OJED
OPEN JOURNALS IN EDUCATION

Undergraduate International Student Enrollment Forecasting Model: An Application of Time Series Analysis

Yu April Chen[a], Ran Li[b] and Linda Serra Hagedorn[b]

Abstract: This study developed statistical models to forecast international undergraduate student enrollment at a Midwest university. The authors constructed a Seasonal Autoregressive Integrated Moving Average model with input variables to estimate future enrollment. This model reflected enrollment patterns by semester through highlighting seasonality. Further, authors added input variables such as visa policy changes, the rapid increase of Chinese undergraduate enrollment, and tuition rate into the model estimation. The visa policy change and the increase of Chinese undergraduate enrollment were significant predictors of international undergraduate enrollment. The effect of tuition rates was significant but minimal in magnitude. Findings of this study generate significant implications for policy, enrollment management, and student services for international students.

Keywords: enrollment forecasting, international students, SARIMA model, time series analysis, undergraduate international enrollment

Introduction

Over the past decades, a number of external changes have influenced the finance operations of U.S. higher education institutions. Since the latest economic recession, college/university revenues have become more reliant on income derived directly from students and their families and less on state government appropriations. Under the tuition-driven revenue model, the influence of student enrollment on budgeting and strategic planning has become crucial. Simply put, the ability to predict accurate student enrollment has become critical for institutional planning and operations.

From the academic years 2006–2007 to 2016–2017, international college student enrollment in the United States increased dramatically from 582,948 to 1,078,822. This represents 5.3% of the entire student body (Institute of International Education [IIE],

---

[a] Louisiana State University.

[b] Iowa State University.

2017a). International students bring many benefits to U.S. campuses, including diverse cultural perspectives and financial resources, especially important to public institutions as most international students will pay a higher non-resident tuition rate. Moreover, some universities have added an international fee on top of non-resident tuition making international students the premium group with respect to cost. Since institutional budgets may rely on this premium, it is crucial to accurately forecast international enrollment for strategic planning and other purposes.

Reasons for international enrollment changes may vary. Tuition rates, employment opportunities, the likelihood of obtaining a permanent residency, visa policy, and campus environment all affect international enrollment (Bass, 2006; Bohman, 2009; Mazzarol & Soutar, 2002; Pimpa, 2004; Shih, 2016). It is imperative to build a sound forecasting model that considers these influential factors.

There is scant research on enrollment forecasting of international undergraduates at the institutional level. This lack of research could be potentially problematic since accurate budgeting and strategic planning are affected by this enrollment. To fill this gap, this study develops a statistical model that can be used to better forecast international undergraduate student enrollment at the institutional level. Specifically, we utilize international enrollment data from Midwest University (pseudonym), a large, 4-year, research-intensive, land-grant public university located in middle America. Although the direct implication may only benefit this particular university, the approach of model building can provide other 4-year colleges and universities with an alternative solution to international enrollment forecasting other than intuitive estimates. Further, because many international graduate students may have assistantships that pay for their tuition and fees, the enrollment trend of international undergraduates may have a more significant influence on budgeting and institutional planning. Thus, we specifically focus on international undergraduate enrollment forecasting at Midwest University.

We utilize time series techniques (i.e., Seasonal Autoregressive Integrated Moving Average [SARIMA] model) to describe the international enrollment trend over time and construct a statistically sound forecasting model. We also incorporate influential factors such as tuition, local employment status, and visa policy changes that may affect international undergraduate enrollment in the forecasting model. The consideration of seasonality (i.e., enrollment data collected by semesters) and influential factors is generalizable to similar statistical approach in other colleges and universities. In sum, our research will highlight a statistically sound approach, namely, the time series analysis, to higher education administrators and practitioners who are interested in accurately predicting future international enrollment in their institutions. We answer the following research questions:

1. What is the enrollment trend for international undergraduate students at Midwest University?
2. What is the best forecasting model for predicting international undergraduate enrollment at Midwest University, considering the effect of seasonality and the impact of input variables such as tuition, local unemployment rate, visa policy changes, and other related events?

Literature Review

International Enrollment in the United States

The last decade has witnessed a rapid increase in the number of international students in American postsecondary institutions. While the overall national enrollment remained relatively stagnant between 2010 and 2016 (Hussar & Bailey, 2016), international enrollment consistently increased. Further, international undergraduate enrollment increased at a higher rate than international graduate enrollment in five of the six most recent academic years (IIE, 2017b). It is highly likely that undergraduate enrollment will continue to play a greater role in the overall international enrollment growth for the foreseeable future.

Cost–Benefit Analysis

International students have diverse reasons and motivations to study abroad. Some international students are highly motivated to obtain U.S. academic degrees/credentials, while others may just want to explore living abroad (Choudaha, Orosz, & Chang, 2012).

A cost–benefit analysis can help to better understand the decision to study abroad. The cost–benefit analysis can be defined as

> . . . a practical way of assessing the desirability of projects, where it is important to take a long-term view (in the sense of looking at repercussions in the distant future, as well as the near future) and a wide view (in the sense of allowing for side-effects of many kinds on many persons, industries, regions, etc.), i.e., it implies the enumeration and evaluation of all the relevant costs and benefits. (Prest & Turvey, 1965, p. 683)

In its classic application in higher education, researchers have argued that if the benefits of attending college are higher than the costs (including opportunity costs and explicit costs) of not attending college, a high school graduate might choose to enter a college rather than immediately enter the job market (Bennett, 1993). The similar analytical approach can be used to interpret international students' decision-making in regards to study in a U.S. college/university. For example, if the benefits of studying abroad are greater than the costs, an international student may choose to study abroad rather than study within the home country, or study in one foreign country over the other. Specifically, strong family financial support might encourage international students to choose study abroad because it will address or greatly help with the costs (Mazzarol & Soutar, 2002). On the other hand, tuition and living cost might serve as a pull factor that direct students to choose one destination country over another (Gomes & Murphy, 2003; Mazzarol & Soutar, 2002; Pimpa, 2004). Furthermore, when deciding which institution to attend, international students often consider financial aid opportunities and part-time working opportunities on campus (Bohman, 2009).

