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The Predictive Validity of the AFIT Graduate Management Program Admission Requirements: a Reassessment and Extension

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THE PREDICTIVE VALIDITY OF THE AFIT GRADUATE MANAGEMENT PROGRAM ADMISSION REQUIREMENTS: A REASSESSMENT AND EXTENSION

THESIS

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AFIT/GAQ/ENV/04M-03

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Abstract

This research is based on the Air Force and AFIT balancing mission requirements of personnel needed for duty and training airmen in advanced studies. Currently, over 50% of AFIT students do not meet AFIT entrance requirements. The purpose of this research was to examine criteria to determine its predictability of graduate success, as measured by graduate GPA, as well as determine whether performance is different for students who require criteria to be waived.

Current AFIT eligibility criteria include undergraduate GPA, GRE test scores, or GMAT test scores. Other variables examined in this study include: GRE-Analytical test scores; rank/grade; prior enlistment; AFSC; gender; and number of members in household.

This research found GMAT scores were a better predictor of success than GRE scores for management students. GRE-Q scores were good predictors for all students, while GRE-V scores were moderately good predictors for management students only. GRE-A scores should be added as a requirement with an appropriate standard. Undergraduate GPAs should be used as a guideline, not eligibility criteria into AFIT.

Waivers should not be given for multiple deficiencies when possible, though there was little difference in the performance of students who met the criteria and those who did not. There was also little difference in the performance of students depending upon the type of waiver given.

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THE PREDICTIVE VALIDITY OF THE AFIT GRADUATE MANAGEMENT PROGRAM ADMISSION REQUIREMENTS: A REASSESSMENT AND EXTENSION

I. Introduction

Background

The United States Air Force is the world leader in aerospace power. Air Force personnel are trained and equipped with the most modern and technologically advanced tools. "They demonstrate the maturity of our ability to plan and execute an array of complex, integrated, and simultaneous coalition operations designed to support objectives across the spectrum of conflict from global strike to humanitarian relief" (Roche, 2003). Yet despite our achievements and dominance, Air Force leaders are continuously seeking new solutions to organize, train, and equip forces to meet the demands of our current and future national security environment. The Air Force needs highly qualified personnel with not only broad knowledge of the Air Force, but also expertise within specific career fields.

The Air Force Institute of Technology (AFIT) provides one option for airmen to advance their educations and gain depth in their career field. The AFIT Graduate School of Engineering and Management offers master and doctoral degrees in engineering, science, and management disciplines tailored to Air Force and Department of Defense needs. The mission of AFIT is "to produce graduates and engage in research activities

that enable the Air Force to maintain its scientific and technological dominance" (AFIT Catalog, 2002: 3). Currently, 500 students graduate from the AFIT in-residence program with a master's degree. Due to a new initiative from the Secretary of the Air Force, James G. Roche, AFIT will increase graduation quotas to 2,500 during the next six years ("AFIT Raises Graduation Quotas," 2003). When speaking about the initiative to increase education of airmen, Dr. Roche stated,

> "I'm proud or our new initiatives to increase AFIT attendance over the next several years and to make advanced academic education available to those senior enlisted members who qualify for our graduate degree programs. You should know, I view this effort as an important investment in those who must maintain and operate the complex systems our Air Force employs, not as hollow philanthropy." (Roche, 2002)

While the quotas for AFIT graduates are increasing, the demand for airmen to serve over seas on contingencies and operations is also increasing. As of November 2003, from a total force of 370,898 active duty personnel, 18,242 were deployed on contingencies to Operation Iraqi Freedom, Enduring Freedom, Noble Eagle, Joint Guardian, and Joint Forge to name a few (AFPCa, 2003; AFPCb, 2003; Lingle, 2003). The mission of the Air Force comes first and senior leaders as well as the Air Force assignment teams must balance meeting today's need with future needs. AFIT's objective of the school is to produce graduates for the Air Force in preparation for future needs. The quality of personnel the Air Force needs to maintain the world's most respected force places AFIT in a precarious situation, finding available career officers with the skills and desire for continued education. Presumably, some officers do not wish to go back to school or had difficulty in undergraduate college and don't feel they are ready for more school and although they were capable of attaining a bachelor's degree,

might not have sufficient skills to finish a rigorous master's program. Not all officers are in the position or are available (due to continued contingencies) to attend and succeed at AFIT. Therefore, entrance requirements to AFIT must be continuously reviewed for their ability to predict a student's ability to graduate while maintaining the dignity of AFIT programs.

AFIT Entrance Requirements

Currently, the criteria for admissions into AFIT include completion of a bachelor's degree at a regionally accredited college or university with a 3.0 grade point average (GPA) on a 4.0 scale, and "satisfactory scores" on standardized tests such as the Graduate Record Examination (GRE) and/or Graduate Management Admissions Test (GMAT.) The recommended minimum test scores for any graduate program at AFIT are 500 on the GRE verbal exam and 600 on the GRE quantitative exam, or a total score of 550 on the GMAT exam (AFIT Admissions Criteria, 2003). However, the director of each academic program can waive admission requirements on a case-by-case basis (AFIT Catalog, 2002: 9).

Studies relating admissions criteria to academic success are common in the academic community, mainly because no universal model has been identified which applies to all graduate (or undergraduate) institutions (Spangler, 1989:8). Some studies on the predictability of admission criteria for AFIT found little or no correlation between test scores, undergraduate GPA, and AFIT success (graduate degree receipt) and therefore "indicate that the ability measures used by AFIT are appropriate but not sufficient for predicting success" (Keith, 1977:36-37; Garwood, 2002:89).

This study will focus on general admission criteria for AFIT and their predictive capabilities within each department of AFIT: Aeronautics and Astronautics (ENY); Electrical and Computer Engineering (ENG); Engineering Physics (ENP); Mathematics and Statistics (ENC); Operational Sciences (ENS); and Systems and Engineering Management (ENV) (AFIT Catalog, 2002). Although doctorate programs are offered, this study will focus on the master students and program entrance requirements for a master's degree: ENY offers five master's programs; ENG offers three; ENP, six; ENC, one; ENS, three; and ENV offers four master's degree programs (AFIT Catalog, 2002). Eligibility requirements differ slightly based upon the program. However, for the purpose of this study, we are seeking the predictive capability of the "general" admission requirements mentioned above, which are standard across the programs.

Selection Process

The traditional, objective application and selection process to AFIT is different for military members and other applicants. Government and non-government civilians and members of foreign militaries are also eligible to attend AFIT. However, in an effort to standardize the population for this study, we will examine active duty U.S. military members seeking full-time, 18-month resident AFIT assignment. To be eligible, applicants must currently not be in permanent change of station (PCS) status, technical training, or PCS professional military education assignment. Prospective students can apply to AFIT with a formal application, including undergraduate transcripts and official GRE or GMAT scores. Students will be assessed on academic background, Air Force Specialty Code, and forecasted requirements for officers with the desired field of study.

All AFIT degrees are matched to specialty codes in coordination with the Air Force Personnel Center (AFPC) assignment teams (Baker, 2004; AFIT Catalog, 2002: 9-10; AFIT Admissions Criteria, 2003).

Once a student submits the required paperwork and specifies a desired academic program, the registrar will assess the student's academic eligibility against the stated admissions requirements. Students meeting all eligibility criteria receive a letter of eligibility which advises the assignment officers at AFPC that the student is academically qualified to attend AFIT. Students not meeting eligibility criteria have their records referred to the director of their preferred academic program for waiver determination. Students receiving a waiver of their deficiencies also receive letters of eligibility. The assignment officers have an allocated number of positions to fill at AFIT and will match the appropriate students from the pool of eligible candidates with the positions at AFIT. If more students apply than positions available, the assignments officer will select students to attend AFIT, consulting with the AFIT program director as needed (Baker, 2004; Monson, 2004).

