ESTIMATION OF GENERAL EDUCATION PROGRAM ENROLLMENT

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ABSTRACT

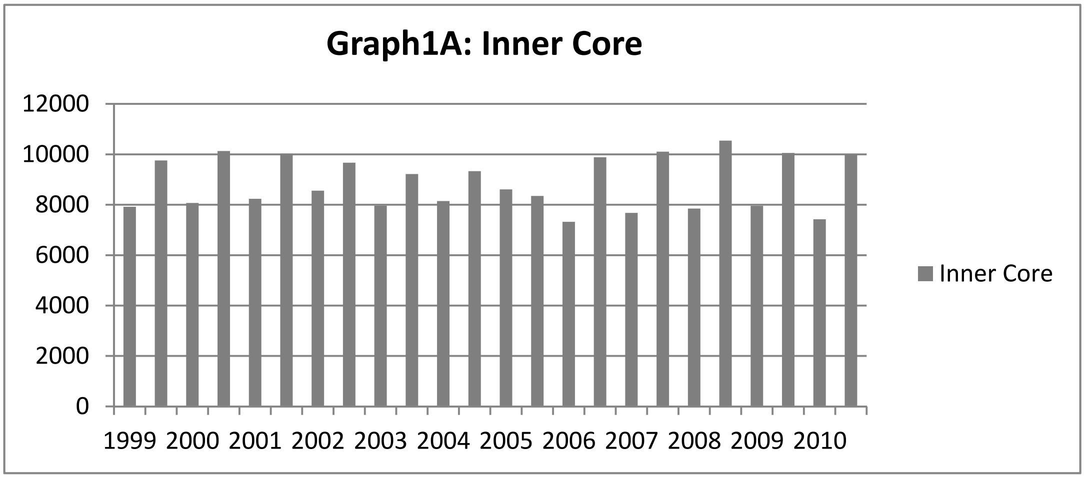
This study examines the differential effect of various factors on three categories of general education program enrollment. Cross-correlation analysis reveals that the relationship between middle core and outer core is positively related. Moreover, the strength of the relationship stays strong and statistically significant up to lag3 (about year and a half). Thus, this study provides evidence suggesting middle core and inner core categories exhibiting long memory. In general, associations between outer core and middle core and middle core with inner core are found to be positively correlated after controlled for trend. This exhibits long-term statistical dependence in these factors. However, the magnitude and the nature of dependency comparatively differ between inner core with middle core and middle core with outer core. These cross-correlations are not widely examined and suggest an additional link between tiered academic programs and factors that are involved in the student enrollment dynamics. In addition, regression results provide confirming evidence of the contrasting effect of semester and time trend on the inner core, middle core, and outer core enrollments.

