Proceedings of the International Conference on Social Psychology and Humanity Studies
DOI: 10.54254/2753-7048/9/20230289

Using Linear and ARIMA Model to Exanimate and Forecast the Grade Inflation Phenomenon in the University of Wisconsin-Madison

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Abstract: Nowadays, in US universities, "A" stands for "average", "B" stands for "below average", and "C" stands for "choose another major", but "B" used to be appreciated, and "A" used to be attainable only to those that are either hardworking or talented, or both. To investigate the ongoing increase of average GPA since decades ago of US universities, this paper utilizes linear and ARIMA model to forecast future average GPA of the University of Wisconsin-Madison. This paper then successfully examines the existence of grade inflation in the University of Wisconsin-Madison and concludes that at least in the near future of 5 years, the average GPA will continue to grow. After considering results of former researchers, this paper provides three possible solutions to mitigate grade inflation: an increase in exam difficulty, a revised SETs system, and a fixed distribution of grades. Hopefully this paper will contribute to stop grades from losing its value and university transforming from the place to learn to the place to get a degree.

Keywords: Wisconsin-Madison, grade inflation phenomenon, ARIMA

1. Introduction

In an era of intense competition in universities, students or professors may have notice a trend of increasing average grade. Researchers who studied this problem decided to call it "grade inflation", which precisely concludes this problem. Inflation causes money to lose values. Similarly, grade inflation causes high grades to lose value. With grade continues to inflate, top students lose their competition power in the labor market, since students all get a score around full, and other students are overestimating themselves with a misleadingly high score. Since when "A" stands for "Average", "B" stands for "Below Average", and "C" stands for "choose another major"? A "B" should be appreciated, and an "A" should be attainable only to those that are either hardworking or talented, or both. Many researchers have been studying this nationwide grade inflation problem, and provided helpful data.

A clear trend of increase can be seen. From year 1983 to year 2013, average GPA increased by about 0.3, which is significant. Although private schools present an overall much higher average GPA than public schools, public schools show a larger increase in average GPA over 30 years (Figure 1) [1].

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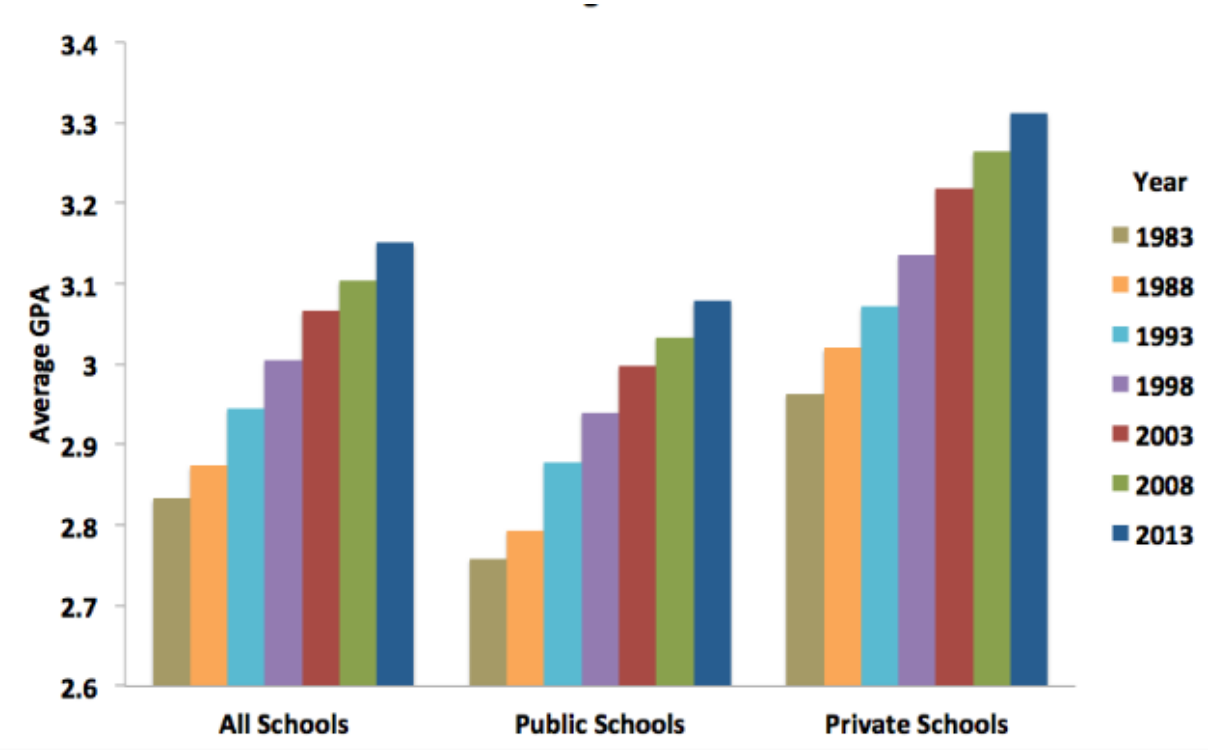