The non-traditional and subjective portion of admission to AFIT happens when the program director waives substandard undergraduate GPA, GRE, and/or GMAT scores for a prospective student. Directors have discretion when deciding which students to waive requirements for and which not to, though each should review the applicant's academic record thoroughly. Directors may request an interview with prospective students to determine their potential for successful completion of the graduate program. Others might review undergraduate transcripts, and any graduate transcripts, to determine the difficulty or applicability of the courses to ascertain successful completion. Still other

directors might do both or automatically grant a waiver based on the need to fill the program's allotted slots (Baker, 2004) but keep in mind the student's difficulties to better work with them throughout the program.

Whether a prospective student gains an assignment to AFIT by meeting the objective criteria or through the waiver process is the focus of this study. Garwood's study (2002) of eligibility criteria used to predict success of the Cost Analysis program at AFIT found 70% of the lowest GPAs and 80% of the ten highest GPAs were earned by students who required a waiver for admission. With the increased quotas for AFIT to fill and the increased number of Air Force personnel needed elsewhere, finding students to fill the quotas for graduate degrees is challenging, particularly in the science, engineering, and logistics programs (Burnside, 2004; Donahue, 2004; Peterson, 2004). Waivers from program directors are becoming common-place, yet nearly 100% of students graduate from AFIT in the allotted 18-month time frame. This discrepancy at AFIT calls into question whether AFIT's admission requirements are valid or even necessary.

Importance of Selection

Selection into the AFIT graduation program is important to a variety of people for a variety of reasons. First, attending AFIT is an excellent opportunity for military members to continue their education free of cost. The Air Force pays all school related costs for a student (tuition and books.) In addition to school costs, they continue to pay military members their salary and housing costs according to the member's rank. For many students (first lieutenants with three years of service through captains with six

years of service,) the government is paying $75K – $95K, including benefits, tuition, and books to attend school for 18 months (DFAS, 2004). This number does not include housing pay or career bonuses. According to Air University Financial Management Department (2004), the total cost of one student to attend AFIT is $301,872. This cost includes direct costs ($118,591,) indirect costs ($38,241,) student costs ($137,631,) and command support costs ($7,409.) Considering that AFIT students are unavailable to serve on world-wide contingencies during their studies, the Air Force is investing a considerable amount of resources to send a student to school. With this investment, the Air Force has a vested interest in selecting qualified students who will successfully complete their studies; however, students also have strong motivation to be admitted to and to succeed at AFIT.

Selection and successful graduation of the master's program is important to the students' military careers. Whether or not a student receives a degree from AFIT, he/she will likely continue to their follow-on duty station, although program extensions are available. Regardless, the student's training report will indicate degree receipt (on non-receipt) which will stay in the military member's records. The records serve as the primary basis for selection both to future positions in the Air Force and for promotion opportunities. Students with a report from AFIT stating the absence of degree receipt will be looked at much less favorably by a promotion board. Students who apply for AFIT want to be sure the 18-month program is what they are interested and motivated to achieve. Selection of a student who is not ready for the program can hurt the student, but it can also impact AFIT.

Student success at AFIT reflects upon the school's ability to maintain their mission and integrity, including accreditation. AFIT is accredited by two governing bodies, the Higher Learning Commission (HLC) and the Accreditation Board for Engineering and Technology (ABET) (for select engineering programs.) The HLC is a member of the North Central Association (AFIT Catalog, 2002; 4). In order to maintain accreditation through the HLC, schools must continually assess: student learning and effective teaching; acquire, create, and apply knowledge; must have a mission and integrity; and prepare for the future (HLC, 2003: 5-7). As mentioned earlier, nearly 100% of AFIT students graduate on time with at least a 3.0 GPA and successful completion of a thesis. AFIT is clearly succeeding in their efforts to accomplish the mission. However, with the increased number of students, a proportional increase in the number of waivers given to students to attend AFIT could impact the integrity of the school if students do not do well. Faculty can also become overburdened if too many students require extra help to make it through the program. Therefore, selection of qualified, motivated, and disciplined students becomes more important and requires more effort on the part of faculty granting waivers, should they decide to wave requirements at all. The school administration is interested in selecting students who will reflect the school's abilities positively through their graduate completion and GPAs.

Problem Statement and Objective

This research seeks to validate the GRE/GMAT and undergraduate GPA as AFIT entrance criteria as well as examine alternative information necessary for both admissions and individual instructors to assess when evaluating students for AFIT programs.

Investigative Questions

The following investigative questions support the research objective:

1. Do current measures of capability, such as the GRE or GMAT standardized tests, have any predictive capability on AFIT student performance?

2. Do current measures of past performance, such as undergraduate GPAs, have any predictive capability on AFIT student performance?

3. Is there a difference in performance between students who meet all admissions requirements and those who require a waiver?

4. Is there a difference in performance depending on which admission requirement is waived (GRE/GMAT scores or undergraduate GPA)?

Summary

Selection of students into AFIT is important to the Air Force, the students, and the school's faculty. Careful consideration of students is necessary to maintain the integrity of the graduate program at AFIT. The department of admissions collects the necessary information to determine eligibility; but individual program directors are faced with the subjective decision of whether or not to waive a student who does not meet admission requirements to attend AFIT. Due to the need for military members elsewhere conflicting with the need for AFIT to increase enrollment by up to 500% over the next five years as a part of increased force development (Roche, 2003), AFIT could be forced

to consider more students who don't meet its fundamental admission requirements. If the program directors better understand the likelihood of success for students they grant waivers, they will better understand the level of commitment and dedication both instructor and student will need to better prepare the incoming student with what lies ahead and give the student and the Air Force assignment system more information with which to make the decision whether or not to apply to AFIT.

II. Literature Review

Chapter Overview

This chapter examines current studies and measurements of graduate school performance presented in literature. Success predictability articles saturate the literature, correlating undergraduate GPA, gender, past work experience, GRE/GMAT test scores (to name a few) with graduate school performance. This chapter will review criteria of success within the literature as well as predictor variables and what researchers have concluded thus far. The chapter will conclude with an overview of AFIT-specific theses in the area of graduate school performance predictability. This overview indicates a need for recurring validation of admission requirements at individual graduate schools.

Success Criteria

Graduate school performance can be measured several different ways: by grades (Morrison and Morrison, 1995; Hoefer and Gould; 2000); comprehensive exams and faculty ratings (Kuncel et al., 2001); degree completion (House, 1997); etc. Kuncel, Hezlett, and Ones (2001) explored eight different measures of success through a comprehensive meta-analysis of GRE predictability: graduate GPA; first year graduate GPA; comprehensive examination scores; faculty ratings; number of publications/conference papers; number of times publications are cited; degree attainment; and time to degree attainment. Many faculty members would argue success is much more than quantitative measures and that the objectives of most institutions are more than academic competence (Walpole et al, 2002; Hartnett and Willingham, 1979).

Walpole and others (2002) conducted interviews with over 100 graduate school staff and faculty members which revealed the most common measures of success were not quantifiable: research/scholarly experience (amount and quality); interpersonal skills/collegiality; broadening viewpoints; and persistence/tenacity. Such conflicting views emphasize a theme one can see throughout graduate success predictability studies: no study has proved to be universally applicable and no one criteria or set of criteria for success at graduate institutions has been determined.

