Professional Leave Report Cover Sheet

Name: Ojoung Kwon

Department: Information Systems and
Decision Sciences

College: Craig School of Business

Leave taken: x Sabbatical   Difference in Pay   Professional Leave without Pay

Time Period: x   Fall

Spring

Academic Year

Other

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Sabbatical Leave Report

Project Title: <u>A Comparison of Artificial Neural Networks and the Statistical Methods in Predicting MBA Student's Academic Performance</u>

Principal Investigator: <u>Ojoung Kwon</u>   **Semester of Leave: <u>Fall 2020</u>**

School: <u>Craig School of Business</u>   **Department: <u>ISDS</u>**

Section 1. Report on proposed activities

(a). Specific goals/objectives achieved during the leave period:

The proposed title was "Comparison Study of the Forecasting Performance of Korea and USA Stocks' Prices using Business Intelligence (BI)," but I could not visit Korea due to the Covid-19 pandemic. During summer 2020, Dr. Harry Xia (CSB Graduate Programs Director) approached me to research the admission criteria for our MBA program, and I gladly decided to switch to this research instead. This project had the following specific objectives:

1. Research on MBA admission criteria
2. Literature review on Artificial Neural Networks (ANN) and Statistical Methods in predicting MBA students' academic performance based on MBA admission criteria
3. Find and design acceptable methodology and measurement
4. Data collection and analysis
5. Compare the measures of ANN and Statistical Methods
6. Present findings in national/international conferences and publish a journal article(s)
7. Timeline for completion of the proposed activity: August 3, 2020 – December 31, 2020

(b). Demonstrate that this is a well-conceived program:

MBA has become one of the most popular and vital professional degrees internationally. The MBA program admission process's essential task is to choose the best analysis tools to accurately predict applicants' academic performance potential based on the evaluation criteria in making admission decisions. Prior research finds that the Graduate Management Admission Test (GMAT) and undergraduate grade point average (UGPA) are common predictors of MBA academic performance indicated by graduate grade point average (GGPA).

Using a sample of 250 MBA students enrolled in Craig School of Business from Fall 2010 to Fall 2017, we test and compare the effectiveness of artificial neural networks (ANNs) against traditional statistical methods of ordinary least squares (OLS) and logistic regression in MBA academic performance prediction. Using the numerical value of GGPA, we find that ANNs generate similarly accurate predictions as OLS regression. By dichotomizing GGPA into categorical variables of "successful" and "marginal," we identify that ANNs offer the most reliable prediction based on total GMAT score and UGPA while logistic regression delivers superior performance based on other combinations of the predictors. Our findings shed new light on adopting ANNs (Machine Learning) to predict academic performance potential with a strong implication in MBA admissions to select qualified applicants in a competitive environment.

(c). The Scholarly Methodology or Approach:

The MBA admission process is crucial for selecting qualified applicants and controlling the programs' quality and reputation, in which a common and critical task is to determine suitable methods to predict future academic success (Romero & Ventura, 2010). The objective of such predictions is to estimate the academic performance potential of the applicants. In practice, the predictive values can be numerical/continuous values of GGPA (Graduate GPA) through regression analysis to determine the relationship between GGPA and one or more independent variables (Draper & Smith, 1998) such as GMAT and UGPA (Undergraduate GPA). Alternatively, they can be categorical/discrete values through classification, a procedure in which individual items (GGPA) are placed into groups based on quantitative information regarding one or more characteristics (such as "successful" and "marginal") inherent in the items (Espejo et al., 2010).

Besides traditional statistical methods, due to the importance of MBA academic performance prediction, which is often fraught with variety, ambiguity, and complexity, ANNs are appealing as a predictive tool precisely because of their expected effectiveness in such a situation (Lippmann, 1987). In practice, along with traditional statistical regression methods, ANNs have been used to predict student grades (Gedeon & Turner, 1993) and applicants' likely performance (Oladokun et al., 2008).

However, the extant literature on academic performance predictive tools provides mixed evidence. Gorr et al. (1994) compare linear regression, stepwise polynomial regression, and fully-connected, single middle layer ANNs with an index for predicting student GPA in professional school admissions and discover that none of the empirically estimated methods show any statistically significant improvement. To address skewed distribution, by introducing skewness in the dependent variable, a comparative analysis of prediction of MBA academic performance using ANNs and regression show that both bias and absolute percentage error are higher among the results generated by the ANNs method (SubbaNarasimha et al., 2000).