Figure 1: Recent trends of average GPA in four-year US colleges and universities.

The website "gradeinflation.com" provides several figures including Figure 1. They all serve well as proofs of the existence of grade inflation.

Tom Lindsay points out in his article that the percentage of students getting an A has tripled from 15% in 1960s to 45% in 2019. A is now the most common score in US Universities [2].

Elizabeth Redden gives a conclusion of research: "In looking at results on those tests, controlling for demographics and exam and course fixed effects, we find that entering school one year later corresponds to a large and statistically significant increase of 0.053 grade points," which is a horribly high increasing rate [3].

Moreover, Donald L. Caruth and Gail D. Caruth concluded that grade inflation isn't followed by an increase of student knowledge, proving grade inflation to be an abnormal phenomenon that needs to be corrected [4].

To study the abnormal increasing trend of average GPA, this paper will study a time series data of average GPA of University of Wisconsin-Madison from first semester 2014-2015 to first semester 2022-2023. This paper will first analysis the current data and eliminate the outliers caused by COVID-19, and use a linear model to estimate the outliers if COVID-19 didn't affect them, and exanimate the existence of grade inflation in the University of Wisconsin-Madison. With the new time series data without COVID-19 affection, this paper will use ARIMA model to forecast the future trend of grade inflation in the University of Wisconsin-Madison and analysis.

2. Methodology

2.1. Data Selection

This paper investigates base on a time series dataset extracted from "Grades and GPA reports" from the University of Wisconsin-Madison [5]. The "Grade and GPA reports" provides detailed grade data of different student groups [5]. However, this paper only focuses on the overall trending of grade

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inflation phenomenon in the University of Wisconsin-Madison, and will only utilize the average GPA for students each semester. The extracted time series data starts from first semester 2014-2015 and ends at first semester 2022-2023. 17 data points are included in this time series data. This set of data was chosen because of the popularity of University of Wisconsin-Madison, credibility of the "Grade and GPA reports" on the official website of University of Wisconsin-Madison, and the easiness of accessing the "Grade and GPA reports".

2.2. Description of Data

Before preforming the investigate, the hypothesis is that grade inflation exists, and future GPA will continue to grow. With R, a free software environment for statistical computing and graphics, a plot of the 17 data points in the time series is graphed.