The Educational Testing Service (ETS) is the administrator of both the Graduate Record Administration Test as well as the Graduate Management Administration Test, the two most widely used standardized exams to ascertain an individual's academic readiness for graduate school. The ETS, in an effort to continually validate their exams, has conducted several validity studies over a broad range of schools and disciplines (Zwick, 1990; Willingham, 1976; Powers, 2001: Schneider and Briel, 1990). A few of their studies have pertained specifically to the "criterion problem," how one defines the criteria of successful performance in an educational program (Enright and Powers, 1991; Harnett and Willingham, 1979). Although the recommendations to develop new quantifiable measures of success (i.e. analytical skills assessment by faculty, discipline-specific simulation testing) are valid, most measures have yet to be implemented. Harnett and Willingham's (1979) report about measures of success in graduate school discusses the nature and importance of the criterion problem:

> "Notions of what constitutes successful student performance and how it ought to be measured naturally vary widely across institutions, disciplines, and types of programs. It is very much a responsibility of individual institutions and departments to wrestle with an issue so central to educational policy." (Harnett and Willingham, 1979: 1)

At AFIT, degree requirements include an overall graduate GPA of at least B (3.00,) completion of 48 coursework credit hours, and completion of a 12-hour independent study research thesis (AFIT Catalog, 2002: 29-30). In light of the requirements, one might assume success at AFIT is based upon graduate GPA and completion of a thesis. Other common measurement factors such as time until degree completion, cited publications, and quality/amount of scholarly study, are generally constant for students at AFIT and are therefore not appropriate measures of success for this study (Garwood, 2002: 8-17). Students are at the same institution with the same professors, same courses (within their discipline) for the same amount of time. Also, while each department has its own goals (AFIT Catalog, 2002,) this study will focus on department commonalities to reduce variance in our study. Not all programs give faculty ratings, require comprehensive exams, or encourage publications, and thus these factors will not be considered as success criteria for the purpose of this study. Common measures of success which apply to all students at AFIT are first year graduate GPA and graduate GPA. Completion of a thesis will not be used as a measure of success because students will not receive a degree without completion and the distribution of thesis grades have been shown to be greatly skewed in programs at AFIT (Garwood, 2002: 43; Zitzman, 2002: 60). It is safe to assume the same distribution of thesis grades can be seen throughout several programs at AFIT.

The graduate GPA and first year GPA are the most commonly used success criteria in graduate success predictability studies (Feldhusen and Jarwan, 1995: 506; Kuncel et al., 2001: 168). Grades have several positive attributes which make them good

measures of success for validity studies. First, they are easily accessible at any institution. In fact, Harnett and Willingham (1979: 11) discuss a study by K.M. Wilson in 1978 which found first year graduate grades are chosen as measures of success because they are the most reliably common criterion to all institutions. This commonality is due at least in part to the number of students who do not complete master's programs, but who complete one year of studies. Because nearly 100% of AFIT students graduate, it is reasonable to assume the final GPA will be a more robust measure of success than the 1st year GPAs of students. Grades are also good success criterion because they presumably represent how faculty feels a student is performing academically. Grades serve as one achievement factor which generally communicates to students, faculty, university administrators, and prospective employers, students' academic ability and capability (Roth et al., 1996: 548; Willingham, 1974: 274). While many good things can be said about using grades as a success criterion, they have several limitations.

Two prominent limitations using GPA as a measure of performance can hinder predictability research (Willingham, 1974: 274). First, most graduate schools consistently give As and Bs so GPAs range from 3.0 to 4.0, which does not allow for much differentiation. And second, grading severity can vary from one institution to another, as well as within institution departments. By limiting this research to students at one graduate institution, we are able to also limit the variance of grading. Also, while this study intends to examine predictability of the whole school heterogeneously, it will also determine predictive capability within each department, thereby limiting the effect of grading differences within the institution.

Although researchers and scholars might have conflicting views about how to define and measure graduate success, most tend to agree that the measures should be valid, reliable, and acceptable (Willingham, 1974: 273). A valid measure will measure precisely what we want to measure, and only what we want to measure. Grades do not necessarily measure success, but can also be an indication of faculty or student characteristics rather than academic knowledge (Harnett and Willingham, 1979: 13). For example, a paper could be graded based upon a professor's personal preference for inductive research rather than deductive research. A reliable measure is one that is stable and dependable from one measurement to another when all else is constant. One can clearly and logically assume a professor's method of grading will not always be consistent from class to class, student to student. And an acceptable measure is one that is accepted by the community at large, feasible, and logical (Leedy and Ormrod, 2001: 24-37; Willingham, 1974: 273). Despite the minor shortcomings of the graduate GPA in validity and reliability, it is certainly accepted by academics at large as the most feasible and logical measure of success we have at this time, evidenced by the large number of research efforts which use it in their studies (Hoefer and Gould, 2000; Peiperi and Trevelyan, 1997; House, 1994; Roth et al., 1996; Nilsson, 1995; Kuncel et al., 2001). Now that we have identified our success criterion as the graduate GPA, we will examine factors of predictability of success.

Factors of Predictability

According to the expectancy theory, performance is a multiplicative function of motivation and ability (Gibson et al., 2003: 142). Further dissecting the formula reveals

performance components (such as graduate GPA, course grades, thesis completion, etc.) are a function of declarative knowledge (what we know,) procedural knowledge and skill (application of knowledge,) and motivation, wherein ability (from the expectancy theory) equals declarative knowledge multiplied by procedural knowledge (McCloy et. al, 1994:493-495).

Applying this definition to the confines of this study, we seek to understand what declarative knowledge (admission requirements) predicts a specific performance component (graduate GPA.) AFIT requires undergraduate GPA, transcripts (individual course grades,) and GMAT or GRE scores for consideration of eligibility. The decision to issue a letter of eligibility is based primarily on these factors (AFIT Catalog, 2002: 8). However, when applicants do not meet the eligibility requirements and faculty must examine records to determine whether or not to waive requirements, the process becomes very subjective. Faculty members need guidance about what to look for other than their own experiences in academics and in the professional working environment. Literature shows factors other than GRE/GMAT scores and undergraduate GPA which could have predictive capabilities include undergraduate school rating, degree type, age, gender, time since degree completion, and work experience. The literature provides numerous studies seeking correlations of some form of declarative knowledge, procedural knowledge and skill, or motivation to performance components, with mixed results (House, 1994; House 1989; Hoefer and Gould, 2000; Nilsson, 1995).

Undergraduate Grade Point Average.

Like most colleges, undergraduate GPA is one criterion AFIT examines for admission to their graduate programs (Kuncel et al., 2001; AFIT Catalog, 2002). Some

of the arguments against using undergraduate GPA are the inconsistent grading of individual professors across multiple disciplines in different schools as well as the suggestion of logical circularity of predicting GPA from GPA (Willingham, 1974: 275). However, using the same argument of logical circularity, Willingham also points out there is no other measure better to predict performance than that which has been used to measure the same performance in the past. Also, having different undergraduate GPAs across several different fields and schools tend to average each other out (Goldberg and Alliger, 1992: 1025) Undergraduate GPA is possibly the most widely examined criteria of any college (undergraduate or graduate) admissions departments (Willingham, 1974: 274; ETS, 2004; Kuncel et. al, 2001: 166).

In the literature reviewed for this study, nearly all the validity studies done by or for the ETS included undergraduate GPA as a possible predictor of graduate school success, along with the standardized test scores (Harnett and Willingham, 1979; Zwick, 1990; Wellington, 1976). Harnett and Willingham (1979) do not believe grades are the optimal predictor of success, but they are useful in other ways. Grades can be used to produce motivation in students, to serve students as a tool for feedback, and to function as a good summary of a student's education (Harnett and Willingham, 1979: 13-15). Many researchers at ETS (ETS, 2004) agree that undergraduate GPA is not the best predictor of success, but at the present time, it is most certainly one indicator of past success and should be considered in admissions to undergraduate and graduate schools, preferably along with other measures. Zwick (1990) examined the predictability of undergraduate GPA along with GMAT scores in doctoral programs and found undergraduate GPA alone is not a very good predictor of success, but combined with

other factors, such as GMAT/GRE scores, can yield very positive results. In fact, Zwick maintains that the undergraduate GPA and standardized test scores together work as much better predictors of doctoral program success than master's program success, in part due to the more selective process of doctoral students.

