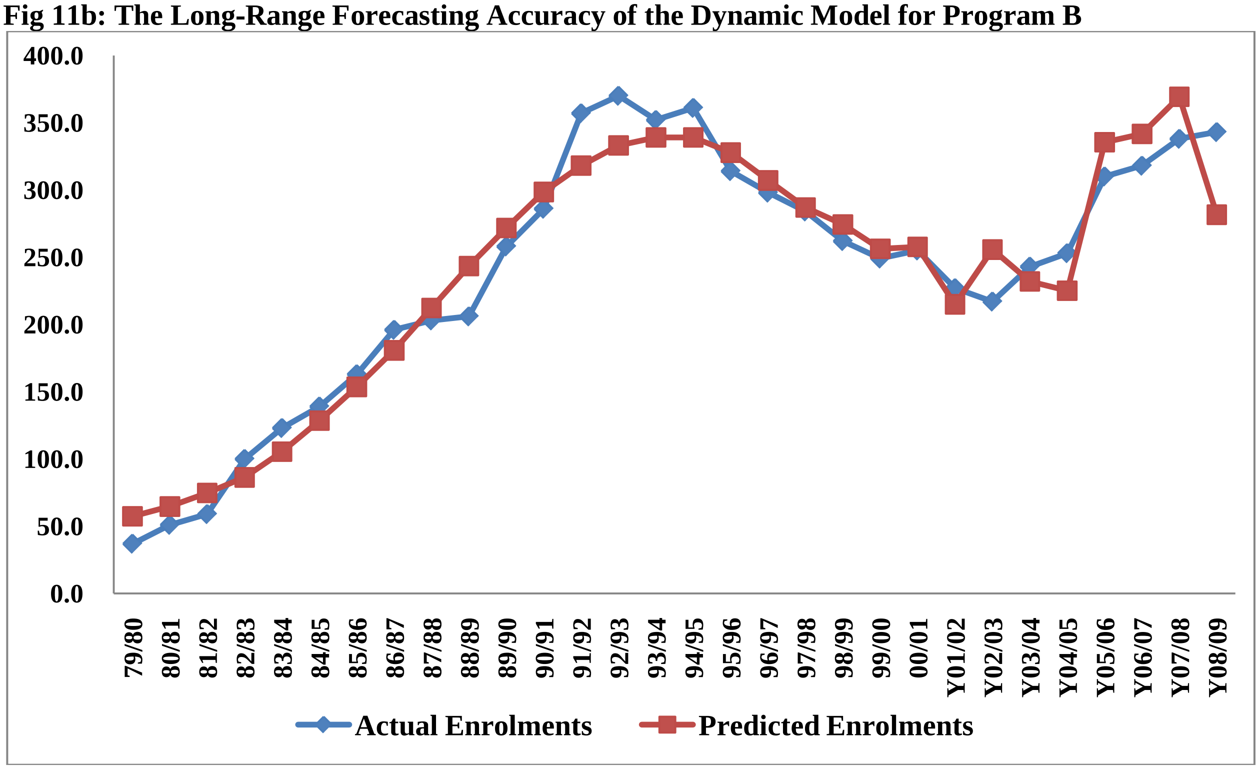


Fig 11b: The Long-Range Forecasting Accuracy of the Dynamic Model for Program B



REFERENCES

Acquah, E H K (1994), *Economic Analysis of Innovation Diffusion Processes in Agriculture: Hybrid Cocoa Trees & Chemicals in Ghana:* An Unpublished PhD Dissertation University Reading, England.

Akinola, A. A. (1984): *A Theoretical and Empirical Analysis of Innovation Processes: A Case Study of Cocoa Spraying Chemicals in Nigeria*, an Unpublished PhD Dissertation University of Manchester, Manchester, England.

Bass, Frank M (1969), "A New Product Growth Model for Consumer Durables," *Management Science* 15 (January), 215-227.

Bass, Frank M (1980), "The Relationship between Diffusion Rates, Experience Curves and Cox, Demand Elasticities for Consumer Durable Technological Innovations," *Journal of Business*, 53, 551-567.

Baum, C. F. (2006). An Introduction to Modern Econometrics Using Stata, Stata Press, Stata Corporation Texas

Brinbaum, B. (1998): "The Life Cycle of Academic Management Fads." Association for the Study of Higher Education (ASHE) Annual Conference

Bruce-Cry, A. (1983): "A crucial regression error in research on Diffusion of State Policies," *Political Methodology*, Vol. 9, pp 201-214.