Another stream of study focuses on categorical approaches. Hardgrave et al. (1994) evaluate the ability of five different methods: OLS regression, stepwise regression, discriminant analysis, logistic regression, and ANNs to predict the success of graduate MBA students, which generate poor results with the best method accurately predicting 60% of the cases. They also find that three categorical methods: discriminant analysis, logistic regression, and ANNs, seem to outperform the numerical regression methods. Asogwa & Oladugba (2015) argue that ANNs outperform Multinomial Logistic Regression in terms of the Average Classification Correct Rate for classifying students based on their academic performance. On the contrary, Walczak & Sincich (1999) conclude that the accuracy of ANNs is not significantly greater than the logistic regression analysis.

It can be observed from the literature that, despite a wealth of research, neither ANNs nor statistical methods deliver conclusive superiority in academic performance prediction, the key task in the MBA admission process. Therefore, our research proposition is to examine and compare the effectiveness of ANNs to the popular statistical methods in predicting MBA students' academic performance. By considering the academic performance proxied by GGPA as a dependent variable, the predictive analysis is conducted using ANNs, OSL regression, and logistic regression, respectively. To test the predictive accuracy, we will compare the outcomes of the numerical and

categorical value of GGPA through statistical tests and F1-score to evaluate the performance of various predictive methods (Paliwal & Kumar, 2009).

(d). Project Plan and Schedule

This project is well planned and executed, as shown in Table 1 below.

Table 1. Project Plan and Schedule

Tasks	Estimated Duration	Completion Date
Research on MBA admission criteria	8/15/20-8/31/20	8/31/20
Literature review	8/15/20-9/15/20	9/15/20
Design methodology and measurement	9/15/20-9/30/20	9/30/20
Data collection and analysis	9/30/20-10/30/20	11/15/20
Compare the measures of ANN and Statistical Methods	11/15/20-11/31/20	11/31/20
Writing papers for a journal article(s)	11/31/20-12/31/20	3/31/21

(e). Planned travel and budget

All international travel was banned due to the pandemic. I had to cancel my trip to South Korea.

Section 2 & 3. Benefits to you as a faculty member and to the university

This research investigates three popular MBA student academic performance (proxied by GGPA) predictive methods: ANNs, OLS, and logistic regression. By employing the numerical value of GGPA, we prove that ANNs deliver similar accuracy as OLS regression based on UGPA, GMAT total, and subtest scores (verbal, quantitative, and analytical writing assessment). Using categorical variables of "successful" and "marginal" with the threshold of 3.6 GGPA, we find that ANNs generate the most significant predictive power based on UGPA and GMAT total while logistic regression delivers more accurate results in the models using other predictor combinations. Our findings contribute to the extant literature by adding direct evidence of ANNs as an effective predictive tool to measure academic performance potential with a strong implication to the critical task of selecting qualified applicants in the MBA admission process.

Although ANNs are particularly accurate in categorical MBA academic performance prediction based on the popular admission criteria of UGPA and GMAT total, we find no overwhelming proof that ANNs can clearly outperform traditional statistical methods in other models and deliver exceptional value considering the extra training time and more sophisticated resources ANNs demand. The possible explanation may relate to the limitations of this study. First, it is subject to a universal challenge of range restriction in educational research with a relatively high mean for GGPA and a small standard deviation resulting in limited variability. Second, this research only involves limited data from one university's MBA program, which also constrains the generalizability of the findings. Finally, the restricted sample size and number of variables are disadvantageous to ANNs, which are more suitable for predictions based on large sample size and nonlinear relation between predictors and dependent variables in future research.

In addition, student academic performance depends on various factors, not just on the ones considered in this research. Future studies in this area, particularly those testing the effectiveness of ANNs in academic performance prediction, may further explore other variables that influence MBA academic performance outcomes, such as work experience, achievement motivation, soft skills, or self-efficacy. This research has helped us understand the impact of various admission criteria on predicting the MBA student academic performance using machine learning and statistical analysis. It will benefit the school and university by admitting better students who fit our MBA programs.