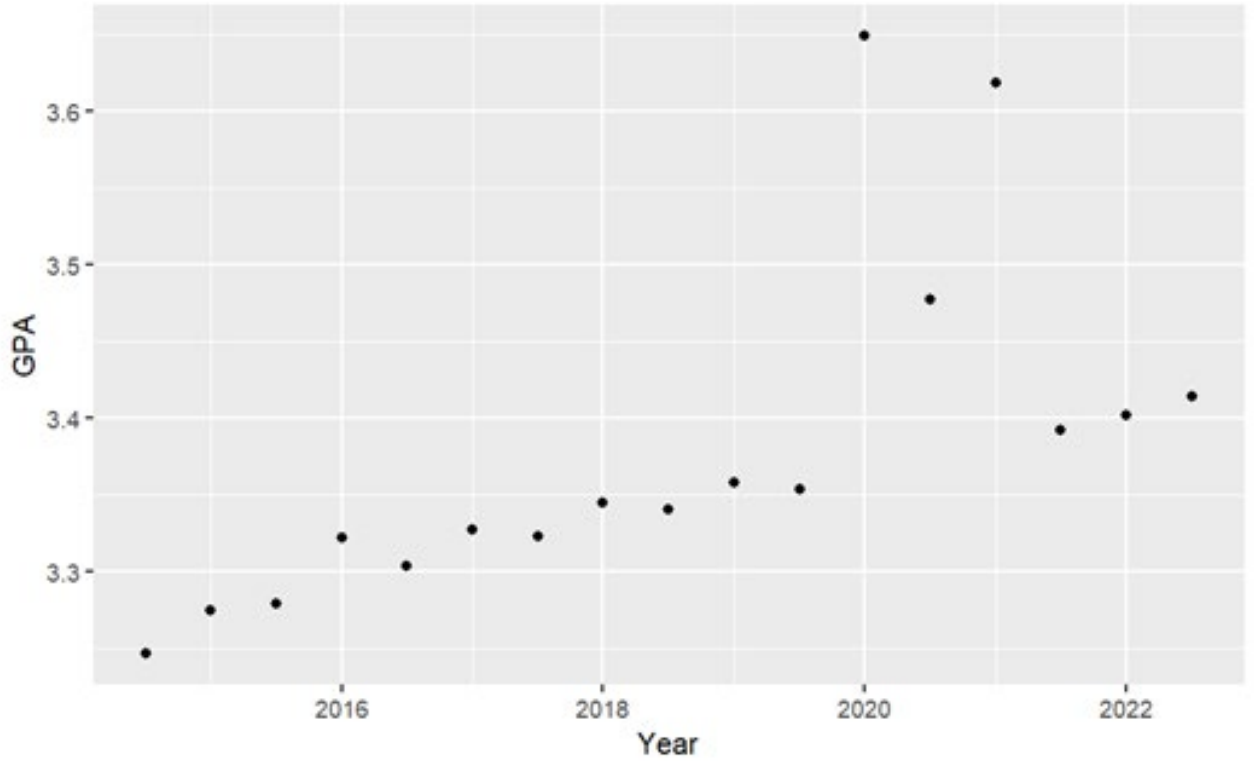

Figure 2: Average GPA and year dot plot.

On this plot, two semesters of a specific year are represented by one decimal point (in Figure 2). For instance, 2016 spring will be represented by 2016.0, and 2016 fall will be represented by 2016.5. As previously mentioned, this dataset starts from first semester 2014-2015 and ends at first semester 2022-2023. Therefore, on this plot, data points start at 2014.5, and end at 2022.5. With eyes alone, three outliers are quickly detected. From 2020 spring to 2021 spring, average GPA for students in the University of Wisconsin-Madison was abnormally high. There is a high probability that this was caused by COVID-19 and online courses. Leaving outliers aside, a clear linear pattern was noticed. GPA steadily increases each year. By applying linear model to this dataset, a regression line is drawn.

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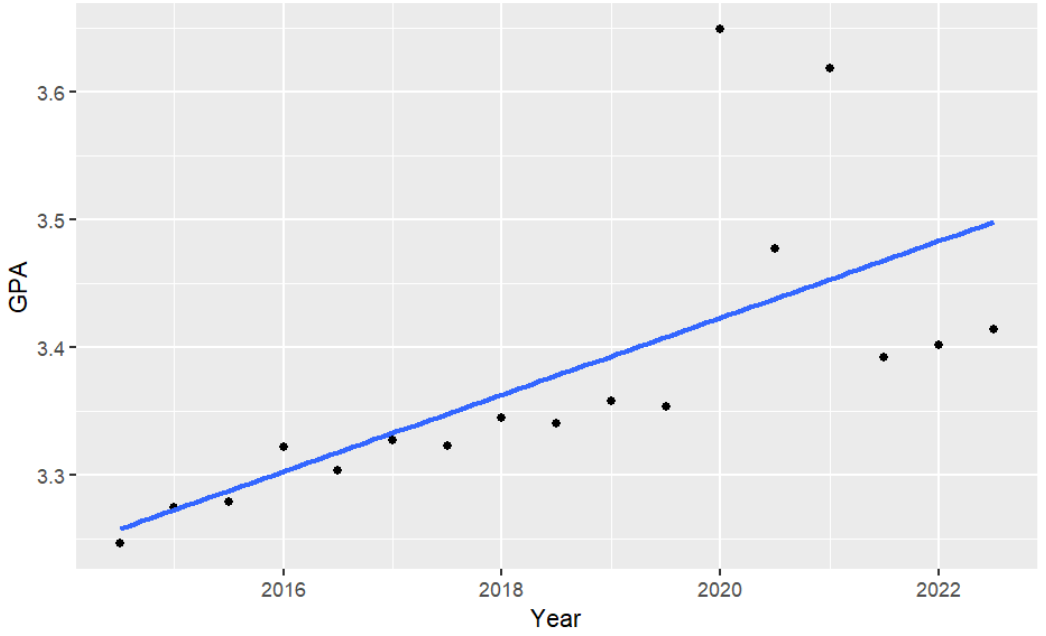

Figure 3: Average GPA and year dot plot with a regression line.