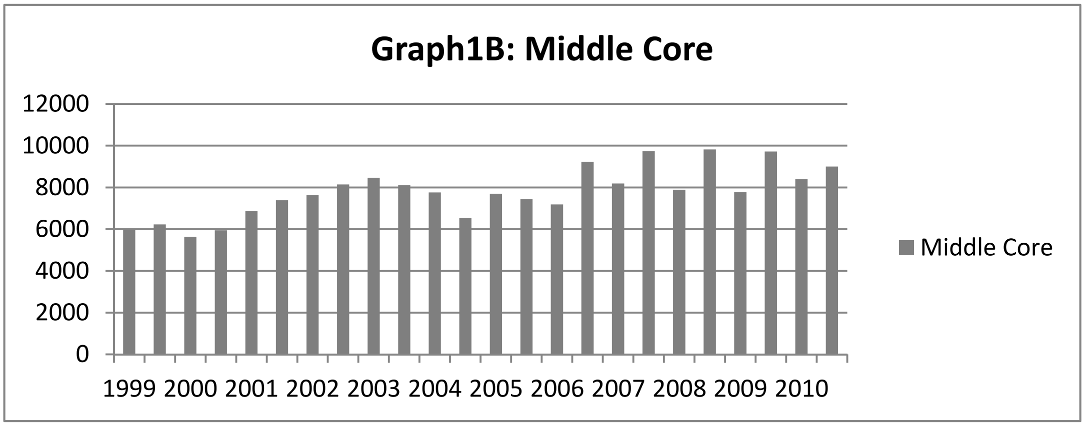
INTRODUCTION

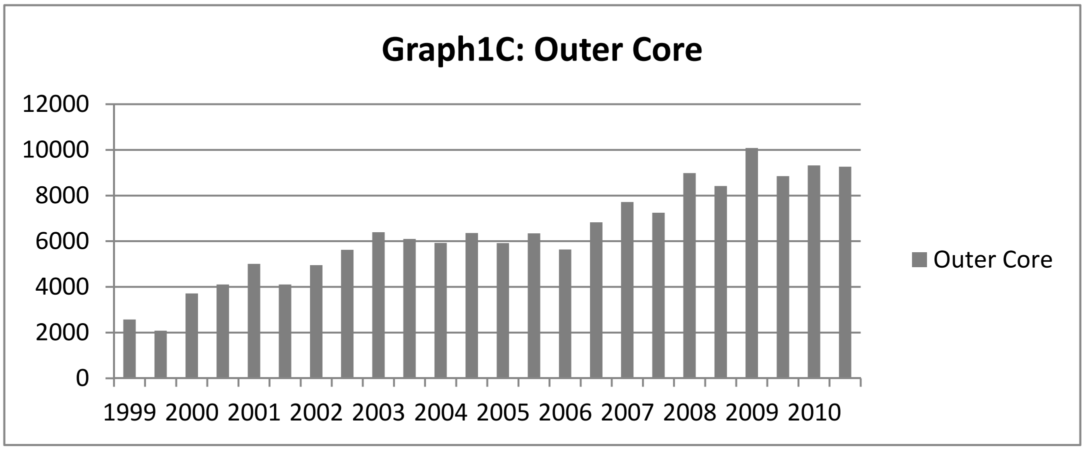
Course schedules are prepared and submitted by departments and schools well in advance of the start of the semester so that students are able to make plans for the timely completion of their academic degree programs. At this mid-western university, course schedules for the next fall semester are due at the beginning of November of the previous year, when admissions estimates, course pass rates, and student retention report are unavailable. However, the freshmen enrollment numbers stay relatively steady at around 3200, rarely differing by more than 100-200 students each fall. The schedules are available to students and advisors by the second week of November, early registration for continuing students begin in mid-March after spring break, spring grades are recorded in May, and freshmen and transfer student orientations begin in early June. Occasionally new instructors have to be hired to meet unexpected needs or current instructors have to have their schedules adjusted because of shifting demand. It is difficult for those instructors who are hired near the beginning of the semester to adequately prepare. It is also difficult for those students who are on a waiting list. Making precise predictions when preliminary schedules are constructed and adjusting these estimates as soon as possible are extremely important. Although complete relevant information on enrollment is not available at the time of prediction, an analysis of historical data makes it possible to construct generic course prediction models that are robust and fairly accurate for estimating the enrollment. This type of course prediction model can facilitate releasing additional seats to new students by better estimating seat requirement. New student registration is distributed over the summer preceding the fall semester through a series of sessions where students may register for courses. Universities use seat release systems to give similar enrollment opportunities to all incoming students. A seat release system also hedges fall course predictions by partially filling each section over time rather than filling each section in sequence. The model we present establishes the estimated demand for seats among three categories of General Education courses, namely Inner Core, Middle Core, and Outer Core courses. The model we present establishes the estimated demand for seats among three levels of General Education courses that were designed to be largely sequential, namely Inner Core, Middle Core, and Outer Core courses.

Enrollment prediction for general education courses, which provides information to the decision makers for budget planning and other aspects of planning, is important in many ways for the institution. Because of such importance, researchers have proposed many prediction methods to improve the accuracy of the enrollment estimation. However, obtaining accuracy on enrollment estimation is not an easy task, as many factors have impacts on the enrollment numbers. Many methods have been proposed and applied in enrollment prediction. Different models generate different results. The growth curve model by Weiler (1980) that was used for forecasting enrollment at the University of Minnesota, generated much variation in forecasting errors. Guo and Zhai (2000) applied survival ratio techniques to a four-year university enrollment. Song and Chissom (1993) applied the fuzzy time series approach to the enrollment prediction. Tsui & Murdock (1997) reviewed seven prediction models and analyzed the margin of errors on those models to comprehend the accuracy of the models.

As accuracy is an important concern in prediction, researchers engage in including more and more factors in their forecasting models. Some of the complex models combine the retention study and enrollment projection study together. These models also include such variables as high school and college grades, SAT or ACT scores, student demographic information, and their economic status. These factors could provide information about whether a student would return next semester or not, thus they might increase the accuracy of prediction of enrollment in the near term. However, models that are applied for the long term enrollment prediction will have little power with such factors. In addition, estimation of more parameters will hurt degrees of freedom and may not sustain the long-term characteristics of those factors over time. Thus, models with parsimonious parameterization characteristics are preferable over complex systems for projecting into the future. Estimating the demand for courses or a group of courses becomes more complicated by the fact that different students have different needs and requirements for their majors, in addition to varying needs for electives, minors, accreditation, etc. Moreover, a variety of choices makes the forecasting model more difficult to build. In addition, new course(s) as well as addition and/or deletion of existing course(s) may force students to make different choices. This paper examines three step projection models for the total general education enrollment projection using historical data of twelve years (both spring and fall). Thus, the process starts with Inner Core enrollment prediction, then Middle Core, and then Outer Core enrollment. Combining these three estimates will provide the total general education enrollment estimate.