Section 4. Previous Leaves

Sabbatical Leave on Fall 2007

References

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SCHOLAR'S QUALIFICATIONS TO ACCOMPLISH THE ACTIVITY UNDER STUDY

1. Evidence of your potential to successfully accomplish the activity under study

Skills or retraining essential to complete the project
I have both technical (BSEE, MSEE, and Ph.D. in AI) and managerial (MBA) training. I also have significant exposure to many high caliber research projects, including AT&T, General Motors (GM), Alabama Power Company, Amdahl Communications, Illinois Division of Oral Health (IDOH), US Department of Transportation (US-DOT), Administrative Office of Illinois Courts (AOIC), and Ballistic Missile Commander (MICOM) under the Strategic Defense Initiative (SDI).

Past software/hardware development:
CyberCollaboratory (http://cyberlab.uis.edu:8080/cyberlab.htm) (1993–2010), initially developed at the University of Illinois at Springfield and moved to California State University at Fresno (http://cyberlab.csufresno.edu:8080/cyberlab.htm). CyberCollaboratory was developed with Donna Dufner and Bill Rogers to provide an asynchronous "virtual teamwork" environment via the Internet; it was programmed in Lotus Notes Scripts and Agents, JAVA, and Visual Basic.

Divorce Advisor (1993–2008), NOK Technologies, Springfield, Illinois.
Divorce Advisor was developed with Jerry Oxley (CPA) and Fred Nergenah (JD).
This software offers financial, legal, and tactical advice on issues that arise in divorce cases; it was programmed in Visual Basic. Currently, the entire system is being converted into a web-based application using Java, XML, and ASP.

Farm Appraiser (1996–1998). developed by Ed Kirby and Ojoung kwon. This software calculates an objective and accurate appraisal value for farmland within a few seconds; it was programmed in Brainmaker (Neural Network Software) and Visual Basic.

GDSS-UIS (1993–1996), This software was developed with six graduate students in the MIS program. This software provides an anonymous 'group meeting' environment via LAN; it was programmed in Visual Basic and MS Access.

ISA (1991–1992), This expert system was developed with Indu Weerakoon. Intelligent Student Advisor (ISA) offers students automated expert advice for academic advising and course scheduling through LAN; it was programmed in Exsys-Pro and Visual Basic.

NetMan (1988–1990), Artificial Intelligence Lab, University of Alabama. NetMan was developed for AT&T Data Processing and Corporate Telecommunications; it provides network management solutions including packet routing path assignment, load balancing policies,

deadlock avoidance, optimal throughput simulation, and much more for AT&T's packet switching network; it uses GENESES and Sim-C on the Cray-II Supercomputer.

Sim-C (1988–1989), Artificial Intelligence Lab, University of Alabama. SIMulation in C (Sim-C) is a system modeling and simulation tool written in C; it was developed for and is used by the NetMan project done for AT&T; it was programmed in UNIX/C.

OSAES (1988–1989), Alabama Productivity Center, University of Alabama. Oil-Sample-Analysis-Expert-System (OSAES) was developed for Alabama Power Company; it provides a meaningful interpretation of oil-sample (from engines/hydraulic systems of construction trucks) analysis results for truck maintenance mechanics; it was programmed in GENESES (my own program).

GENESES (1987–1988), Artificial Intelligence Lab., University of Alabama; **GEN**eric **E**xpert **S**ytems **E**nvironment**S** (GENESES); this program was developed for and is used by the NESTOR and NetMan projects for AT&T; it was programmed in UNIX/C.

NESTOR (1987–1988), Artificial Intelligence Lab., University of Alabama. Nestor was developed for AT&T Data Processing and Corporate Telecommunications; it provides very accurate network design change specifications for AT&T's packet switching network; it was programmed in UNIX/C. It was implemented and used by AT&T (with a 500% productivity gain!).

FMS Designer (1986–1988), Artificial Intelligence Lab, University of Alabama. FMS Designer was developed for GM; it analyzes the output from an FMS simulation model, determines whether operational and financial objectives are met, identifies design deficiencies or opportunities for improvement, and proposes designs that meet given objectives; programmed in KEE, OPS83, and SIMAN.

AutoCon (1981–1982), Department of Electronics Engineering, Yeungnam University, Taegu, Korea. With this hardware, I designed, developed, and implemented an automated temperature controller for a semiconductor-baking electric furnace; I used Intel 8085 CPU (and related) chips and programmed it in HEX code.