Similarly, outside studies and meta-analyses have included undergraduate GPA as a predictor of success (Kuncel et. at, 2001; Willington, 1974; Abedi, 1991). Hoefer and Gould (2000: 228) found undergraduate GPA had a correlation with graduate GPA of .25. Kuncel and others (2001: 169-170) found that when combined, undergraduate GPA ($r = .26$) and GRE scores ($r = .21$-$.24$) have lower predictability to graduate GPA than either variables alone (undergraduate GPA, $r = .30$; GRE scores, $r = .32$-$.36$). When Kuncel and others divided the population into sub-disciplines, undergraduate GPA predictability was high for the math and physical science departments ($r = .38$) and slightly lower for the social sciences ($r = .29$). In Willington's 1974 study (274), he found similar results (undergraduate GPA, $r = .31$). Yet in contrast, the GRE-undergraduate GPA composite showed a much stronger correlation to graduate GPA ($r = .45$). Abedi (1991: 158,) on the other hand, completely disagrees with Kuncel and others as well as Willington and found undergraduate GPA "has virtually no relationship with any of the measures of academic success." He contributed the findings to a skewed relationship in undergraduate GPAs, noting that those with low undergraduate GPAs would typically not apply to graduate school.

General Records Examination and Graduate Management Admission Test.

The Educational Testing Service (ETS) is the administrative body which collectively develops and administers more than 12 million tests worldwide, including the

Graduate Record Examination and the Graduate Management Admission Test. It is vitally important to the ETS, and is included in their mission, vision, and values, that their tests be both valid and fair to all students regardless of race, language, gender, age, or any other individual characteristics (ETS, 2004). However, realizing no test is perfect and that the results of standardized tests make up only a portion of the capabilities of an individual, they caution institutions to use more than GRE/GMAT scores to determine admissions and also discourages the use of GRE/GMAT "cut-off scores" whereby the school will not consider applicants with a "lower than" GRE/GMAT score (ETS, 2004). Several studies by the Educational Testing Service (ETS) as well as other academic institutions have conducted validation studies on both the GRE and GMAT examinations (Morrison and Morrison, 1995; House, 1997, 1998; Zwick, 1990; Nilsson, 1995; Kuncel et al., 2001) but repeatedly encourage institutions to conduct their own validation study due to the complete disagreement of the academic community as to the predictive capabilities of any standardized test (ETS, 2004). GRE/GMAT scores will be included in this study in an effort to continuously validate AFIT's current practices.

In Morrison and Morrison's (1995) meta-analysis of the predictability of the GRE, they found moderate correlations with graduate GPAs (GRE-V, r = .28; GRE-Q, r = .22). The sample was taken from twenty-two published studies from 1955 to 1992. J. Daniel House (1999) found similar results in his study of psychology master's students (GRE-V, r = .31; GRE-Q, r = .21) though the results in his (1994) study of education master's students were slightly lower (GRE-V, r = .275; GRE-Q, r = .18). Kuncel and others (2001) conducted a meta-analysis across 1,521 studies yielding 6,589 correlations within the database, by far the most inclusive meta-analysis to date. Not only have they

included far more studies than any previous meta-analysis, but they have also examined correlations across multiple disciplines using eight criterion measures. The study supports the use of the GRE for predictive capability of graduate success (GRE-V, r = .34; GRE-Q, r = .32).

Validity studies of the GMAT are conducted much less than for the GRE. The GMAT is the standardized test specifically designed to "help business schools assess the qualifications of applicants for advanced study in business and management" (GMAT, 2004). While AFIT will accept scores from the GMAT, applicants overwhelmingly use GRE scores. Considering a portion of AFIT focuses on a management discipline, perhaps the GMAT would serve as a better predictor of performance for students applying to the disciplines within the management programs1. Nilsson (1995) conducted a comparison study between the GMAT and GRE using a population from a mid-sized southern college. Thirty subjects took the GRE and were enrolled in English, education, psychology, sociology, and music master's programs. Thirty others took the GMAT and were enrolled in Master of Business, Administration, Professional Accounting, or Public Administration programs. The results showed the GRE had a "moderate," though stronger, correlation to GGPA (r = .449) than did the GMAT (r = .231) (Nilsson, 1995). The literature was unclear whether Nilsson compared verbal and quantitative scores or only compared total scores of the GRE to total scores of the GMAT. The ETS clearly encourage schools to carefully consider any use of composite measures and guides those interpreting scores to view verbal and quantitative scores as separate and independent measures (ETS, 2004). It would be interesting to examine the results of the study by separating the tests.

Hoefer and Gould (2000) conducted a study in which the GMAT's quantitative, verbal scores, and undergraduate GPA together created the highest correlation with GGPA ($r = .45$; $r^2 = .20$) which supports the ETS's findings to combine the GMAT/GRE scores with the UGPA for best correlations with success in graduate school (ETS, 2004). An interesting finding in their study is that when they separated the subjects into part-time and full time students, the GMAT was a better predictor of performance for full time students. AFIT students for this study are all full time students. Also, Hoefer and Gould (2000) found the GMAT was more predictive for females than males, older students than younger, and students from tier 1 schools than tier 2 schools (undergraduate school rating according to "America's Best," *US News*, 1996).

Peiperi and Trevelyan (1997) also looked at characteristics other than the GMAT, though the focus of the study was GMAT predictive capabilities. The GMAT verbal test had a higher correlation to final GPA than the GMAT quantitative test. Also, Peiperi and Trevelyan found the GMAT was more predictive for younger students than older (contradictive to Hoefer and Gould,) married students than single, and that gender and work experience had no significant relationship with GGPA (contrary to House, 1994). However, there were no correlation values or evidence to back up the claims of this study. Disagreements about what factors are not the only thing academics focus on. They cannot even agree on an acceptable correlation level.

In the meta-analysis performed by Morrison and Morrison (1995), the authors concluded the GRE-V and GRE-Q scores accounted for such small variance as to be, "useless from a prediction standpoint" (Morrison and Morrison, 1995: 313). Similarly, Ahmadi and others (1997) found the GMAT together with UGPA did not sufficiently

predict graduate success, though their results showed a correlation between GMAT and GGPA to be higher than most studies reviewed (r = .433) (Ahmadi et al., 1997). Ahmadi and others concur with the ETS's philosophy that other factors should also be considered when admitting graduate students. Goldberg and Alliger (1992) conducted a meta-analysis across 10 studies and found correlations considerably lower than Morrison and Morrison as well as Kuncel and others (GRE-V, r = .15; GRE-Q, r = .15), yet found the GRE to be a significant predictor of success in graduate education. Most agree the GRE/GMAT and UGPA cannot be the only criteria graduate schools look at when considering admissions. They cannot universally measure a student's motivation, commitment, ability to work autonomously, ability to work as a group, and many other traits necessary to succeed in a graduate program (Harnett and Willingham, 1979; Science, 1993; Walpole, 2002; Willingham, 1974).

Other Predictors of Success found in the Literature.

As mentioned earlier, many other predictors have been examined to determine their correlation to graduate school success: age, gender, work experience, motivation, general cognitive abilities, specific cognitive abilities, ethnic background, undergraduate school attended, marital status, course background, and first year graduate GPA. However, research results often yield more contradictions about which variables are good predictors and which are not.

Ree, Earles, and Teachout (1994: 519-521) found sufficient evidence to suggest job or school performance is based primarily on cognitive ability. They argue specific abilities are not necessary in today's workforce and employers as well as academic institutions look at general knowledge more than specific knowledge. Their findings lend

support to standardized exams being good predictive tools of graduate success. Similarly, as mentioned before, McCloy, Campbell, and Cudeck (1994: 493-494) found performance is a reflection of declarative knowledge (like standardized exams,) procedural knowledge and skill (like hands-on job experience and training,) and motivation (deciding to expand a certain amount of effort for a certain amount of time.)

Interviews with graduate faculty (Walpole, 2002: 9-10, 14) indicate use for more qualitative measures when selecting students for graduate school, such as evidence of a fit between student and program goals, writing/communication, integrity, fairness/openness/honesty, trustworthiness, maturity, responsibility, work habits, and consistency. Walpole's subjects support the use of applicants submitting a written statement to admissions stating why they want to attend the institution and what their goals are to assess students' writing skills and fit of the student to the program. Others (Hoefer and Gould, 2000: 229; Willingham, 1976) agree, qualitative measure should be used, though most seem to be unable to offer ways to quantify qualitative student information other than through the use of interviews, which, given the large numbers of graduate applicants, do not seem to be practical. The ETS (2004) has added a written exam in addition to the quantitative and verbal sections of the exam (something the GMAT already includes) to assess writing skills, but many institutions (such as AFIT) do not require the assessment portion of the exam for entrance.