General Education

One of the continuing concerns for any college or university is to provide enough seats in General Education classes to all students who need them. General Education provides a basic structure for students in terms of knowledge and skills in such foundational areas as writing, speech, and mathematical and scientific literacy. It is necessary to have these courses early in a student's academic career in order to prepare him or her for more advanced classes, including those in the major. Despite many challenges, it's necessary to come up with some type of model to predict the number of seats that are needed in different categories so that students stay full time, become well prepared for more advance academic classes and their major, and are able to be exposed to the variety of liberal arts that make up general education.

At this University, there is a three-tiered system in which students take foundational courses in writing, speech, mathematics, and science in their first year, and build on that foundation in subsequent semesters in multidisciplinary courses in the Middle Core in areas such as Quantitative Reasoning, Language in the Humanities, United States Traditions, Individuals and Civic Life, and Individuals and Society. The Outer Core is more discipline specific in that students need one course in each of four different areas: Social Sciences, Fine Arts, Humanities, and Science, Mathematics, and Technology.

The program's overall structure is designed to ensure that developmental objectives are achieved through the coherent and sequential interrelationship of courses. Inner Core courses provide basic knowledge and skills upon which Middle Core courses build, and those courses in turn prepare students for courses in the Outer Core. The complete General Education Program consists of 14 courses (42 semester hours), which is approximately one third of the total credits required for graduation. Students will take most General Education courses during their freshman and sophomore years, along with some courses in their major or other elective courses.

Inner Core: The Inner Core courses focus on the acquisition and practice of specific academic skills: language, mathematics, and science. These courses offer a structured context for the development of abilities and understanding, and are important to subsequent undergraduate course work. Students are expected to take Composition as Critical Inquiry or Communication as Critical Inquiry the first semester of their freshman year and the other course in their second semester. The mathematics and natural science requirements are to be completed as early as possible.

Middle Core: This General Education category is of two varieties. Quantitative Reasoning and Language in the Humanities courses provide opportunities for the continued development of academic skills applied to a range of topics and involving a variety of disciplinary perspectives. Courses in the other Middle Core categories: United States Traditions, Individuals and Civic Life, and Individual and Societies foster the application of academic skills to traditional knowledge bases. Students take one course from each of the five categories.

Outer Core: These courses give insight into the varied nature of disciplinary knowledge; introducing students to the ways that specific disciplines create knowledge and examining the interplay between disciplinary inquiry and the larger world in which such an inquiry is situated. Students take one course chosen from each of four discipline groups: Science, Mathematics, and Technology; Social Sciences; Fine Arts; and Humanities.

DATA AND METHODOLOGY

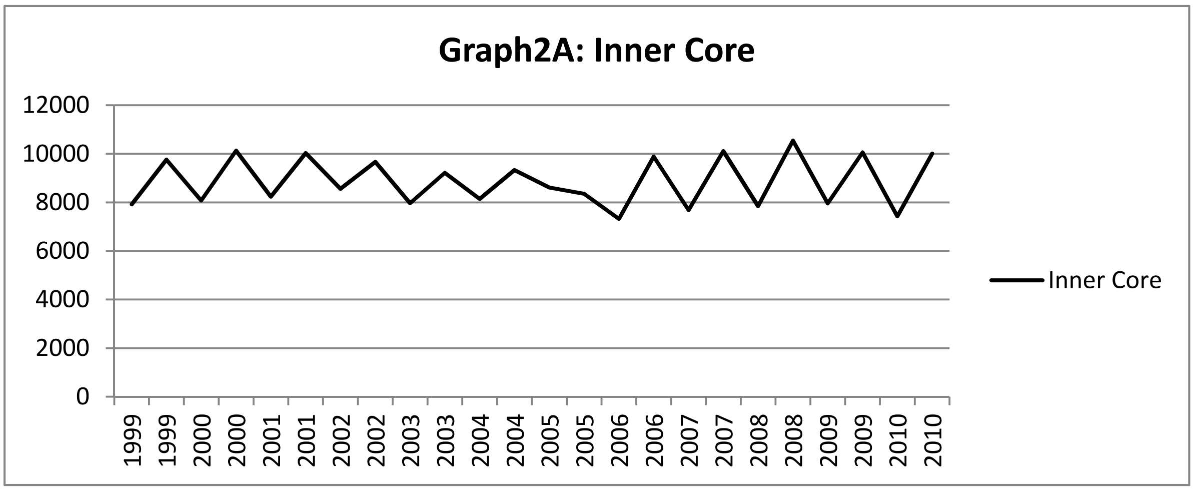
Data were collected from the enrollment record of General Education courses for twelve consecutive years and thus provides us a time-series data for 24 semesters. Enrollment numbers were grouped into three different General Education categories. The General Education Program at this university is an integrated set of courses that focuses on the development of communication and problem-solving skills and abilities, such as persuasion, listening, and argumentation; logical and quantitative thinking; and understanding varying perspectives on issues. These skills and abilities provide an essential grounding for work in the student’s major. The program’s overall structure is designed to ensure that developmental objectives are achieved through the coherent and sequential interrelationship of courses. Inner Core courses provide basic knowledge and skills upon which Middle Core courses build, and those courses in turn prepare students for courses in the Outer Core. Therefore, we hypothesize that Outer Core enrollment depends on Middle Core enrollment and Middle Core depends on Inner Core enrollment. In addition, semester (spring and fall) can also be a determinant for enrollment projection. We therefore, include semester as a categorical (dummy coded) independent variable during the model building phase.