The discussion of costs and benefits regarding studying abroad can be further expanded beyond economic/financial factors. For example, limited access to higher education in the

home country and the high reputation of higher education credentials in the host country (benefits) may motivate international students to study abroad (Bohman, 2009; Gomes & Murphy, 2003; Pimpa, 2004). Specific to study in the United States, an IIE report indicated that 77% of prospective students believed that the United States has a high quality higher education system, and 78% believed that the United States has a wide range of institutions and programs to fit their individual needs (IIE, 2015).

Visa Policy

An overarching reason international students study in the United States is to expand career and life opportunities (Borjas, 2002; Chang, Schulman, & Lu, 2014). The visa policy in the United States serves as a critical gatekeeper for international students to obtain such opportunities. It is important to note that post-9/11policies emphasized the screening of student visa applicants (Alberts, 2007; Urias & Yeakey, 2009; Walfish, 2002), leading to longer waiting times to acquire student visas. As a result, acquiring a student visa has become a serious concern for many prospective international students worldwide (IIE, 2015).

Further, in 2017 President Trump established a travel ban affecting students from Iraq, Syria, Iran, Libya, Somalia, Sudan, and Yemen. Since Iran is the 11th leading country sending international students, this ban had a significant effect on the number of students coming to the United States. Therefore, the travel ban threatened and reduced the diversity of the international student pool. As a result, the number of new international enrollment decreased by 3.3% in the 2016–2017 academic year (IIE, 2017a) due to visa denials, a more complex visa application process, and fears and uncertainties due to the unpredictable political environment under the Trump administration (Redden, 2017).

In addition, legislators tightly controlled and restricted high-skill immigrant labor through changes in the H-1B visa program for international employment. For example, a year cap was placed on H-1B working visa applicants based on their origin countries. In October 2003, the H-1B visa cap significantly reduced the number of visas from 195,000 to 65,000 overall (U.S. State Department, n.d.). Economic studies revealed that this dramatic drop significantly impacted the quantity (lowered international enrollment by 10%) as well as the quality of international enrollment in the subsequent years (Kato & Sparber, 2013; Shih, 2016). Moreover, Shih (2016) concluded that H-1B visa issuances have a strong positive association with international enrollment even after controlling for other economic indicators such as home country gross domestic product, exchange rates, trade linkage between countries, workforce demand, and demographics.

In sum, previous studies have reported findings concerning international enrollment in the United States. While some studies have revealed critical predictors of international enrollment changes, others indicated factors that influence international students' decision-making at the individual level. Although little research has focused on forecasting international enrollment, previous studies indicated potential predictors (i.e., tuition cost, living cost, visa policy changes, local workforce indicators, etc.) that should be considered in a forecasting model. More methodological knowledge about constructing such a forecasting model is summarized in the following section.

Student Enrollment Forecasting Using a Time Series Approach

Time Series Approach

Student enrollment is a key factor influencing budget allocation, program planning, and appropriations from state legislatures. For planning purposes, institutional administrators must project enrollments for the upcoming academic year as well as extended time periods (e.g., 10 years). Despite its importance, an accurate enrollment forecast is difficult due to (a) unexpected turning points in enrollment patterns, (b) uncertainty of appropriate forecasting methods, and (c) difficulty of identifying and measuring factors influencing student enrollment (Chen, 2008). A number of techniques have been used for enrollment forecasting, including subjective judgments, the ratio method, results from a cohort survival study, simulation methods, time series analysis, and regression analysis (Chen, 2008; Layzell, 1997). Time series analysis is often considered to be robust and superior to other methods when its assumptions are met and when sufficient data points are available (National Center for Educational Statistics, 2013).

As a sequential and ordered collection of observations through equally spaced time intervals, a time series can be used to forecast future values (Wei, 1994). The nature of time series is based on a fundamental assumption that the data points close to each other in a time series are correlated. In other words, the predicted future values depend on the currently available data values while the present values depend on the values in the past (Vandaele, 1983; Wei, 1994).

The SARIMA Model

There are several time series techniques which can be applied to generate a mathematical model that approximates a historical pattern and forecasts the future values of a time series. The Box-Jenkins or Autoregressive Integrated Moving Average (ARIMA) method (Box & Jenkins, 1970) is one of the major forecasting techniques used. A typical ARIMA model involves both autoregressive (AR) and moving average (MA) processes. The autoregressive process is a stochastic process in which future values are calculated based on a weighted sum of past values. For example, AR (1) is the first order process, in which the current value is based on the immediately preceding value. A moving average is a calculation of analyzing data points by creating a series of averages of different subsets of the data. A moving average term often helps time series analysis to smooth out short-term fluctuations.

One disadvantage of applying the ARIMA model in enrollment forecasting is that it requires a minimum of 40–50 longitudinal observations to extract a good prediction (Chen, 2008). Institutions may have difficulty tracking data back for 40 or 50 years for international enrollment. Moreover, due to the significant shifting of international relations through the decades, going back 50 years may not provide a predictable pattern for international student enrollments. One solution to this problem is to introduce seasonality to the ARIMA model.

Seasonality occurs when a time series has a repeating pattern corresponding to regular seasonal periods. In order to take the influence of seasonality into account, Box and Jenkins (1970) extended the stochastic ARIMA models to Seasonal ARIMA (SARIMA)

models. Very few previous studies in education have utilized the SARIMA technique. One exception is Koopmans' (2011) attempt of using a SARIMA model to analyze daily attendance patterns in two urban high schools over a 1-year period. In this study, the SARIMA model allows the prediction of enrollment by academic semesters (Koopmans, 2011). Tracking by semesters may not only present a more feasible model but is also more in line with the data archived by institutions specifically pertaining to international students. In other words, by using the semester measures, we may be able to establish a forecasting model with 15 or 20 years of international enrollment data.