This regression line is pulled upwards by the three unnaturally high outliers, leading to a bad fit of the regression line, and most of the actual GPA are below the predicted GPA by the regression line (Figure 3).

Table 1: Four parameters of the linear model.

Parameters	Value given by R
Multiple R-squared:	0.4631
Adjusted R-squared:	0.4274
F-statistic:	12.94
p-value:	0.00264

This regression line has a multiple R-squared of 0.4631, and an adjusted R-squared of 0.4274, showing a relatively low level of correlation between actual GPA and GPA predicted by the regression line. A p-value of 0.00264 is low enough to reject the null hypothesis, which is there is no correlation between GPA and year (Table 1). Grade inflation in the University of Wisconsin-Madison is exanimated.

However, considering that the effect on GPA by COVID-19 reduces each year, and data points after 2021 spring semester are back to normal level, it is safe to assume that future GPA will also be not affected by COVID-19. Therefore, this paper will perform another linear model on a dataset that eliminates the three outliers.

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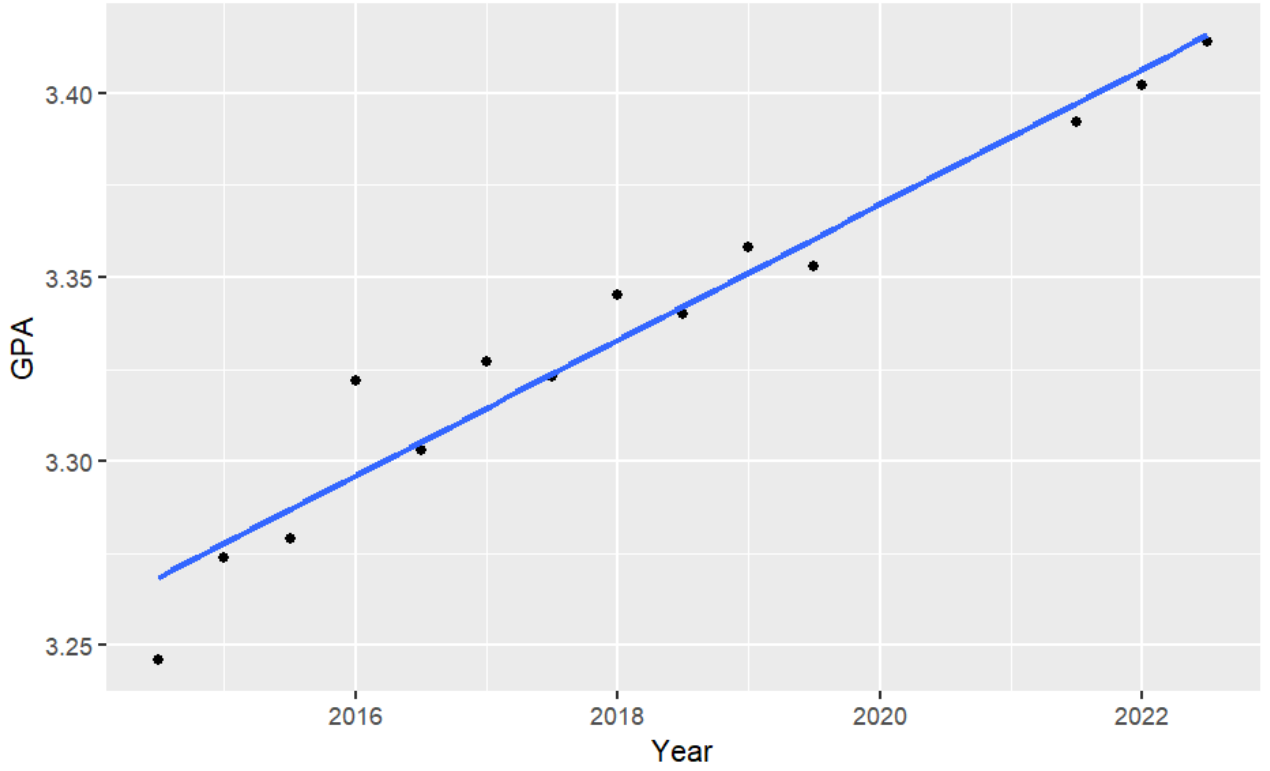

Figure 4: Average GPA and year dot plot without outliers with a regression line.