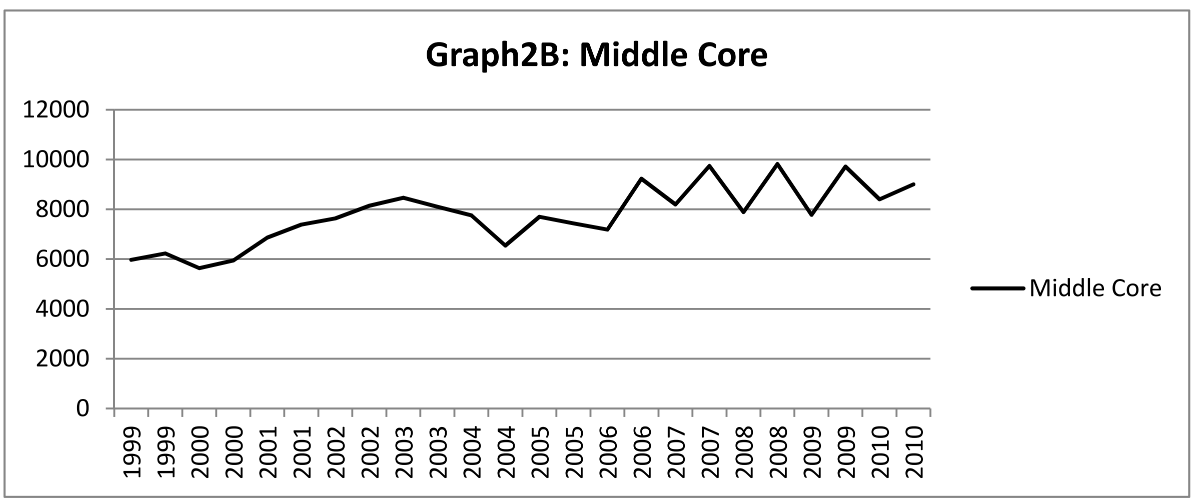
TABLE-1A: Summary Statistics of Inner Core, Middle Core, and Outer Core Enrollment numbers for year (1999-2010).					
Variables	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**
Inner Core	24	8866.83	1026.78	7320.00	10541.00
Middle Core	24	7781.88	1203.68	5638.00	9823.00
Outer Core	24	6316.71	2150.54	2082.00	10087.00