Determining Input Variables

Multiple external factors may influence student enrollment trends in higher education. For international enrollment, in particular, such external influences may be from visa policy changes, local labor market indicators, tuition rates, and other related national events (Bohman, 2009; Mazzarol & Soutar, 2002; Pimpa, 2004; Shin, 2016). The accuracy of forecasting enrollment may largely depend on selecting appropriate variables to represent the influences (or input) from external factors (Chen, 2008). Transfer function modeling techniques can be used to specify forecasting models that contain input variables. Transfer modeling is often used to capture external events such as strikes, sales promotions, and public policy changes (Wei, 1994). The technique has been successfully used to study the impact of air pollution control and economic policies (Box & Tiao, 1975; Wei, 1994). In the current study, we use transfer function modeling to study the influences from various input series. For example, visa policy changes, tuition rates, local unemployment rates, and national events related to international enrollment may be considered as input variables in our SARIMA model.

Human Capital Theory as a Theoretical Framework

The human capital framework has its roots in the works of Becker (1975). Human capital theory and its application have been closely related to the cost–benefit analysis framework. Becker (1975) viewed workers' skills and knowledge as a certain stock of productive capital. This type of capital was derived from schooling and training and would bring economic returns in the form of earnings. Thus, for obtaining more economic capital in the labor market, one must invest in education and training to increase human capital (Becker, 1975; Catsiapis, 1987).

Studying in the United States can be a huge investment in human capital for international students and their families. The decision of making this investment might be strongly influenced by the perceived labor market returns such as earnings with a U.S. degree versus a domestic degree and working opportunities in the U.S. job market. It might also be influenced by the explicit costs associated with studying in a U.S. college/university, or in particular, the tuition and living costs when studying in the United States. For higher education institutions that actively recruit international students, the perceived benefits and explicit costs are likely two highly important indicators to predict international enrollment. The opportunity costs (i.e., the foregone opportunities

and benefits of enrolling in a domestic college/university) are related to the individual countries' higher education systems and hence difficult to control.

Research Method

Data Source

We obtained data for the total full-time equivalent (FTE) enrollment of international undergraduates at Midwest University from fall semester of 1999 to spring semester of 2014 from the Office of the Registrar at Midwest University. The FTE enrollment was calculated on the 10th day of the fall and spring semesters (i.e., early September and late January) and the 10th day of the second summer session (i.e., late June) of the college schedule. The timing of FTE calculation considered the add/drop deadline schedules (census dates) that are 1 week after the first day of class for all semesters. The FTE enrollment calculation was conducted in a way to avoid errors caused by add/drop activities (i.e., 10th day of fall and spring semesters) and to include accurate enrollment in summer sessions (i.e., 10th day of the second summer session).

Midwest University is a large, research-intensive, public land-grant institution with an FTE enrollment in the fall of 2012 of over 30,000. The FTE enrollment has steadily increased each year since Fall 2012 (e.g., the FTE enrollment was 34,573 in Fall 2017). According to the enrollment data in Fall 2017, the undergraduate student body at Midwest University consisted of 42.5% female and 13.7% racial/ethnicity minorities (Midwest University, 2017).

For our analyses, we examined only the international undergraduate enrollment data at Midwest University. We included all undergraduate international students with either an F1 or a J1 visa at the time of data collection. Midwest University enrolled a total of 2,204 international undergraduate students in Fall 2014, comprising over half of the entire (graduate and undergraduate) international enrollment and 6% of total enrollment (Midwest University, 2017). This number included both new and returning students. Compared with 1,051 international undergraduate students in Fall 1999, the international undergraduate enrollment increased more than 110% during the period of Fall 1999 to Fall 2014.

Overall, 68 data points over time were included for describing and forecasting international undergraduate enrollment. This is a sufficient sample size to construct a reliable ARIMA/SARIMA model (Chen, 2008). In addition to the international undergraduate enrollment data, we also obtained the international tuition rate at Midwest University. Further, we gathered local unemployment rate data from state government reports. Finally, the trend of Chinese undergraduate enrollment data was acquired from Open Doors data of the Institute of International Education. China was recognized as the number one origin country of international undergraduates for the seventh consecutive year (IIE, 2017a).

Input Variables Used in This Study

Our choice of potential input variables was based on the theoretical framework and previous literature. We considered two input variables that describe the impact of visa

policy changes. One variable was added to reflect the post-9/11 policy in student visa (F1 and J1 visa) applications. Another variable was added to reflect the significant drop in working visa (H-1B visa) approvals since 2003. These two variables were dummy coded. For example, the values of the post-9/11 policy variable were coded as "0" from Fall 1999 and changed to "1" since Fall 2012. Similarly, the values of H-1B variable were coded as "0" from Fall 1999 and changed to "1" beginning Fall 2003. The critical role of student visa (F1 and J1 visas) policies is obvious. Successfully obtaining a student visa is associated with the economic costs (e.g., application fees, travel fees, etc.) and directly influences students' decision of enrollment (i.e., failed to obtain a student visa on-time will cause an international student not be able to enroll). The working visa (H-1B visa) policy also had a significant influence on international enrollment since it is an indicator of job opportunities and post-graduate training opportunities in the U.S. It also may lead to obtaining a permanent residency for foreign workers (green card).

Further, we added an input variable that reflects the rapid increase of Chinese undergraduate enrollment. According to IIE, Chinese undergraduate students increased 8.2% in 2006–2007, and continued growing rapidly over the next 10 years. Particularly during the years of 2007–2008 and 2012–2013, Chinese students increased more than 20% every academic year while the number of international students from India (the second leading place of origins) was stagnant or declining. The Chinese enrollment increase was the primary drive on overall international enrollment during those academic years. As a result of the constant rapid increase, China has been the number one origin country for international undergraduate students since 2009–2010 (IIE, 2017a). In 2016, Chinese students made up more than 30% of the entire international enrollment (or, 328,547 students) in U.S. higher education institutions. While the Chinese enrollment at Midwest University reflected this national trend. We were not able to obtain nationality breakdowns of international enrollment by semester. Therefore, we decided to create a dichotomous variable to reflect the rapid increase of Chinese enrollment and its continuous impact on international enrollment at Midwest. In particular, the values of Chinese enrollment variable was coded as "0" from Fall 1999 and changed to "1" since Fall 2007.