The new regression line still indicates a positive relationship between GPA and Year. More actual GPA are below predicted GPA by the regression line due to a seasonal oscillation of GPA between 2016 spring and 2019 fall, with a local maximum at spring semester and a local minimum at fall semester. The variation due to this seasonal factor decrease as year increases, and disappears after the COVID-19 period (Figure 4). Since this seasonal trend is noticeable only between 2016 spring and 2019 fall, this paper will not focus on it. The coefficients of the new regression line are show in Table 2.

Table 2: Coefficients of the new regression line.

	Estimated Std.	Error	T-value
Intercept	1846.804	11.952	154.51
GPA	51.368	3.584	14.33

With Table 2 produced by the summary function, the correlation between GPA and Year is again proved. A p-value of 6.54e-09 indicates that if GPA and Year have no correlation, then a dataset like this will only happen once in 15 million times, nearly impossible. Therefore, it is safe to reject the null hypothesis and state that there is a correlation between GPA and Year, and according to the positive estimated GPA coefficient, it is safe to claim that grade inflation exists in the University of Wisconsin-Madison.

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Table 3: Four parameters of the new linear model without outliers.

Parameters	Value given by R
Multiple R-squared:	0.9448
Adjusted R-squared:	0.9402
F-statistic:	205.4
p-value:	6.542e-09

This new fit without outliers can be used as a better fit with more accuracy and precision, since it has a F-statistic of 205.4, compared to the old fit with a F-statistic of 12.94. Moreover, a multiple R-squared of 0.9448 and an adjusted R-squared of 0.942 indicate a very strong correlation between actual GPA and predicted GPA. With these parameters proving the accuracy and precision of this linear model, this paper decides that this model is able to predict GPA of 2020 spring to 2021 spring if COVID-19 never happened, but not able to forecast several years ahead. Linear model is suitable when predicting data points within the range of the earliest data and the latest data, but it is not the best choice to predict future, which is out of the range. Taking that into account, this paper will use the linear model to predict GPA of 2020 spring to 2021 spring if COVID never happened, and fill the eliminated outliers with these three predicted data, and use ARIMA model to model the modified time series to forecast future trend of GPA in the University of Wisconsin-Madison.

3. Empirical Analysis

The equation of the regression line can be attained from table 2:

$$y = 1846.8+51.37x \quad (1)$$

With y representing year number and x representing GPA at a specific year, this equation indicates that every student in the University of Wisconsin-Madison gets an “F” at year 1846, and after that, there is a 0.00973 increase in the average GPA each semester, and at fall semester of 2052, all students in the University of Wisconsin-Madison will have a GPA of 4.0. There is an incredible coincident that the University of Wisconsin Madison was actually founded at 1848, only less than 2 years around the y-intercept.

With this formula of the regression line, GPA unaffected by COVID between 2020 spring and 2021 spring can be calculated, and a new COVID-free time series set can be produced.

Table 4: Two parameters of ARIMA (3,0,4) model.

Log likelihood	AIC
49.75	-81.5

An ARIMA model is performed based on this new time series set. After trying different p, d, q values of ARIMA (p, d, q) models, ARIMA (3,0,4) model with a log likelihood of 49.75 and an AIC of -

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81.5 is chosen to be the best fit (Table %). This model has the highest log likelihood and the lowest AIC. Also, the curve of forecast it the one with the best credibility.

Table 5: Coefficients of ARIMA (3,0,4) model with their standard errors.

Coefficients:	AR(1)	AR(2)	AR(3)	MA(1)	MA(2)	MA(3)	MA(4)	intercept
	1.0390	0.9026	-0.9537	-0.3346	-1.2374	-0.3347	0.9998	3.3067
S.e.	0.0603	0.1214	0.0612	0.5224	0.4122	0.5018	0.5468	0.0564

The coefficients of the model are given by AR(1), AR(2), AR(3), MA(1), MA(2), MA(3), and intercept. They represent the autoregressive (AR) and moving average (MA) coefficients, respectively. The intercept term is the constant term of the model. According to Table 5, the equation of this model is:

$$y_t = 1.0390y_{t-1} + 0.9026y_{t-2} - 0.9537y_{t-3} - 0.3346e_{t-1} - 1.2374e_{t-2} - 0.3347e_{t-3} + 0.9998e_{t-4} + 3.3067 + e_t \quad (2)$$

where yt is the time series value at time t, et is the error term at time t, and et-1, et-2, et-3 and et-4 are the lagged error terms.