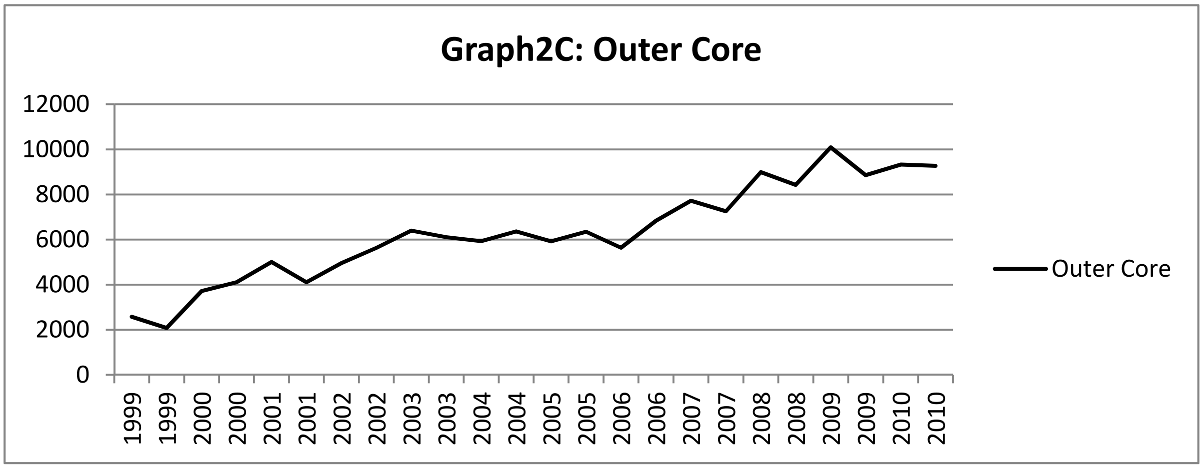
TABLE-1B: Summary Statistics of Inner Core, Middle Core, and Outer Core Enrollment numbers for Spring Semester (1999-2010).					
Variables	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**
Inner Core	12	7977.67	391.17	7320.00	8609.00
Middle Core	12	7455.58	897.08	5638.00	8463.00
Outer Core	12	6353.83	2285.03	2575.00	10087.00

TABLE-1C: Summary Statistics of Inner Core, Middle Core, and Outer Core Enrollment numbers for Fall Semester (1999-2010).					
Variables	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**
Inner Core	12	9756.00	571.31	8344.00	10541.00
Middle Core	12	8108.17	1411.51	5945.00	9823.00
Outer Core	12	6279.58	2108.49	2082.00	9264.00

Table 1(A,B,C) shows the distributions of Inner Core, Middle Core, and Outer Core enrollments for the time period mentioned above. As observed in Table 1A, the average number of Inner Core enrollment is 8,866.83 for an academic year (spring and fall). However, enrollment is observed to be much higher in the fall compared to the spring (see Table 1B & 1C). In addition, variability is much lower when observed by semester compared to year. This implies that the Inner Core enrollments are homogeneous within the semester and heterogeneous between semesters. Thus, the semester can be an important predictor for enrollment projection for Inner Core. Similar but smaller differences can be observed for Middle Core enrollment. The Middle Core enrollments do not show much difference, if any, due to semester differences. Thus, we can hypothesize that semester differences can be useful to predict Inner Core enrollment, but not for Middle Core or Outer Core. The range for Outer Core (8,005) is much higher than the range for Middle Core (4,185), or Inner Core (3221) for the time period considered (see Table 1-A) in this paper. Similar results can also be observed by semester. This outcome instigates us to examine possible trend behavior in the enrollment data. In fact, there is an observable upward trend for Outer Core enrollment (see graph 1C and 2C), whereas the trend in the Inner Core enrollment is nonexistent as depicted in graph 1A and 2A. Therefore, we hypothesize that time trend can be an important predictor for Middle Core and Outer Core enrollment projection. In addition, there may be time lag effect of Middle Core on Outer Core and Inner Core on Middle Core.







To examine our hypotheses we perform our research analyses as follows. First, we use the cross-correlation analysis with lag predictors to examine the direction of the association and whether the Inner Core or Middle Core enrollment exhibit any long memory to influence the projection; the term refers to long-term statistical dependence in time series data. Second, we use time-series regression to examine the magnitude and significance of Inner Core, Middle Core, and Outer Core enrollment using semester as one of the factors over time and to observe any acceleration /deceleration of the momentum of the enrollment. Specifically, we regress the enrollment (Inner Core, Middle Core, or Outer Core) on the semester, time trend, and a relevant preceding core enrollment. In our study, we examine all these factors' differential effect to obtain a superior forecasting model to estimate three different enrollment quantities for Inner, Middle and Outer Core categories.

Additionally, Durbin-Watson statistic of ordinary least squares (OLS) estimates indicated the presence of positive autocorrelation. Longitudinal studies, in general, exhibit autocorrelation significance in the regression model (see, Choudhury, 2010). Durbin-Watson test statistic is not reliable to detect autocorrelation for processes other than the first order (see Harvey, 1981; pp. 209-210). Therefore, we have evaluated the autocorrelation function (ACF) and partial autocorrelation function (PACF) of the OLS regression residuals using SAS procedure PROC ARIMA (see SAS/ETS User's Guide, 1993). This allowed the observance of the degree of autocorrelation and the identification of the order of the residuals' model that sufficiently described the autocorrelation. After evaluating the ACF and PACF (see Box, Jenkins, & Reinsel, 1994), the residuals' models are identified and estimated as below.

$$InnerCore_t = \beta_0 + \beta_1 Semester_t + \nu_t \qquad \text{------- (1)}$$

and $\nu_t = \phi_5 \nu_{t-5} + \varepsilon_t$.