In addition, we added several input variables that reflect local impact. First, we included international tuition rates between Fall 1999 and Spring 2014 at Midwest University. The international tuition rate increased 105.4% during the period (from $4,674 in Fall 1999 to $9,767 in Fall 2014). While the full-time enrollment tuition rates for fall and spring semesters are reported clearly, we had to manually calculate full-time enrollment tuition rates for summer semesters. A summer-session student has to register for six credit hours courses to be counted as full time. Therefore, tuition charges for six credit hours were calculated as the full-time enrollment tuition rates for summer semesters between Fall 1999 and Spring 2014. Second, we reflect the local employment environment by adding information about the unemployment rate between 1999 and 2014. We calculated the unemployment rate by semester through averaging the monthly unemployment rate during fall, spring and summer semesters as reported in the State Workforce Development Annual Report.

Data Analysis

Our data analysis involved three phases. In Phase 1, we described the trend of international undergraduate enrollment at Midwest University from Fall 1999 to Spring 2014. We conducted this procedure by plotting the data points. The plot served as a base for identifying the initial SARIMA model in phase two.

In Phase 2, we constructed a SARIMA model for forecasting international undergraduate enrollment in the future. A SARIMA model is denoted as , where, *p* is the amount of autocorrelation (or an autoregressive term); *d* is the systematic change over time (or the trend); *q* is the moving average term of the time series data. Further, *P* indicates the seasonal autocorrelation (or a seasonal autoregressive term); *D* is the seasonal trend; *Q* is the seasonal moving average term; *s* is the seasonal period. Three steps were involved in the model identification process: tentative identification, estimation, and diagnostic checking (Meeker, 2001). Tentative identification includes investigating the characteristics of data, determining transformation, tentatively identifying models based on the sample autocorrelation function, the sample partial autocorrelation function, and the model fits. Once the tentative models had been identified, maximum likelihood estimation was used to estimate the parameters (e.g., *p*, *d*, *q*, *P*, *D*, *Q*, and *s*) of the tentatively identified models. Next, we conducted the diagnostic checking on residual statistics, Ljung-Box test (Ljung & Box, 1978), and others to determine model fit. When there were multiple models identified, diagnostic checking was used to identify the best model. In addition to the above diagnostic statistics, Akaike Information Criterion (AIC) was used to compare the model fits and inform the model selection.

The goal of Phase 3 was to improve the forecasting model developed in phase two by introducing input variables. We adopted transfer function modeling techniques to introduce potential input variables into the model. The criteria of model selection included (a) the significance of the input variable as a predictor of the enrollment; (b) the model fit changes (i.e., AIC, log-likelihood, etc.) due to added input variables; and (c) previous literature and theory support. The final forecasting model included the input variables that significantly impact international undergraduate enrollment. We also supported the inclusion of selected input variables through findings in previous studies. All analyses were conducted in the statistical program R.

Results

Describing the Trend

In the first phase of data analysis, we plotted international undergraduate enrollment from Fall 1999 to the Spring 2014 semesters (Figure 1). The international undergraduate enrollment shows a very strong seasonality. For each year, the highest FTE numbers were in the fall semester, while the lowest was in the summer semester. The spring semester typically had the second highest number and was very close to the fall FTE number. After a decrease from 2005–2006 to 2008–2009, the international undergraduate enrollment at Midwest University increased rapidly.

The SARIMA Forecasting Model

In Phase 2, we identified a forecasting model with seasonality. After comparing several competing models, we identified international undergraduate FTE enrollment model as the with log transformation (). Figure 2 displays the model output. In the Figure, the black dots after the 2014 spring semester represent forecasting of international undergraduate enrollment. The surrounding blue lines provide the 95% prediction intervals.

In this SARIMA forecasting model, we have a regular moving average term and a seasonal moving average term with the first order of seasonal differencing (). This means that the international undergraduate enrollment at Midwest University is influenced and forecasted by (a) the moving average of previous semesters, and (b) the moving average of the enrollment in similar semesters in previous years.
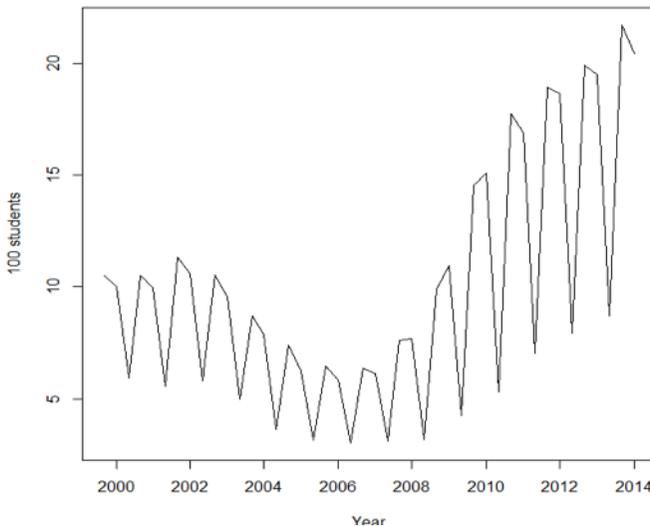
Figure 1. The trend of international FTE student enrollment at Midwest University (1998–1999 to 2013–2014).