Gender is sometimes used as a predictor of success in graduation success studies, though it comes with such mixed results, it doesn't seem very practical a distinguisher of applicants. Hoefer and Gould (2000) as well as House (1994) found gender to be moderately, yet negatively, correlated to graduate GPA, meaning females performed

better in graduate school. Perperi and Trevelyan (1997) and Paolillo (1982) found gender had no correlation or predictive capability of graduate GPA. It is interesting to consider, however, how many institutions would reject applicants based on gender if gender showed a high correlation to GPA. The same could be said for age and marital status correlation studies, though researchers continue to look for correlations of different age groups with graduate GPAs (Hoefer and Gould, 2000; House, 1998; Peiperi and Trevelyan, 1997). None reviewed in this study revealed any consistent significant differences.

Degree type can make a difference in graduate success in the science and engineering fields due to the specific nature of work in these disciplines (Van Scotter, 1983). Faculty ratings have also shown to have predictive capabilities. Kuncel and others (2001: 172) examined 190 records in which faculty ratings in verbal abilities as well as quantitative abilities correlated highly with graduate GPA ($r = .40$ and $r = .41$ respectively). However, not all students have faculty ratings, they are extremely subjective, and have not shown to be a valid measurement of students' capabilities (Harnett and Willingham, 1979). Kuncel and others also examined the predictability of first year graduate GPA which correlates moderately with graduate GPA ($r = .15$-$.27$), but if an applicant has not previously attended graduate school, admissions cannot rely on this measure as appropriate. Previous work experience has the same limitations as first year graduate GPA, and it has not shown to have significant predictability to graduate GPA (Peiperi and Trevelyan, 1997: 356) This study contradicts research by McCloy and others (1997), but supports Ree and others' research (1994) that general cognitive ability is all that really matters when predicting performance.

Although the literature has produced many research papers and studies about the predictive abilities of measures other than standardized tests and undergraduate GPA to graduate GPA, none have provided very useful tools to graduate institutions. Even standardized tests, undergraduate GPAs, and written exams have provided very mixed results for the general graduate admissions process. Like other schools, AFIT must rely on the tools it has been given to assess candidates for its programs.

AFIT Specific Research

Currently, at least nine studies have been conducted for AFIT, in-residence, master's students about the predictability of success. Six theses have focused the research on one or two particular disciplines at AFIT (Garwood, 2002; Zitzmann, 2002; Spangler, 1989; Prokopyk, 1988; Humphreys, 1983; Keith, 1977). Similar to other literature examined, the studies clearly show there is no consistent variable to predict success at AFIT. One purpose of validation studies, however, is to find the most predictive variables possible to help admission department look for the best combination of factors when selecting students for their specific programs (ETS, 2004).

In 1977, Keith conducted the first predictability studies for AFIT's Graduate Systems Management and Graduate Operational Research programs. The study included 223 male U.S. Air Force officers from 1971-1976, a time when the admission requirements and rules of graduation were quite different than they are today (Keith, 1977: 52-54; AFIT Catalog, 2002: 9-11). Keith used the traditional GRE/GMAT scores and undergraduate GPA as measures of ability, AFIT volunteer status and number of pre-admission tests as measures of motivation He also used marital status, age, time since

graduate degree, etc. as additional factors that could predict success at AFIT. At the time of the study, students either applied to AFIT (volunteers) or were centrally identified as highly qualified individuals and selected to attend AFIT (non-volunteers.) He found the most significant predictors of degree receipt (his first success criterion) were included in the motivational measures and marital status. Of the 23 students who did not receive a degree, ten of them were single, non-volunteers to AFIT; none were single volunteers. Twelve of the other thirteen students who did not receive a degree were married, over 30 years old, and had GMAT-T scores below 500 (or they did not take the test at all.) Keith (1977) concluded AFIT's admission measures were appropriate for assessing capability, but not for assessing motivation. He also concluded the GMAT-Q ($r = .437$, $r^2 = 19.1$) was the most predictive of graduate GPA (his second success criterion) and the GMAT was more predictive than the GRE for these two programs.

In Humphrey's 1983 study of the Graduate Engineering Management program, he examined 24 different variables to predict graduate GPA for a sample of 194 male U.S. Air Force officers. Humphrey's definition of success is a little different. He states success is measured by whether or not a student completed the requirements on time or not (degree receipt/non receipt,) but then categorized three different level of success based upon graduate GPA. Twelve subjects did not graduate on time. Humphrey found age, years in the military, months since undergraduate degree, architectural degree and previous math experience to be contributing factors of success for this particular sample. However, some of his results could be questioned since there was only one student in the study who received an undergraduate architectural degree. Contrary to most other studies in this literature review, GRE and GMAT scores apparently did not play a significant role

in the prediction analysis though he contributes this finding possibly due to the way the data was manipulated during the course of the study (GRE-Q, r = .055; GRE-T, r = .096).

Prokopyk (1988) conducted a research study on the Graduate Operations Research and Graduate Strategy and Tactics programs. Unlike Keith (1977), Prokopyk used only graduate GPA as the success criterion, though he used as many as 29 different predictor variables in his study. His findings were different from Keith's eleven years earlier. He found undergraduate GPA to be the most significant factor in predicting graduate GPA, supporting the belief that past performance predicts future performance (Willingham, 1974). He also made the conclusion, that although only two programs were studied, each variable's correlation to graduate GPA was different according to which program students were enrolled in.

Spangler (1989) studied the Graduate Logistics Management (GLM) program from 1986 – 1989 (N = 140). The research included eighteen predictor variables at the beginning of his study, but in the end, found only a few variables which offered significant correlation with graduate GPA. Although Spangler agreed with Prokopyk's (1988) conclusion about undergraduate GPA, he chose to add a variable of undergraduate GPA multiplied by a school ranking score, based upon where the undergraduate degree was obtained and how difficult the school's admission requirements were (RATGPA). RATGPA's correlation was much stronger than that of undergraduate GPA alone (r = .24 vs. r = .48). Spangler also looked at undergraduate math grades and courses to be predictive of graduate GPA, but found little correlation. This is not surprising since the GLM requirements for graduation do not include many mathematics courses (AFIT Catalog, 2002: 161-162). Other significant correlations were the GMAT-V (r = .449,)

GRE-T (r = .483,) and GRE-Q (r = .502). Interestingly, Spangler conducted a smaller study within the study using a small sample of 1989S students who completed a motivational survey with stronger results than any other measure (r = .514) clearly supporting many views that motivation is a key factor in graduate school performance (McCloy et. al, 1994; Roth et. al, 1996; Keith, 1977).

Zitzman (2002) and Garwood (2002) completed the most recent predictability studies only two years ago. Zitzman's study included a sample size of 146 students from the 1995-2002 Graduate Engineering and Environmental Management program. Garwood's study included 106 students from the 1992-2001 Graduate Cost Analysis program. Zitzman measured admission requirements' (undergraduate GPA, GRE-V, GRE-Q, and undergraduate math GPA) correlation to four success criteria (graduate GPA, thesis grade, coursework graduate GPA, and first year graduate GPA.) Overall, the GRE-V scores, GRE-Q scores, and undergraduate GPA correlated with graduate GPA, coursework graduate GPA, and first year graduate GPA. However, no admission requirements significantly predicted thesis grades (perhaps due to the largely skewed grade distribution) and the undergraduate math GPA did not significantly correlate to any of the success criteria (despite the overwhelming number of undergraduate engineering degrees). Again, however, the graduate degree focus is management, not applied engineering. Interesting to note, Zitzman (2002) conducted regression analysis on rank, undergraduate school, gender, and ethnicity, but due to the small representation of women and minorities (AFIT is historically white, male dominated,) he was unable to detect any significance for gender or ethnicity. Needing significant representation of groups within the sample was further emphasized by a good representation of variety of

rank and undergraduate schools, where significance was noted, though the variance explained was not significant enough for the variables to be considered an important factor in his study.