InnerCore = number of Inner Core enrollment, Semester = 0 , if spring and Semester = 1, if fall.

$$MiddleCore_t = \beta_0 + \beta_1 TimeTrend_t + \beta_2 InnerCore + \nu_t \qquad \text{------- (2)}$$

and $\nu_t = \phi_1 \nu_{t-1} + \phi_2 \nu_{t-2} + \varepsilon_t$.

MiddleCore = number of Middle Core enrollment, TimeTrend = 1 to 24 in one unit increment.

$$OuterCore_t = \beta_0 + \beta_1 TimeTrend_t + \beta_2 MiddleCore_{t-3} + \nu_t \qquad \text{------- (3)}$$

and $\nu_t = \phi_1 \nu_{t-1} + \varepsilon_t$.

OuterCore = number of Outer Core enrollment.

Maximum likelihood estimation method is used instead of two step generalized least squares to estimate the regression parameters in the regression model. Maximum likelihood estimation is preferable over two step generalized least squares, because of its capability to estimate both regression and autoregressive parameters simultaneously. Moreover, maximum likelihood estimation accounts for the determinant of the variance-covariance matrix in its objective function (likelihood function). Further discussion on different estimation methods and the likelihood functions can be found in Choudhury, Hubata & St. Louis (1999); also SAS/ETS User's Guide, 1993 for the expression of the likelihood functions. Likelihood function of the regression model with autocorrelated errors can be expressed as follows:

$$L(\beta, \theta, \sigma^2) = -\frac{n}{2}\ln(\sigma^2) - \frac{1}{2}\ln|\Omega| - \frac{(Y - X\beta)'\Omega^{-1}(Y - X\beta)}{2\sigma^2}$$

Table-2: Lagged Correlations between Inner, Middle, and Outer Core

	Year	Semester	Inner Core	Inner Core Lag1	Inner Core Lag2	Inner Core Lag3	Middle Core	Middle Core Lag1	Middle Core Lag2	Middle Core Lag3	Outer Core
year	1.0000 24	0.0000 1.0000 24	-0.036 0.8644 24	0.0476 0.8252 24	0.0361 0.8700 23	0.0679 0.7639 22	0.7469 <.0001 24	0.74407 <.0001 24	0.74688 <.0001 23	0.72642 0.0001 22	0.9550 <.0001 24
Semester	0.0000 1.0000 24	1.0000 24	0.8846 <.0001 24	-0.826 <.0001 24	0.8184 <.0001 23	-0.809 <.0001 22	0.2769 0.1902 24	-0.01590 0.9412 24	0.04128 0.8516 23	0.01905 0.9330 22	-0.017 0.9348 24
Inner Core	-0.0368 0.8644 24	0.8846 <.0001 24	1.0000 24	-0.759 <.0001 24	0.7871 <.0001 23	-0.757 <.0001 22	0.3440 0.0997 24	-0.10862 0.6134 24	0.10147 0.6450 23	-0.07652 0.7350 22	-0.040 0.8495 24
Inner Core Lag1	0.0476 0.8252 24	-0.826 <.0001 24	-0.759 <.0001 24	1.0000 24	-0.743 <.0001 23	0.7736 <.0001 22	-0.227 0.2845 24	0.30377 0.1490 24	-0.14097 0.5212 23	0.03665 0.8714 22	0.1731 0.4185 24
Inner Core Lag2	0.0361 0.8700 23	0.8184 <.0001 23	0.7871 <.0001 23	-0.743 <.0001 23	1.0000 23	-0.721 0.0001 22	0.3582 0.0933 23	-0.17682 0.4196 23	0.35475 0.0967 23	-0.06008 0.7906 22	0.0336 0.8789 23
Inner Core Lag3	0.0679 0.7639 22	-0.809 <.0001 22	-0.757 <.0001 22	0.7736 <.0001 22	-0.721 0.0001 22	1.0000 22	-0.162 0.4706 22	0.31992 0.1467 22	-0.21888 0.3278 22	0.30077 0.1738 22	0.1430 0.5253 22
Middle Core	0.7469 <.0001 24	0.2769 0.1902 24	0.3440 0.0997 24	-0.227 0.2845 24	0.3582 0.0933 23	-0.162 0.4706 22	1.0000 24	0.57133 0.0035 24	0.72581 <.0001 23	0.50969 0.0154 22	0.7301 <.0001 24
Middle Core Lag1	0.7440 <.0001 24	-0.015 0.9412 24	-0.108 0.6134 24	0.3037 0.1490 24	-0.176 0.4196 23	0.3199 0.1467 22	0.5713 0.0035 24	1.00000 24	0.56327 0.0051 23	0.71006 0.0002 22	0.8062 <.0001 24
Middle Core Lag2	0.7468 <.0001 23	0.0412 0.8516 23	0.1014 0.6450 23	-0.140 0.5212 23	0.3547 0.0967 23	-0.218 0.3278 22	0.7258 <.0001 23	0.56327 0.0051 23	1.00000 23	0.55574 0.0072 22	0.7750 <.0001 23
Middle Core Lag3	0.7264 0.0001 22	0.0190 0.9330 22	-0.076 0.7350 22	0.0366 0.8714 22	-0.060 0.7906 22	0.3007 0.1738 22	0.118 <.000 2329	-0.308 <.000 2329	-0.240 <.000 2329	1.000 2329	0.385 <.000 2329
Outer Core	0.9550 <.0001 24	-0.017 0.9348 24	-0.040 0.8495 24	0.1731 0.4185 24	0.0336 0.8789 23	0.1430 0.5253 22	0.143 <.000 2329	-0.448 <.000 2329	-0.326 <.000 2329	0.385 <.000 2329	1.000 2329