The Final Forecasting Model with Input Variables

Based on the SARIMA forecasting model identified in Phase 2, we further added potential input variables to improve the model. The potential input variables that involved in this process were (a) a dummy-coded variable representing the one-time impact of post-9/11 student visa policy change since Fall 2002; (b) a dummy-coded variable representing the rapid decrease of H-1B working visas and its continued influence since fall 2003; (c) a dummy-coded variable representing the rapid increase of Chinese undergraduate enrollment nationwide since Fall 2007; (d) a longitudinal numeric variable representing the tuition rates by semester; and (e) a longitudinal numeric variable representing the state's unemployment rates. We constructed a full model with all input variables included
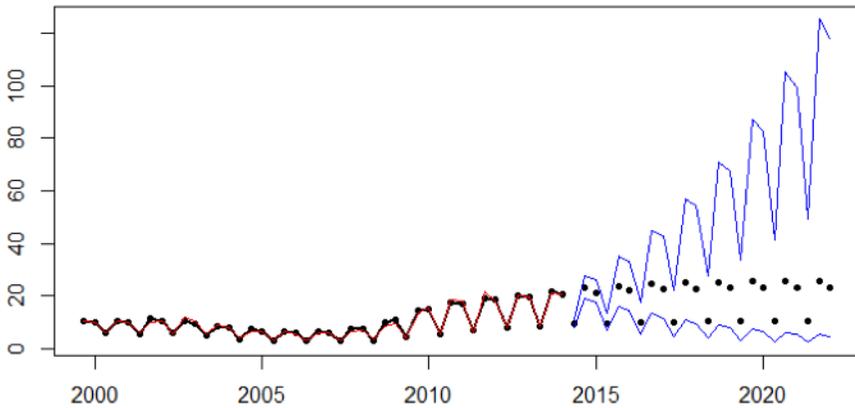
Figure 2. The SARIMA forecasting model.

Note. The black dots indicate observed data points between Fall 1999 and Spring 2014 (connected by red lines) and forecasted data points after the Spring 2014 academic year (connected by blue lines). Blue lines also demonstrate prediction intervals.

as well as several forecasting models with some of the input variables included. Among these competing models, we identified the final model which included the input variables (a) tuition rate by semester, (b) H-1B policy impact since Fall 2003, and (c) the rapid increase of Chinese undergraduate enrollment nationwide since Fall 2007. Table 1 displays the model summary, parameter estimates, and model fit for three models: a baseline SARIMA model without input variables (Model 1), the final model with three selected input variables (Model 2), and a competing model with all input variables included (Model 3).

A linear regression analysis was conducted in order to identify the input variables that significantly influence international undergraduate enrollment. All five potential input variables were used as independent variables. According to the results, post-9/11 student visa policy changes and state unemployment were not significant in predicting international undergraduate enrollment at Midwest University. Table 2 illustrates the summary of the regression analysis with three selected input variables. The results indicated that tuition rate, the decrease of H-1B issuance and rapid increase of Chinese undergraduate students were significant predictors of international undergraduate enrollment. However, it should be noted that the magnitude of the influences from the tuition rate is minimal.

Figure 3 illustrates the final forecasting model with three selected input variables (i.e., tuition rate, H-1B visa policy, Chinese student enrollment increase). This model had a better model fit compared with the forecasting model without any input variables (Model 1 in Table 1). The model-fit comparison was based on examining the magnitude of the AIC and the −2 log likelihood. Smaller numbers of these two model-fit indicators demonstrate a better model fit. Furthermore, the model diagnostic tests confirmed the goodness of fit for the final model (Figures 4 and 5). The plot of residuals versus fitted value supported the

Table 1. Model summary.

	Model 1	Model 2	Model 3
SARIMA(p, d, q)(P, D, Q)$_3$	(1, 0, 1) (1, 1 , 0)$_3$	(1, 0, 1) (1, 1, 0)$_3$	(1, 0, 1) (1, 1, 0)$_3$
γ transformation	0	0	0
D (differences)	1	1	1
Numbers of intervention term	0	3	5
φ_1	0.879***	0.876***	0.889***
(SE)	(0.007)	(0.088)	(0.086)
θ_1	0.307*	0.285*	0.368*
(SE)	(−0.006)	(0.167)	(0.169)
Φ_1	0.286*	0.359*	0.391*
(SE)	(−0.005)	(0.172)	(0.176)
β_1 (tuition)		−0.0001	−0.0001
(SE)		(0.0002)	(0.0002)
β_2 (H1B Visa)		0.041	−0.002
(SE)		(0.054)	(0.052)
β_3 (Chinese enrollment)		−0.033	0.004
(SE)		(0.050)	(0.048)
β_4 (9/11)			−0.047
(SE)			(0.042)
(Unemployment rate)			0.050*
(SE)			(0.022)
SBC	0.083	0.083	0.077
AIC$_c$	−78.378	−68.288	−69.85
-2log(likelihood)	−86.378	−82.288	−87.85

Note. Model 1 = no input variables; Model 2 = three input variables; Model 3 = all input variables; *SE* = Standard Error; *SBC* = Schwartz Bayesian Criterion; *AIC* = Akaike Information Criterion.
* p <.05, *** p < .001.

Table 2. Summary of regression analysis.

Variable		SE	t	p	R^2
Model					0.738
Constant	−6.796	2.123	−3.201	.003**	
Tuition	0.003	<0.001	7.810	<.001***	
H1B	−8.429	1.324	−6.366	<.001***	
Chinese	3.284	1.227	2.676	.011**	

*Note.*** < .05; *** < .001

assumption of linearity with a few outliers and suggested the variances of the error terms are roughly equal. The normal Q-Q plot showed the points forming a roughly straight line indicating normality of the data distribution.
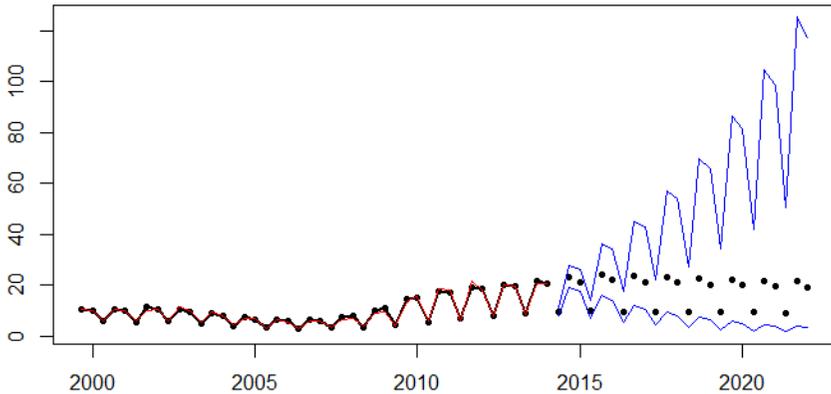
Figure 3. The SARIMA forecasting model with three input variables.