Utilizing this model, a plot of forecasted future GPA in 5 years is produced.

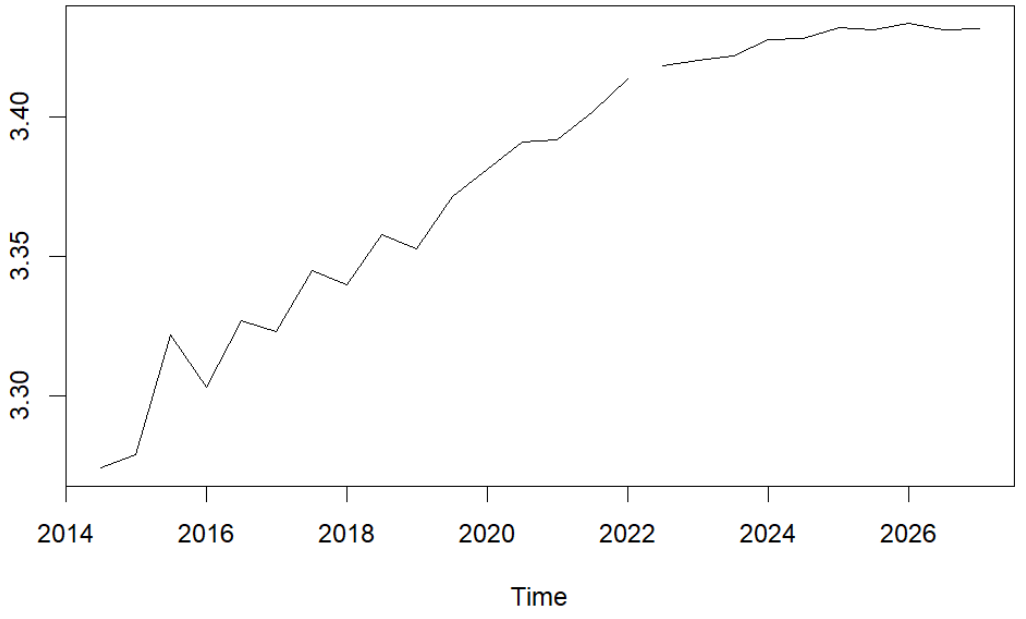

Figure 5: Five years future GPA forecasted with ARIMA (3,0,4) model.

The overall trend of GDP is still positive, however with a decreasing speed. There are within each year slightly oscillations, indicating a seasonal factor. If this model is used to forecast future GPA in 10 years, the plot will present an unexpected pattern (Figure 5).

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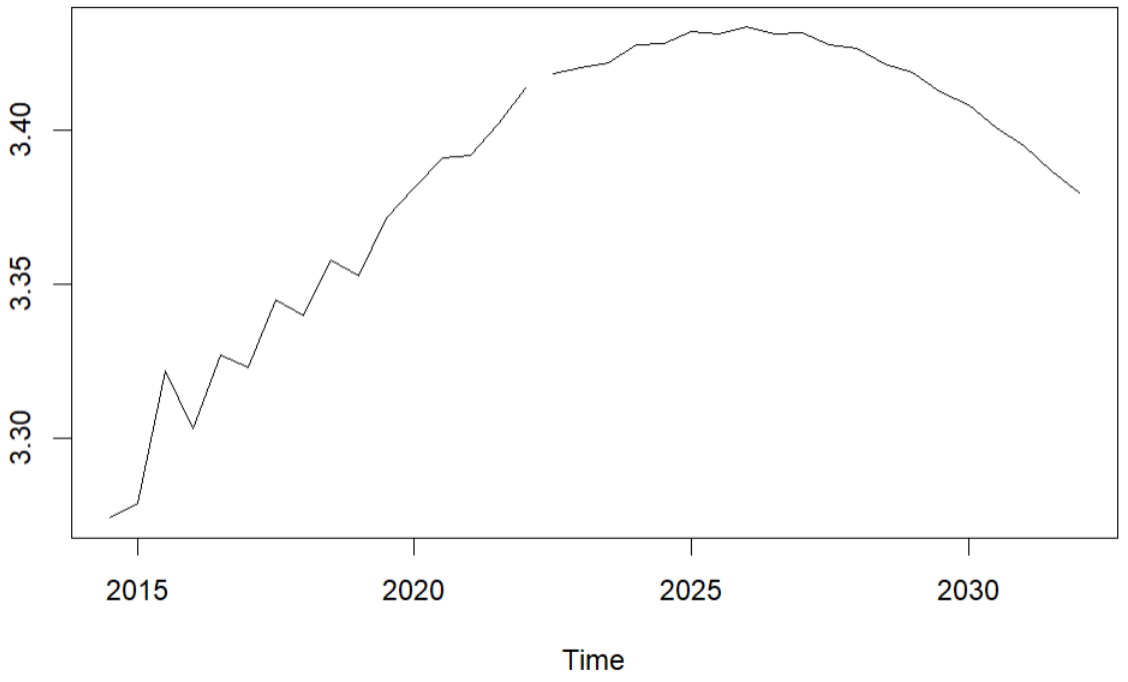