Cox, William E, Jr (1967): "Product Life Cycles as Marketing Models." *The Journal of Business* 40 (October) pp375-384

Cray, V. (1973): "Innovation in the States: A Diffusion Study," *American Political Science Review* Vol. 67, pp1174-1185

Day, G. S. (1981): "The Product Life Cycle: Analysis and Application Issues." *Journal of Marketing* Volume 45 (4) pp 60-67

Fourt, L. A. & Woodlock, J. W. (1960): "Early Prediction of Market Success for New Grocery Products," *Journal of Marketing*, No. 2 (26)

Haines, G. H, Jr (1964): "A Theory of Market Behaviour after Innovation," *Management Science,* No. 4, Vol. 10, July.

Hallam, D. (1990): *Econometric Modeling of Agricultural Commodity Markets*. Routledge, London: p. 155

Hopkins, David S. (1977): *Business Strategies for Problem Products*. New York: Conference Board

Howell, D. C., (2002). Statistical Methods for Psychology (5^{th} edition) Pacific Grove, CA:

Duxbury

Kmenta, Jan (1971): *Elements of Econometrics*. The Macmillan Publishing Company, New York, pp 440-446

Kotler, Philip (2000) *Marketing Management: Analysis, Planning and Control*, Millennium Edition, Englewood Cliff, NJ: Prentice Hall

Lakatos, M (2009) "Managing Program Life Cycle: A Model of Indicators & Strategies." Paper

Maddala, G. S. (1988): Introduction to Econometrics. MacMillan Publishing Company. New York, pp. 498-499.

Mahajan, Vijay & Eitan Muller (1979), "Innovation Diffusion and New Product Growth Models In Marketing," *Journal of Marketing* 43 (Fall), 55-68.

Mahajan, Vijay & M. E. F. Schoeman (1977): "Generalized Model for the time pattern of the Diffusion process," *IEEE Transactions of the Engineering Management EM*-24: 12-18

Mahajan, Vijay, K. E. Kumar & K. E. Haynes (1977): "Modelling the Diffusion of Public Policy Innovations among the US States," *Socio-Economic Planning Sciences* 11, pp 259-263.

Mahajan, Vijay & R. A. Petersen (1979)" "First purchase Diffusion Models of new product Acceptance," *Technological Forecasting and Social Change,* Vol. 15, pp 127-146.

Modis, T. (1994): "Life Cycle: Forecasting the Rise and Fall of Almost." *The Futuristic 28 (5): 20-25*

Monks, James and Ronald G. Ehrenberg (1999): "*U.S. News & World Report's* College Rankings: Why Do They Matter?" *Change* 31 (6): 42-51

Mukerji, Siran & Purnendu Tripathi (2004): "Academic Program Life Cycle: A Redefined Approach to Understanding Market Demands." *Journal of Distance Education* Volume 19 (2)14-27

Polli, Rolando & Victor Cook (1969): "Validity of the Product Life Cycle." *Journal of Business* 42 (October) pp 385-400

Rink, David R & Swan, John E. (1982): "Fitting Market Strategies to Varying Product Life Cycles," *Business Horizons*, January-February, 1982, pp 72-76.

Rink, David R & Swan, John E. (1979): "Product Life Cycle Research: A Literature Review," *Journal of Business Research* 78 (September) 219-242.

Robinson, V. & C. Lakhani (1975): "Dynamic Price Models for New Product Planning," *Management Science* Vol. 21, pp 1113-1122.

Rogers, E. M (1962): *Diffusion of Innovations*, New York: The Free Press, 1962.

Shane, S. A. & K. T. Ulrich (2004): "Technological Innovation, Product Development, and Entrepreneurship in Management Science," *Management Science* 50 (2): 133-144

Shewchuk, J. (1992): "Life Cycle Thinking: An Approach to Better Business Decisions and Behaviours that will Maximize Profits" CMA Magazine, 34-36

Shultz, S R & S R Roa (1986): "Product Life Cycles of Goods for the Home." *Journal of the Academy of Marketing Science* Volume 14 (1) pp 8-12.

Stevens, Mitchell (2007): *Creating a Class: Admissions and the Education of Elites*. Cambridge, MA: Harvard University Press.

Tellis, Gerard J. & C. Merle Crawford (1981): "An Evolutionary Approach to Product Growth Theory," *Journal of Marketing* 45 (fall)

Walker, J. L. (1969): "The Diffusion of Innovations among the American States," *American Political Science Review*, 63, pp 880-899.

William E. (1967): "Product Life Cycles as Marketing Models." *The Journal of Business* 40 (October) pp 375-384

Wind, Yoram (1981): *Product Policy: Concepts, Methods and Strategy*, Reading, MA: Addison-Wesley

Zaltman, Gerald and Ronald Stiff (1972): "Theories of Diffusion," in *Consumer Behaviour: Theoretical Sources,* Scott Ward and Thomas S. Robertson, eds. Englewood Cliffs, NJ: Prentice Hall