Note. The black dots indicate observed data points between Fall 1999 and Spring 2014 (connected by red lines) and forecasted data points after the Spring 2014 academic year (connected by blue lines). Blue lines also demonstrate prediction intervals.

Lastly, we compared our prediction numbers with recently updated international enrollment statistics at Midwest University. Figure 6 added three actual enrollment numbers of Fall 2014, Fall 2015, and Fall 2016. Specifically, our prediction of this three time points was 2,309 in Fall 2014, 2,409 in Fall 2015, and 2,347 in Fall 2016. The actual enrollment was 2,202 in fFall 2014, 2,138 in Fall 2015, and 2,204 in Fall 2016. All data points were within the prediction interval.

Discussion

This study established an enrollment-forecasting model for international undergraduate enrollment at Midwest University. We adopted time series techniques and considered the impacts of seasonality as well as critical input variables. To reflect the seasonality, we collected international undergraduate enrollment data by semester. The seasonal pattern of enrollment (fall semester has the most enrollment and summer semester has the least enrollment) was well captured by the SARIMA model (Figure 2). Technically, adding the seasonality also solved the issue of lacking data points. It is very common that higher education institutions would not have sufficient records of international undergraduate enrollment to establish a high-quality time series model. Instead of tracking back 40–50 years of international enrollment data, introducing seasonality into the model allows institutional researchers to conduct a robust time series analysis by analyzing 15–20 years of the enrollment data.
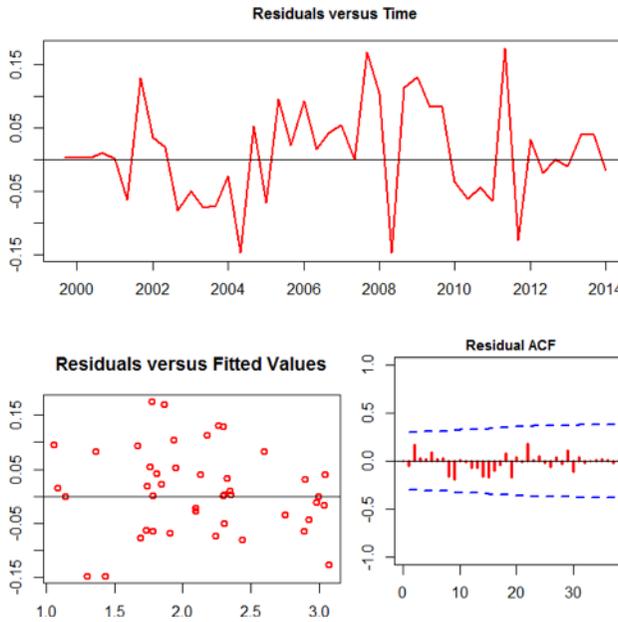
Figure 4. Diagnostic tests of the finalmodel.
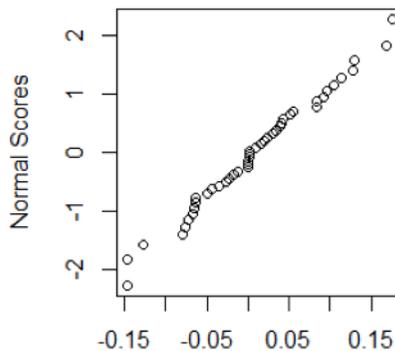
Figure 5. Normality of the final model (normal QQ plot).

In addition, the final forecasting model includes several critical predictors (or input variables) of international undergraduate enrollment. First, two input variables represented visa policy changes that were critical to international students' decision-making regarding studying abroad. For example, a dramatic drop in H-1B issuance and its subsequent influences significantly predicted the international undergraduate enrollment. This finding was consistent with previous economic studies (Kato & Sparber, 2013; Shih, 2016). It also confirmed that enhancing career and life opportunities is an important reason for studying abroad (Borjas, 2002; Chang et al., 2014). Many
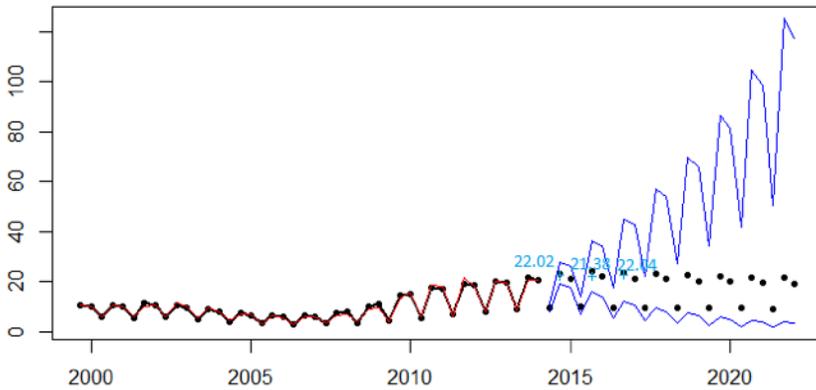
Figure 6. Comparing the prediction and actual enrollment.

Note. The black dots indicate observed data points between Fall 1999 and Spring 2014 (connected by red lines) and forecasted data points after the Spring 2014 academic year (connected by blue lines). Blue crosses indicate the actual enrollment data from Fall 2014 to Fall 2016. Blue lines demonstrate prediction intervals.

international students come to the United States because they would like to explore career opportunities in the U.S. workforce in addition to receiving a high-quality higher education credential. It should be noted that international students do not receive an H-1B visa (or a working permit) unconditionally. In fact, most must graduate with a valid postsecondary degree and be sponsored by a U.S. employer before applying for an H-1B visa. Moreover, the number of H-1B visas are capped by country. A prospective international student may hear stories from previous international students about the waiting time and complexity of acquiring a working visa related to his/her country. This is a clear indicator of the difficulty to work legally and eventually obtain a permanent residency in the United States. Therefore, for those who value working opportunities, postgraduate training, and potential immigration opportunities, changes of the U.S. working visa policy may alter international students' decision of study abroad destination.