EMPIRICAL ANALYSIS

We report the results of statistical analysis investigating the association between enrollment, semester, and preceding core enrollment (contemporaneous and lagged). Table 2 presents lead-lag correlations along with their p-values for three different core enrollments and enrollment effect up to 3 semester (year and a half) lag. Strong positive correlations are observed with Outer Core and the Middle Core. Even though the association remains statistically significant up to 3 semesters long, the strength of the association diminishes slowly indicating the impact on Outer Core is more pronounced during the recent semesters than distant past. In contrast, correlations between Middle Core and Inner Core are weaker and oscillate between positive and negative correlations in alternative lag periods and slowly diminish. This is perhaps due to the interaction effect of semester that plays a role on affecting Middle Core enrollment in conjunction with Inner Core enrollment. Results also show that Middle Core exhibit stronger long memory on the Outer Core. The concept of long memory in a time series is used to indicate statistical dependence in which the autocorrelation function decays at a much slower rate than in the case of short-term statistical dependence. Long-term dependence has only begun to be addressed recently in macroeconomic and financial time series data (Abderrezak, 1998). The positive impacts of Middle Core on Outer Core become statistically significant even after year and a half delay. This delayed positive impact is consistent with the idea that more student enrollment in the Middle Core increases the supply of students that are eligible to take Outer Core courses and consequently impacts the enrollment number in the outer core courses. This result is consistent with other research findings in that it suggests protracted upward spiral momentum of the process mechanism known as domino effect (Choudhury & Campbell, 2004).

Table 3: Regression Results for Inner Core Enrollment (Maximum Likelihood Estimation).

Independent Variables	Maximum Likelihood Estimates of Parameters	Standard Error	t Value	Approx Pr > |t|
Intercept	6346	233.4308	27.19	< 0.0001
Semester (Spring & Fall)	1653	149.1943	11.08	< 0.0001
R-Squared	0.83	0.78 (OLS)		
Durbin-Watson	1.70	1.42 (OLS)		

Note: The regression residuals model is identified as, $\nu_t - \phi_5 \nu_{t-5} = \varepsilon_t$ and the estimated fifth order autoregressive (AR) parameter from SAS is, $\nu_t + \underset{(1.94)^{*}}{0.4647}\, \nu_{t-5} = \varepsilon_t$.

Autoregressive parameter's t-statistic is reported in the parentheses. It is significant at the ten (*) percent level of significance (with p-value = 0.065).

Regression results reported in Table 3, 4, and 5 provides confirming evidence of the contrasting effect of Inner Core and Middle Core on the Middle Core and Outer Core respectively. Time trend is positively associated with Middle Core and Outer Core; however, the effect is almost twice as much on Outer Core compared to Middle Core (432 vs. 244, see Tables 4 & 5), suggesting a rapid expansion of Outer Core enrollment. On the other hand, there is no apparent trend visible in the Inner Core enrollment and thus makes it a steady process. We applied forward, backward, and mixed stepwise methods to select the regression model through the R-squared statistics and significance level as a criterion to add variables into the model or delete variables from the model. Moreover, the model resulting from stepwise selection provided the same conclusion that time trend, preceding core enrollment including lag effect, and semester difference (in case of Inner Core), are significant factors in impacting the projection of student enrollments.