Garwood (2002), also noting the skewed distribution of thesis grades, removed them from the final graduate GPA and based success primarily upon the adjusted GPA. He conducted analyses on both GPAs, but found the adjusted GPA worked best. The GMAT-T scores had the highest correlation to adjusted GPA (r^2 = .201,) which suggests the GMAT should be the standardized test of choice for the AFIT Cost Analysis program, another management program. He also concluded the GRE-Q had much more predictive capability than the GRE-V (r^2 = .194 and r^2 = -.032 respectively.) Garwood (2002) goes so far as to say the GRE-V score should not even be considered in the admission criteria of future students. Also important to note, undergraduate GPA had low predictability on its own, but when added with other variables such as GMAT/GRE scores, its significance increased dramatically, supporting the ETS recommendation to use both factors when assessing prospective students (ETS, 2004). Similar to Zitzman's (2002) findings, Garwood (2002) found undergraduate math scores had no significance in any of the models tested. Work experience oddly had a negative effect on final grades; the more work experience and time in service a student had, the worse the GPA. This begs the question of how valuable the individuals with considerable work experience consider the AFIT degree and what they believe is essentially important in their careers as officers. Prior enlisted students never received a grade higher than 3.8 or lower than 3.2; however, no obvious correlation significant enough to be of consequence in this study. One other finding was interesting in Garwood's study: contrary to Spangler (1989) and Hoeffer and

Gould (2000,) but in accordance with the findings of Zitzman (2002,) undergraduate GPA combined with an undergraduate school ranking had no significant predictive capability for the Cost Analysis program population.

Although justification of research within individual disciplines is certainly valid and encouraged (ETS, 2004), it is appropriate to conduct another AFIT-wide study to include the science and engineering departments within the analysis. We expect to notice differences in predictive variables across disciplines, but it is unclear what types of differences we will find. At least three AFIT thesis studies have focused on AFIT-wide predictive capabilities and application (Van Scotter, 1983; Buckley, 1989; Sny, 1991;). All have concluded what we have already noticed in other AFIT studies: no one or two predictors are the same for any program, or even any of the different research years presented.

Van Scotter (1983) examined a population of 2170 students across AFIT from 1977-1982. He found no admissions criteria significantly correlated to graduate GPA for all programs. For example, GRE-V had significant values for only 6 of the 17 masters programs and that was the highest correlated variable. His findings, however, supported his hypotheses, which were all to determine that each program's needs were different, not to find the most predictive admission criteria. He proved his hypotheses to be true in every aspect. The variance for each predictor variable (GRE/GMAT scores, UGPA, prior service, rank, time in service, etc.) was so great from program to program, Van Scotter could make very few solid conclusions. He did mention, however, prior enlisted students performed generally worse than those with no prior service and that although undergraduate GPA and GRE/GMAT test scores were not significant across all programs,

he believes they should still be used to make admission decisions above subjective "passes" into AFIT.

Sny (1981) examined a population of 4507 from 1975-1987 which duplicated Van Scotter's thesis efforts, though expanded the time frame. Buckley's (1989) thesis covered the time period of Van Scotter and Sny together (1977-1987) minus two years in the beginning to give a comprehensive view of the two theses combined (N = 4170). Sny and Buckley both used undergraduate GPA, GRE, and GMAT scores as predictor variables, though Sny also included students' age, enlisted years of service and commissioned years of service. Collectively, they both concluded no variables were consistent across all programs, though the GRE/GMAT scores had generally more predictive capabilities than other factors. When they broke the population into sub-populations according to program, there was often not enough data to give any significant results for any program. This could be due to the lack of information technology and poor record keeping of AFIT (Baker, 2004) of student information. Although the researchers had sufficient populations, missing data fields probably contributed to low uses of predictor variables in their analyses. This could also be true for Van Scotter's results as well.

Although only three of the nine studies examined in this literature review were conducted for all of AFIT programs and departments, no study has been conducted to include all AFIT students in over ten years. According to registration officials, record and data keeping are still deficiencies being worked on at AFIT (Baker, 2004). With the increase in information technology, every graduate school should keep records of students if, for no other reason, than to validate school policies and admission criteria.

This research effort will only include the last three years of data from AFIT in an effort to validate current practices of admissions, which are very subjective and "loose" in accordance with the educational testing service recommendations (AFIT Catalog, 2004; ETS, 2004) that many factors be examined when admitting students to graduate programs.

Summary

This chapter has review historical and current literature in the area of predictive capability of admission requirements to graduate schools. First, a thorough review of literature about success criteria was examined. Although a variety of success criteria exists, graduate GPA appears to be the most appropriate criterion for this study. Next, GRE/GMAT scores, undergraduate GPA, and other criteria were examined for their predictive capabilities of graduate school success. Although no researcher agrees on specific predictive criteria, several studies have shown varying results for each of the criteria which will be used in this study. And finally, this chapter covered AFIT specific research in the area of predictive admissions criteria through the years and programs. Once again, no specific criteria demonstrated to be the most significant for different studies or programs, validity studies have been necessary to AFIT's administration when reviewing standards of admission throughout its history. Chapter 3 will explain the methodology used in this validity study for AFIT admission requirements.

III. Methodology

Chapter Overview

The purpose of this chapter is to examine the methodology for this research effort. The study is a validation study to satisfy that the requirements of AFIT admissions are appropriate and valid. We seek to find correlations of undergraduate GPA, GRE/GMAT scores, and graduate GPA. In addition, we seek to discover if students who require a waiver perform as well as, worse than, or better than students who do not receive a waiver for admissions. This chapter will present the data collection methodology, research design, research analysis methods, and the restrictions and limitations.

Data Collection

The data for this effort was obtained from two separate databases. Military data about students was obtained from the Air Force Personnel Data System from the military personnel flight at AFIT. Academic information was obtained from the computer support personnel at AFIT. The data was then combined in a single excel spreadsheet for use in the study. Permission to view student records was given in accordance with the Air Force Instruction 33-332, Privacy Act Program, paragraph 12.4.5, exception 5 and the Family Educational Rights and Privacy Act of 1974 as Amended, section 34 CFR § 99.31 (a)(1).

Data was collected on 311 full time military, master's students entering the residence program at AFIT full time in 1999, 2000, and 2001, graduating in 2001, 2002, and 2003 respectively. Academic data collected on each student included undergraduate

GPA, GRE and/or GMAT scores, graduate GPA, start time into AFIT, and graduation date. Other information collected on each student included active duty service time, date of commissioning (to determine whether or not a student had prior enlisted service time,) primary Air Force Specialty Code (possible prior work experience,) marital status, gender, and number of people within the household. Once the data was consolidated for each student, a randomly assigned identification number was assigned to each record and all names or identifying information was deleted from the files. All data was handled within the limitations of the Privacy Act of 1974.

Research Design

As the literature reviewed showed, the results of similar predictability studies at AFIT, other institutions, and across institutions have very mixed and sometimes competing results. A correlational study, like the research shown in Chapter II, "examines the extent to which differences in one characteristic or variable are related to differences in one or more other characteristics or variables. A correlation exists if, when one variable increases, another variable either increases or decreases in a somewhat predictable fashion" (Leedy and Ormrod, 2001: 191). The purpose of this study is not to examine every contributor to the success or failure of graduate students since no measure exists which can include all the contributing factors of success or failure ("Predicting Performance in Graduate School", 1993: 494). The purpose is to validate current admission criteria and to understand if waivers should be given to students who do not meet the guidelines set for admission criteria. Therefore, the design of this research is to

choose which success criterion and predictor variables contribute solely to the objectives of the study.