2. Bibliography of <u>relevant papers</u> (including a summary of previous research awards)

2.1. Book Chapter:
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- Kwon, O.; Kurniawan, I.; and Bowerman, D. (2005) "Chapter 2. Intelligent Facilitation Agent: Automating Group Meeting Facilitation," Intelligent Decision Support Systems in Agent-Mediated Environments, published in the subseries of ***Knowledge-Based Intelligent Engineering Systems***, ***Frontiers in Artificial Intelligence and Applications***, (Eds) Gloria E. Phillips-Wren and Lakhmi C. Jain, Volumn 115, IOS Press, Netherlands, pp. 37-70.
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2.2. Articles in Refereed Journals:
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SUMMARY OF PREVIOUS FUNDING ACTIVITIES

- **Graduate Online Pedagogy & Mentorship Grant**: developing online graduate courses, $1,500. June 11, 2018.
- **New Course Development Grant**: Title: "Developing New DS 70 Course to satisfy EO 1100 & EO 1110," $31,831from Dr. Dennis Nef (Associate Vice President of CSU Fresno). May 17, 2018.
- **eScholar Grant**: Title: "Curriculum Redesign: IS 187 (IS Practicum)," the President's Strategic Plan for Excellence, upon completion of the program, participants receive a certificate, a digital badge, and $2,500 in professional development funds. January 27, 2016.
- **DISCOVERe Grant**: Title: "Curriculum Redesign using a Tablet Technology," the President's DISCOVERe Tablet Program, funded $5,500 plus a Microsoft Surface 3 Pro tablet. August 6, 2014.
- **Research, Scholarship and Creative Activity Grant**: Title: "Comparison Study of the Forecasting Performance of China and USA Stocks' Prices using Business Intelligence (BI)," California State University, $5,000 for July 2014–June 2015, received on May 16, 2014.
- **CSALT FLC Grant**: Title: "FLC for SAP ERP," 2013 Faculty Learning Community (FLC) Grant from the Center for the Scholarly Advancement for Learning & Technology (CSALT), funded $4,100. August 8, 2013.
- **Title V & Plan for Excellence Grant**: Title: "IS130 Curriculum Redesign," 2012 Summer Teaching Innovations Academy, funded $5,000 plus 2 iPads to redesign IS130 (Management Information Systems) with high emphasis on hands-on technology. June 4-15, 2012.
- **BIE Grant**: Title: "International Curriculum Development Project for IS Capstone Course," The GLOBAL Project: Business and International Education Program, US Department of Education, funded $3,500 to develop an IS Capstone curriculum with strong Global perspectives. The grant was received on September 10, 2008.
- **BIPP Grant**: Title: "Investigation of the Feasibility of IS/IT Technology Certification," Business

Associates, a community partners association for Craig School of Business, funded $5,000 to research the possibility of offering industry certifications to the students. The grant was received on November 2006.

- **BIPP Grant**: Title: "CyberCollaboratory Support for Fresno City's LMTF Project," Business Associates, a community partners association for Craig School of Business, funded $5,000 to set up CyberCollaboratory as the Labor-Management collaboration workspace at the City of Fresno. The grant was received on September. 27, 2004.

- **BIPP Grant**: Title: "CyberCollaboratory Support for the City of Fresno Telework Project," Business Associates, a community partners association for Craig School of Business, funded $2,500 to set up CyberCollaboratory for the Tele-workers at the City of Fresno. The grant was received on September. 15, 2003.

- **CSB Research Mini Grant**: Title: "Measuring the Success/Effectiveness of Reward Policy using CyberCollaboratory," Craig School of Business, California State University, $1,500 for August 2003–June 2004, received on August 29, 2003.

- **Research, Scholarship and Creative Activity Grant**: Title: "Measuring the Success/Effectiveness of Reward Policy using CyberCollaboratory," California State University, $5,000 for July 2003–June 2004, received on June 2, 2003.

- **BIPP Grant**: Title: "Development of Advanced Database Curriculum at CSU-Fresno," Business Associates, a community partners association for Craig School of Business, funded $2,000 to establish IS156T: Advanced Database (Oracle DBA) curriculum at CSU-Fresno. The grant was received on Feb. 21, 2003.