Furthermore, it was unexpected that the post-9/11 student visa policy would not be a significant predictor. This finding might be contradictory to previous studies that highlighted the impact of delaying student visa application after 9/11 (Alberts, 2007; Urias & Yeakey, 2009; Walfish, 2002). One explanation may be that the impact of student visa policy changes was only valid for a few years immediately after 9/11. Subsequently, there remained only a limited influence on international enrollment. However, it should be noted that post-9/11 student visa policy remained stringent to international students majoring in certain Science, Technology, Engineering, and Math (STEM) fields. For those STEM majors, post-9/11 student visa policy may continue to play a significant role in predicting future international enrollment.

Second, we initially included two economic indicators—tuition, and local unemployment rates—that reflect the costs and benefits of studying in the United States. These

indicators were found significant in predicting domestic student enrollment (Chen, 2008). However, the local unemployment rate was not a significant predictor, and the tuition rates only had a minimal impact on international undergraduate enrollment. In the final model, we decided to retain tuition rate but eliminate local unemployment rate. Besides the consideration of statistical significance in the regression analysis, we also recognize that international students may be less bounded to a certain location in the United States when entering the job market. For example, states such as California, New York, and Texas are perceived to have more job opportunities and a better working environment for international workers (Jagwani, 2014). These states may attract international students from other states. As such, international students may be less sensitive to the local economic indicators; rather, their decision-making of attending a particular college/university in the United States may be dependent on economic indicators within a specific major. On the other hand, we believe that tuition rate plays a significant role in international students' decision-making (Bohman, 2009; Mazzarol & Soutar, 2002). The small magnitude of influence might be due to the data availability of this study. In particular, we had to calculate tuition data by semester in order to reasonably add it into our seasonal forecasting model. We had limited flexibility of reflecting the diversity of the summer tuition across majors and years. We highly recommend future research to continue analyzing the effects of tuition changes and explore alternative solutions in terms of tuition calculation.

Third, the rapid rise of Chinese undergraduate enrollment had a critical influence on the international undergraduate enrollment at Midwest University. China has been the top origin country for international undergraduates since 2009/10 (IIE, 2017b). There is no doubt that this national trend played a significant role at Midwest University. This finding called the attention to institutional agents, especially to those who work directly with international students, in terms of understanding the characteristics and needs of Chinese undergraduates to better serve them.

Limitations

There are several limitations worthy of mention. First, this study focused on predicting international undergraduate enrollment at Midwest University. Results of this study may only be helpful to those institutions that share similarities with Midwest University (i.e., large, 4-year, research-intensive, land-grant public university with predominantly White students). Nevertheless, we believe the process of identifying the best forecasting model can serve as a guide to all higher education institutions for building their own forecasting model.

Further, several input variables were not originally in a seasonal format (i.e., by semester). As a result, we had to change the format of variables through additional calculation and recoding as well as using alternative variables. For example, it would be ideal if we could have had seasonal enrollment statistics (or, enrollment data by semester) of Chinese undergraduates. However, nationality breakdowns of international enrollment were only available for the academic year at Midwest University. Thus, we had to dummy code this variable to reflect the effect of the rapid increase of Chinese undergraduates since Fall 2007. We believe that the model fit might be further improved if Chinese undergraduate enrollment by semester could be obtained. The same rationale also applied

to the variable representing H-1B policy changes. It was impossible to add H-1B influences by semester since the issuance of H-1B visas were calculated on a yearly basis. Thus, we added a dummy-coded variable that described the impact of the rapid decrease of H-1B issuance since 2003. In addition, the model cannot predict political upheaval, changes in government policy, natural or unnatural disaster, or terrorism that will likely affect visa policy.

Finally, we were not able to include some potential confounding variables in the statistical analysis. For example, it would have been ideal if we could have distinguished international transfer students from first-time international freshmen. Possibly, previous experiences in a U.S. higher education institution can influence international students' decision-making regarding transfer into another university/college. Similarly, it was uncertain if the international admission policy at Midwest University has changed during the period of Fall 1999 to Spring 2014.

Implications

Implications for Policy and Practice

Findings of this study indicate policy implications for student visas, working visa/permits, and immigration processes. This study inferred that the negative impact of post-9/11 student visa policy on overall international undergraduate enrollment is fading. However, the uncertainty of H-1B visa policy changes may continue to impact international enrollment. International students might be future high-skill immigrants. Previous studies showed that the odds of international students receiving a green card were 6 times larger than those receiving a green card through a lottery system (Borjas, 2002). The current H-1B process may contribute to an image of the United States as a less than a welcoming working place for potential immigrants with postsecondary degrees. At the same time, the home countries of these potential immigrants, such as China, India, and South Korea (the top three countries of origins among international students), have been developing, expanding, and improving their own higher education and workforce. It is in the national interest to attract and retain young international talents, especially those within STEM fields, to study and work in the United States in order to sustain a leadership role in the competitive global economy. One starting point of the policy reform might be extending student and working visas as well as expediting residence application processes for temporary international workers with STEM degrees.

Further, this study focused on international undergraduate enrollment at the institutional level. This can help a higher education institution to plan financially and strategically in order to accommodate the growth of international undergraduate enrollment. Specifically, leaders and practitioners in enrollment and international student offices may apply our model to forecast future international enrollment in subsequent semesters. Although this study was restricted to one 4-year, research-intensive university located in the Midwest, higher education institutions across the nation may find our procedures useful in building their own forecasting model.

Lastly, higher education leaders and practitioners should be aware of the limitations of our forecasting model. In particular, our model might not be able to capture certain

policy changes such as the travel ban in 2017. Thus, leaders and practitioners should consider additional strategies (e.g., conduct environment scanning on a regular basis) for anticipating unexpected changes.