Figure 6: Ten years future GPA forecasted with ARIMA (3,0,4) model.

After reaching a maximum GPA of 3.4337 around year 2026, the relationship between GPA and year shifts from positive to negative, and a grade recession will replace the current grade inflation (Figure 6).

The hypothesis of existence of grade inflation cannot be rejected, and the hypothesis of continued inflation is proven to be true by both linear model and ARIMA model at close future.

4. Discussion

Grade inflation is no only a crisis in the University of Wisconsin-Madison, but a global one. Many have researched grade inflation and conclude reason for it. Robert Birnbaum considers grade inflation to be caused by "real increase in student achievements", while grading criteria remain unchanged, and other factors like politic or economy environment [6]. Jephcote, C., Medland, E., & Lygo-Baker refuses to call this trend of increasing grade "grade inflation", but an enhancement our education system [7]. On the other hand, Stroebe states that instead of actual increase of student performance, the wide usage of Student Evaluations of Teaching (SETs) is the main factor of grade inflation [8]. SETs lead to a situation where students attend courses that give good grades, and professors give good grades in exchange for a good SETs [8].

According to David Casalaspi, the start of grade inflation was the Vietnam War, where students with low grades (usually C and below), has a possibility to be deployed [9]. However, the trend of grade inflation continued after Vietnam War, and David conclude that a "bargaining" process between students and professors might lead to the current grade inflation [9].

Despite different conclusion of factors that lead to grade inflation, grade inflation is no doubt a global problem that needs to be solved. According to the factors other researchers concludes and David Blum's suggestions [10], this paper will propose some solutions.

First, an increase in exam difficulty. Many courses give out low-level exams to increase the average score of students, which contributes to grade inflation. Even though difficult exams may lead

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to an average lower than C or D, an upward curve is able to move the distribution of grades back to normal. However, in the case of easy exams, applying a downward curve is always considered immoral, and will be rejected by students

Second, a revised SETs system. Instead of focusing on the grade distribution of students, the evaluations should rather focus on the amount of knowledge students absorbed after finishing the course. This shifts the effort of professors from giving out good grades back to producing better teaching qualities, and the effort of students from bargaining with professor back to learning.

Last but not least, the introduction of a fixed distribution of grade can also stop the inflation. Professors can give As to the top 15% of students, and Bs to the next 25% of students, etc. This eliminates grade inflation from the source, and the difference of effort and talent of students can clearly be seemed.

5. Conclusion

To analysis and forecast grade inflation, this paper has used linear model and ARIMA model to predict future trend of average GPA in the University of Wisconsin-Madison. This paper concludes that at least in the near future of 5 years, average GPA will continue to inflate in the University of Wisconsin-Madison. For US students and professors, grade inflation is a problem closely connected, and should be stopped. This paper provides three solutions: an increase in exam difficulty, a revised SETs system, and a fixed distribution of grade. Actions are necessary to stop grade inflation before University becomes the place that exchange degrees with money, instead of knowledge with money. However, this paper has several deficiencies. Due to the lack of access to all US Universities, only one University is studied, and the data only contains 17 data points, making the ARIMA model to have a probability of overfitting. In order to attain a time series data of wider range, an effort of contacting the University of Wisconsin-Madison is made, but no relies are received. Future researchers can widen the scope of nationwide to worldwide and prove grade inflation as a global problem, continue to search for factors of grade inflation and provide solutions based on the results, or investigate the positive and negative effects of grade inflation.

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