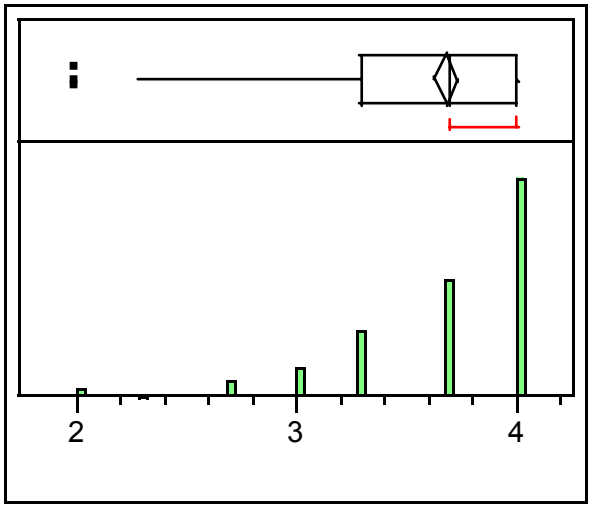
Success Criterion

As previously mentioned, the success criterion for this study will be academic achievement measured by graduate GPA. Ultimately, the success of a student at AFIT is degree attainment, though the GPA will be a good determinant of what students have learned in their coursework. Two of the Higher Learning Commission's proposed criteria for accreditation include "student learning and effective teaching" and "acquiring, creating, and applying knowledge" (HLC, 2003: 6-7). The measure of a GPA has proven to be a widely accepted measure of learning and student progress (AFIT Catalog, 2002: 27, 29-30; Walpole et. al, 2002: 12).

A review of the literature showed other measures of academic achievement were not applicable to the students at AFIT. For example, number of publications and comprehensive exams are not a requirement of graduation. Time to completion and degree attainment are not appropriate measures of success due to the fact that almost all students graduate in the 18 month period. The few who do not would not statistically make a difference in this study. Previous studies (Garwood, 2002: 43; Zitzman, 2002: 60) have shown thesis grades heavily skewed towards higher grades. Garwood theorizes this is due to the fact that the advisor, who assigns the thesis grade, has reviewed the document so many times that the final thesis is tailored to what the advisor is looking for, "even if the student lacks the ability to produce that quality of document on his/her own" (Garwood, 2002: 43). As was the case in Garwood (2002) study, the thesis grades for this study are also skewed (Figure 1). However, this study is looking at the student's

entire graduate experience which includes the thesis grade in the undergraduate GPA. Thesis grades will be included in the final GPA of students and not considered a separate measure of success.

Figure 1. Distribution of Thesis Grades



Graduate GPA was collected as a portion of the data from computer support data system. Courses with a pass/fail grade or 0.0 credit hours (such as math laboratories and colloquium courses required of all students) are not calculated into final grades. Also, any transfer credits from previous graduate studies are not included in the AFIT final GPA. Calculation of the final grade is figured by individual grades for courses multiplied by the credit hours assigned to that course, added up and divided by the number of total credit hours for all courses added together. The AFIT grading scale shown in Table 1 (AFIT Catalog, 2002: 24).

Table 1. AFIT Grade and Points System

Grade	Points	Grade	Points
A	4.0	C+	2.3
A-	3.7	C	2.0
B+	3.3	C-	1.7
B	3.0	D	1.0
B-	2.7	F	0.0

It is important to note that after a reorganization of the structure of AFIT, the thesis grade increased in worth to 16.7% of the final grade, whereas it used to be only 12.1% of the final grade (Garwood, 2002: 44). This could be due to the emphasis AFIT places on research and independent study. Part of AFIT's mission is to "engage in research activities that enable the Air Force to maintain its scientific and technological dominance" (AFIT Catalog, 2002: 3). The thesis is an important part of each student's education and is reflected in the final GPA, our success criterion.

Predictor Variables

As discussed in chapter two, several variables have been used in the past to predict graduate school performance such as: undergraduate GPA, GRE/GMAT scores, faculty rating/ranking of students, letters of recommendation, gender, marital status, and age. This research effort will focus on the current admission criteria for the whole school as predictor variables. Admission criteria vary slightly between individual programs, though the scope of this study will be overarching programs and we will not examine the differences. For example, the engineering programs require an undergraduate degree in engineering, which we will assume all students accepted into the program have obtained. Certain programs also require undergraduate math courses through algebra or calculus, depending on the math requirements for the master's degree.

Also, this study will mainly examine predictive variables which are practical and logical for use by AFIT. For example, we will not examine if age, or marital status have correlation to graduate GPA because AFIT faculty would not typically use those variables to determine a student's eligibility to attend AFIT. Our main focus will be on the predictability of undergraduate GPAs and GRE/GMAT scores, the primary criteria for admissions into AFIT (AFIT Catalog, 2002: 9).

Undergraduate Grade Point Average

Undergraduate GPA is required for admissions into AFIT. The GPA must be at least a 3.0 on a 4.0 scale from a regionally accredited university college (AFIT Catalog, 2002: 9). Once AFIT receives the transcripts of a prospective student, their undergraduate GPA is configured according to AFIT operating procedures. The GPA is based upon all courses taken, with no credit given for pass/fail courses or courses which were audited. Any course that was taken twice is counted twice. For example, if a student failed a course the first time (quality point = 0) and retook the course for a better grade and received a B (quality point = 3,) both the 0 and 3 are added to the total quality point value in the registrar's new undergraduate GPA configuration and both courses are included when computing total course hours taken.

Reconfigured GPAs only figure in whole letter grades; all plusses and minuses are omitted (i.e. B+, B-, and B all receive a new score of 3.0). If the school uses a grading scale of 5.0 and no grades are assigned to classes, AFIT converts the points into the uniform scale based upon the instructions on the transcripts. If no instructions exist, admission counselors from AFIT will call the undergraduate institution to request more information about their grading system. All grades are assigned a point value based upon

the following scale: A = 4.0; B = 3.0; C = 2.0; D = 1.0; and F = 0.0. If a student has studied at the graduate level at another institution, less weight may be placed upon the undergraduate record. However, if the prospective student's undergraduate GPA is below a 3.0, he/she will still require a waiver to attend AFIT (Hoon, 2004). The value of the AFIT system is to allow students to be evaluated for admissions based upon a standardized system.

The undergraduate GPA for all students is maintained in their academic records as well as within the AFIT database. Undergraduate GPAs for this study were obtained by the computer support personnel at AFIT. Any missing undergraduate GPA fields within the database were manually populated by going back to the student's original, hard-copy records. All data was handled with the guidelines set forth in the Privacy act of 1974.

Graduate Record Examination/Graduate Management Admissions Test

The GRE is divided into three separate tests, two of which are required for entrance to AFIT. The admission criteria state a student must meet or exceed a score of 500 on the GRE Verbal reasoning exam (GRE-V) and a 600 on the GRE Quantitative reasoning exam (GRE-Q). A student may also submit a score that meets or exceeds 550 on the total GMAT examination.

The GRE-V scores have a range from 200 to 800 with a mean of 469 and a standard deviation of 119. Students who receive a score of 500 on their exam, the minimum score for entrance into AFIT, performed better than approximately 59% of all students who took the exam from 1 July 1999 through 30 June 2002. The GRE-Q scores have the same range with a mean of 591 and a standard deviation of 148. Students who receive a score of 600 on their exam, the minimum score for entrance into AFIT,

performed better than approximately 48% of the other students taking the exam during the same year period mentioned above (ETS, 2004).

Although GRE Analytical reasoning (GRE-A) scores are not required for admissions into AFIT, they will be included in this study. The GRE-A includes writing tasks of "issue" and "argument." The range for GRE-A scores is from 0 to 6, given in half point increments. Students who took the exam from 1 July 1999 through 30 June 2002 who scored 4.5 or higher scored better than approximately 47% of examinees; 5 or higher scored better than 67%; and 5.5, 84% higher (ETS, 2004). However, in the data received from computer support, the scores have been converted into a range from 200 to 800 similar to the GRE-V and GRE-Q scores.

The GMAT total scores have a range from 200 to 800 as well, with a mean of 528 and a standard deviation of 112. Students who completed the GMAT from January 2000 through December 2002 and scored 550, the minimum required score for eligibility into AFIT, scored higher than 54% of other examinees (GMAT, 2004).