- **Research, Scholarship and Creative Activity Grant**: Title: "Development of an Autonomous Reward Allocation System in CyberCollaboratory," California State University, $5,000 for July 2002–June 2003, received on May 29, 2002.

- **Program Development Grant**: Title: "Establishment of CyberCollaboratory Research Program at CSU-Fresno," Craig School of Business and Craig Foundation, $5,000 for June 2002–May 2003, received on April 17, 2002.

- **Summer Research Grant**: Title: "Design, Development and Implementation of Reward Allocation System in CyberCollaboratory." Craig School of Business and Craig Foundation, $6,600 for summer 2002, received on March 1, 2002.

- **BIPP Grant**: Title: "Establishing CyberCollaboratory at CSU-Fresno," Craig School of Business and Craig Foundation initially funded $15,267 to establish CyberCollaboratory at CSU-Fresno including a Dell server with 50 user licenses of Lotus Notes/Domino. BIPP grant provided additional 100 user licenses enabling us to deploy an experiment with up to 125 subjects. $5,000 received on Nov. 2001.

- **POLARIS Project**: Building a statewide Data Warehouse and Decision Support System (Probation Case Management) for Administrative Office of Illinois Courts (AOIC), working with the Center for Legal Studies, University of Illinois at Springfield, $500,000 (5 year contract), Aug. 2000–July 2001 (I had to move to California July 2001).

- **County ADR Project**: Data quality assessment and development of meta-data for counties Civil Case Management, Administrative Office of Illinois Courts (AOIC), working with the Center for Legal Studies, University of Illinois at Springfield, $50,000, Jan.–June 2001.

- **QDM Instructional Lab Software Grant**: A generous Instructional Lab Software Grant for BB Project, valued at $17,700, was awarded from QDM, Inc. on December 29, 1999.

- **Microsoft Instructional Lab Software Grant**: A generous Instructional Lab Software Grant, valued at $74,550, was awarded from Microsoft, including MS Windows NT, MS Visual Basic Professional, and MS Office Professional, August 20, 1997, renewed in 1998.

- **ParaSoft Lab. Software Grant**, a 10 user license of Insure++ ($19,195) and a 10 user license of CodeWizard ($9,950) lab; this software grant was offered by ParaSoft Corporation on February 5, 1997. Insure++ is a powerful environment for the development of "Total Quality Software." Insure++ automatically detects large classes of programming and run-time errors. It quickly pinpoints algorithmic anomalies, bugs, and deficiencies. Insure++ visualizes in real-time the memory manipulation of the program, helping developers spot bugs and inefficiencies in memory handling. CodeWizard helps developing clean codes for C++ and J++.
- **UI-ALTHE '97 Grant** of $18,500 to Ojoung Kwon and Peter Wenz (University of Illinois Advanced Learning Technologies in Higher Education Grant)   for "Development and Use of an Asynchronous Learning Environment for a Humanities Course (PHI 452)," $18,500, December 15, 1996.
- **UI-ALTHE '97 Grant** to Ojoung Kwon and, University of Illinois Advanced Learning Technologies in Higher Education Grant, with D. Dufer, J. Thompson, and H. Frost-Kumpf, "Using Lotus NOTES via the Internet as a CyberCollaboratory for Electronic Cooperatives: Asynchronous Collaborative Learning for Student Team Projects," $22,375, December 15, 1996.
- **Microsoft Instructional Lab Software Grant**, 50 licenses each for MS Windows NT, MS Visual Basic Professional, and MS Office Professional Suite including MS ACCESS, MS EXCEL, MS WORD, MS MAIL, and MS POWERPOINT, valued at $12,500, July 24, 1995, renewed in July 25, 1996
- **Microsoft Software Grant** to Ojoung Kwon, University of Illinois at Springfield, a software grant including Windows for Workgroups (Win 3.1.1), MS-Access 1.0, and Visual Basic 1.0 was provided from Microsoft to develop GDSS-UIS. November 12, 1993.
- **EXSYS-Professional** (Expert Systems software) Computer Lab Software Grant from EXSYS Co., 20 licenses for EXSYS-Pro, valued at $30,000, given by Mr. Mike Eskew, Vice President of Sales, EXSYS company by telephone, August 1992.