Middle Core enrollment including lag and time trend have direct impact on the Outer Core enrollment, as indicated by the positive coefficients that resulted in increasing enrollments of Outer Core. More specifically, one can assert that if the time trend increases by one semester, Outer Core enrollment increases by approximately 432 students. Similarly, an additional increase of four students in the Middle Core enrollment in a year and a half ago, current Outer Core enrollment will be increased by one more student (approximately).

Table 4: Regression Results for Middle Core Enrollment (Maximum Likelihood Estimation).

Independent Variables	Maximum Likelihood Estimates of Parameters	Standard Error	t Value	Approx Pr > |t|
Intercept	-484462	92823	-5.22	<.0001
Time Trend	244.0590	46.2815	5.27	<.0001
Inner Core	0.3418	0.1507	2.27	0.0351
R-Squared	0.77	0.70 (OLS)		
Durbin-Watson	1.97	1.36 (OLS)		

Note: The regression residuals model is identified as, $\nu_t - \phi_1 \nu_{t-1} - \phi_2 \nu_{t-2} = \varepsilon_t$ and the estimated first and second order autoregressive (AR) parameters from SAS are, $\nu_t - 0.4711\ \nu_{t-1} + 0.3825\ \nu_{t-2} = \varepsilon_t$.

$(-2.07)^{*}$ $(1.64)^{-}$

Autoregressive parameter's t-statistic is reported in the parentheses. First parameter is significant at the ten (*) percent level (with p-value = 0.052) and the second parameter is not significant at ten percent (with p-value = 0.117).

On the other hand, Inner Core enrollments do not exhibit any statistically significant time trend, but they do differ due to semester differences. Specifically, one can assert that estimated demand for Inner Core seats would be 1653 more in the fall as opposed to the spring semester. In addition, this one explanatory factor alone explains 83% of the variation in the Inner Core enrollment after adjusted for autocorrelation. After being adjusted for autocorrelation, the Durbin-Watson test-statistic (DW=1.70) indicates that the errors are not correlated.

Table 5: Regression Results for Outer Core Enrollment (Maximum Likelihood Estimation).

Independent Variables	Maximum Likelihood Estimates of Parameters	Standard Error	t Value	Approx Pr > |t|
Intercept	-862375	130915	-6.59	<.0001
Time Trend	432.4971	65.5636	6.60	<.0001
Middle Core_Lag3	0.2613	0.1100	2.37	0.0289
R-Squared	0.93	0.91(OLS)		
Durbin-Watson	1.73	1.25 (OLS)		

Note: The regression residuals model is identified as, $\nu_t - \phi_1 \nu_{t-1} = \varepsilon_t$ and the estimated first order autoregressive (AR) parameters from SAS are, $\nu_t - \underset{(-1.62)^*}{0.3658}\, \nu_{t-1} = \varepsilon_t$.

Autoregressive parameter's t-statistic is reported in the parentheses. It is not significant at the ten (*) percent level of significance (with p-value = 0.121).

CONCLUSION AND DISCUSSION

This paper makes a number of significant contributions to the literature. It provides additional evidence of differential effect of various factors on three categories of General Education enrollment. In addition, it also provides evidence suggesting the number of enrollments display long memory. Associations between Outer Core and Middle Core and Middle Core with Inner Core are found to be positively correlated after controlled for trend. However, Inner Core projection does not require any other factor(s) except for semester information to be able to project into the future. These results while important are not unexpected given the dynamic structure of the three tier General Education program.

Considering Inner Core enrollments dependency only on the semester and not on any other factors illustrates how policy makers can benefit from this simplicity and using the results of this study for Inner Core enrollment projection. In addition, the three forecasting models for three different categories that we have developed in this study can be estimated sequentially without any simultaneous consideration. Since the association between Middle Core and Inner Core, and Outer Core and Middle Core are positive and separated; preceding core enrollment can be used as an indicator for understanding the future trend movement of Middle or Outer Core enrollment. Therefore, understanding the mechanism of lead-lag relationship between different core enrollments will provide an advantageous position to the policy makers to prepare an appropriate policy design for enrollment projection.

Thus, these results add another dimension to the study concerning the effect of factors on the enrollment activity in higher education. Additional theory development is needed, particularly with regard to the linkage between factors and their interaction effect on the enrollment dynamics. To determine further whether the association between Inner Core and Middle Core or the association between Middle Core and Outer is stationary, future research could examine these structures over different institutions and different time periods.

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