Implications for Future Research

This study is the first exploratory step of forecasting international undergraduate student enrollment. We were limited by the availability of the data as well as other restrictions (see discussion in the limitation section). However, the limitations indicate directions for future studies. For example, we recommend future research to add more input variables to the forecasting model. Potential input variables may include local living cost, local/campus safety indicators, international diversity of the campus, etc. Also, we encourage future studies to consider the impact of origin countries. To be specific, it will be beneficial to build and test a forecasting model for international students from a certain foreign country. In such models, we can consider the impacts of additional input variables such as home country higher education accessibility, currency exchange rates between the United States and the home country, home country job market indicators, etc. Besides origin countries, international students' enrollment patterns can differ based on whether they are first-time freshmen or transfer students. We encourage future studies to distinguish these two groups and develop specific enrollment models for them respectively.

In addition, it will be beneficial to consider the impact of institutional characteristics (e.g., location, public/private, selectivity/reputation, featured program/majors, etc.). Such an approach may involve data collection from multiple institutions. Some potential research questions might include the following: Does the prediction model vary for public and private institutions? Rural institutions versus urban and suburban institutions? Does international enrollment grow faster at historically high international-enrollment institutions? Does the level of selectivity and reputation significantly impact international enrollment?

Finally, the utilization of the time series analysis offered an alternative way to forecast the enrollment trends for other student groups. For instance, future research on enrollment trend by student's major, demographics, and other factors (e.g., in-state/out-state, transfer students from community colleges, etc.) may be warranted.

References

Alberts, H. C. (2007). Beyond the headlines: Changing patterns. in international student enrollment in the United State. GeoJournal, 68(2–3.

Bass, M. (2006). Student of migration: Indian overseas students and the question of permanent residency. *People and Place*, *14*(1), 8–23.

Becker, G. S. (1975). *Human capital: A theoretical and empirical analysis, with special reference to education.* National Bureau of Economic Research, New York, NY.

Bennett, B. (1993). The demand of the higher education: A cost/benefit analysis of the human capital theory. Honors Projects.

Bohman, E. (2009). Headed for heartland: Decision-making process of community college bound international students. *Community College Journal of Research and Practice, 34,* 64–77.

Borjas, G. J. (2002). An evaluation of the foreign student program.

Box, G. E. P. & Jenkins, G. M. (1970). *Time series analysis: Forecasting and control.* Francisco: Holden-Day, San.

Box, G. E. P. & Tiao, G. C. (1975). Intervention analysis with applications to economic and environmental problems. *Journal of American Statistics Association, 70,* 70–79.

Catsiapis, G. (1987). A model of educational investment decisions. *Review of Economic and Statistics, 69*(10), 33–41.

Chang, L., Schulman, P., & Lu, Z. (2014). Bridging the digital divide: Segmenting and recruiting international millennial students. *WES Research & Advisory Services Research.*

Chen, C. (2008). An integrated enrollment forecast model. *IR Applications, 15.*

Choudaha, R., Orosz, K., & Chang, L. (2012). the same: Understanding segments, mapping behavior. *WES Research & Advisory Services Research.*

Department, U. S. S. (0). Immigrant visa statistics.

Gomes, L. & Murphy, J. (2003). An exploratory study of marketing international education online. *The International Journal of Educational Management, 17*(3), 116–125.

Hussar, W. J. & Bailey, T. M. (2016). *Projections of education statistics to 2024.* U.S. Government Printing Office, Washington, DC.

Jagwani, V. (2014). Four ways international students can explore job opportunities.

Kato, T. & Sparber, C. (2013). Quotas and quality: The effect of H-1B visa restrictions on the pool of prospective undergraduate students from abroad. *The Review of Economics and Statistics, 95*(1), 109–126.

Koopmans, M. (2011). *Time series in education: The analysis of daily attendance in two high schools.* New Orleans, LA.

Layzell, D. T. (1997). The future is now: Limitations of the Crystal Ball and other lessons learned. New Directions for Institutional. *Research, 93,* 95–99.

Ljung, G. M. & Box, G. E. P. (1978). On a measure of a lack of fit in time series models. *Biometrika, 65,* 297–303.

Mazzarol, T. & Soutar, G. (2002). "Push-pull" factors influencing international student destination choice. *The International Journal of Educational Management, 16*(2), 82–90.

Meeker, W. Q. (2001). Graphical tools for exploring and analyzing data from ARIMA time series models.

Pimpa, N. (2004). The relationships between Thai students' choices of international education and their families. *International Education Journal, 5*(3), 352–359.

Prest, A. & Turvey, R. (1965). Cost-benefit analysis: A survey. *The Economic Journal, 75*(300), 683–735.

Redden, E. (2017). New international enrollments decline. Inside Higher.

Shih, K. (2016). Labor market openness, H-1B visa policy, and the scale of international student enrollment in the United States. *Economic Inquiry, 54*(1), 121–138.

University, M. (2017). Fall semester 2017 enrollment undergraduates.

Urias, D. & Yeakey, C. C. (2009). Analysis of the U.S. student visa system misperceptions, barriers, and consequences. *Journal of Studies in International Education*, *13*(1), 72–109.

Vandaele, W. (1983). *Applied time series and Box-Jenkins models*. Academic Press, New York, NY.

Walfish, D. (2002). Student visas and the illogic of the intent requirement. *Georgetown Immigration Law Journal, 17*, 473.

Wei, W. S. (1994). *Time series analysis.* City, Redwood.

Author biography

Yu April Chen is an Assistant Professor in the School of Education, College of Human Science and Education, Louisiana State University. Her major research interests include international students, community college student success, STEM pathways, and data-driven decision making.

Ran Li is a Postdoctoral Research Fellow in the School of Education, Iowa State University. His major research interests lie in the areas of international education, shadow education (private tutoring), and community colleges.

Linda Serra Hagedorn is Emeritus Professor of Higher Education in the School of Education at Iowa State University. She is a prominent researcher in international education as well as the area of community college success.