AFIT Program, Air Force Specialty Codes, and Prior Work Experience

The program each student is assigned to will be examined separately as well as in comparison to each other. The data collected contains students from each of the following programs: Logistics Management (GLM); Information Resource Management (GIR); Applied Physics (GAP); Astronautical Engineering (GA); Computer Systems (GCS); Operations Research (GOR); Electrical Engineering (GE); Graduate Acquisition management (GAQ); Space Operations (GSO); Aeronautical Engineering (GAE); Meteorology (GM); Engineering and Environmental Management (GEE); Computer Engineering (GCE); Nuclear Engineering (GNE); and Electro-Optics (GEO). The

purpose of correlating the students in each program with graduate GPAs is to possibly establish a base-line between programs for total institution correlation with graduate GPAs. The students in each program typically have similar courses and professors. If the students in one program maintain high graduate GPAs while students in another program maintain low GPAs, questions could arise as to the level of students each program accepts or to the standards of grading and/or individual attention program directors and faculty within the program give to students in their programs. The quality of instruction a student receives from program faculty members can also be a reflection of the ratio of students to professors in the separate programs as well.

We will examine the correlation of Air Force Specialty Codes, prior work experience while in the military, and prior enlisted time as variables to predict graduate GPA. Though the education at AFIT is similar in many ways to the general education a student would receive at any institution, many examples in class as well as thesis topics are focused on real situations an individual might experience in future career positions within the military. Program directors and faculty members who decide upon waiving requirements into their program could possibly make a better informed decision based on how much work experience a prospective student has in the area of program studies.

All the predictive variables chosen for this study have usefulness to AFIT faculty members as well as the students themselves. As more students apply for and/or are chosen for AFIT, waivers could become standard practice. Currently, the main focus of admissions is upon undergraduate GPA and standardized test scores, but as more researchers give conflicting results from validation studies, AFIT must rely on more subjective methods of granting admissions and waivers for admission. The predictive

variables within this study are quantitative examples available within student records which they can rely on to make decisions about students who might require admission criteria to be waived.

Research Analysis Methods

The first two investigative questions of this study are: 1) Do current measures of capability, such as the GRE or GMAT standardized tests, have any predictive capability on AFIT student performance? and 2) Do current measures of past performance, such as undergraduate GPAs, have any predictive capability on AFIT student performance? Although the main focus is on current admission criteria, we will also examine the predictability of the variables mentioned above. The research analysis regarding predictability of graduate performance will be through a multiple regression model. The final two questions, 3) Is there a difference in performance between students who meet all admissions requirements and those who require a waiver? and 4) Is there a difference in performance depending on which admission requirement is waived (GRE/GMAT scores or undergraduate GPA)?, will be examined using a paired difference experiment to determine if there is a significant difference between the populations in question.

Multiple Regression Model

Many factors contribute to the success of graduate school students. One way to analyze the correlations of the different variables which contribute to success is through multiple regression analysis. Multiple regression models are probabilistic models that incorporate more than one independent variable and typically follow the general form:

$$E(y) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k + \varepsilon$$

where y, the dependent variable, is a function of k independent variables ($x_1, x_2, \ldots x_k$), β_k weightings which describe the contribution of the independent variable x_k, and and error term, ε, which represents the random error within the equation to make it a probabilistic model rather than deterministic (McClave et. al, 2001: 534). The purpose of using a multiple regression model is to predict a future response based on historical data. This study seeks to predict future graduate success at AFIT based on the success of previous students.

After data collection, several steps must be taken to determine the predictability of graduate success from our independent variables. Once the data is collected, the information must be "coded" into appropriate parameters for use in the software. The independent variables incorporated into this study include: undergraduate GPA, GRE-V scores, GRE-Q scores, GRE-A scores, GMAT scores, Air Force Specialty Codes (AFSC,) prior enlisted experience, prior work experience (work exp,) program assigned to at AFIT (program,) gender, number in household, rank, and SCI/MGT (a dichotomous variable indicating if a student is in a scientific program (0) or management program (1). Because the undergraduate GPA and test scores are numeric, they will be entered exactly as they appear. However, prior enlisted experience will also be a dichotomous variable coded one (1) if they have prior experience in the military and zero (0) if not. The independent variable work experience will be coded as the number of years a student has in the military prior to entrance to AFIT, including prior enlisted time. Each program will be coded using dummy variables. A list of the codes for dummy variables can be found in Appendix A. For example, if a student is assigned to the GAE program, the

code entered will be 1, GAI will be 2, etc. One program must be coded 0 to create a baseline for the software to interpret the information. In this study, the baseline 0 code will be assigned to the GA program. A list of AFSCs and their dummy codes can also be found in Appendix A.

Next, scatter plot graphs were generated to examine any correlations the independent variables have to one another. The purpose of this step is to determine if redundancy in the data exists. For example, if GRE total scores were one of our independent variables, the scatter plot graphs would show a high correlation of the GRE total scores with GRE-V, GRE-Q, and GRE-A scores. This would indicate redundancy in the data and one of the variables would not need to be placed in the model. In fact, if redundancy exists in the model, we will not achieve the results we would like to see, but will incorporate biases within our analysis.

Scatter plot graphs with each individual independent variable with the dependent variable will give indications of which variables have some predictive capability. A pattern in the graph will show positive or negative correlations to graduate success and can help us determine which variables to include in our full regression model.

The full regression model is not our final model, though we will treat it as one before we begin paring it down to the kernel model. The kernel model is the best fit model with the existing data, the most predictive model achievable given the data which exists for the study. At this point, several diagnostic tests must be completed on the full model as well as the reduced kernel model. A summary of fit test, analysis of variance, Cook's Distance plot, studentized residual plot, and a constant variance test will be conducted to determine the reduced kernel model is the best model available. The final

model will indicate the predictive probabilities that our independence variables have on graduate success, answering investigative questions one and two.

Tests of Hypothesis

Investigative questions (IQ) three and four seek to determine differences from at least two populations. First, IQ 3 seeks to determine if there is a difference in the graduate GPAs of students who require a waiver and those who do not. IQ 4 seeks to determine if there is a difference in graduate GPAs of students who receive a waiver for undergraduate GPA and students who receive a waiver for their standardized test scores. The statistical method used will be to make inferences through tests of hypothesis.

In IQ three, our two populations are 1) students who met all the admission criteria and 2) students who required at least one waiver to attend AFIT. This study proposes that there will be a difference in performance between the two populations, that the graduate GPA for students who meet all admission criteria will be larger than students who do not meet all admissions criteria. The null hypothesis is that there is no difference between the means of the sample graduate GPAs (1: students without a waiver and 2: students with a waiver). Our alternative hypothesis is that the difference in the means is greater than 0, or the mean graduate GPA of students who meet all the requirements is greater than the mean graduate GPA of students who do not meet all the requirements. He hypothesis test is as follows:

H_0: $(\mu_1 - \mu_2) = 0$

H_a: $(\mu_1 - \mu_2) \rangle 0$

The test statistic calculated will indicate whether or not the null hypothesis can be rejected. If the null hypothesis is rejected, it is important to remember the results do not

prove the students who receive a waiver have more success, only that statistical evidence suggests we can reject the null hypothesis, or that a positive difference in graduate GPAs exists. The formulas we will use to determine test statistic is:

$$\text{Large Sample TS} = \frac{(\text{Xbar}_1 - \text{Xbar}_2) - 0}{\sqrt{[(\sigma_1^2 / n_1) + (\sigma_2^2 / n_2)]}}$$

where n = sample size;

Xbar = sample mean; and

σ = sample standard deviation.

We will reject the null hypothesis if the value of the test statistic is greater than z_α, where $\alpha = .05$, which is the standard alpha for hypothesis testing. Assumptions for using hypothesis testing include: 1) the samples of graduate GPAs have an approximately normal distribution and 2) the samples are randomly selected from the population (McClave et al., 2001: 412-415). Our experiment meets both assumptions.

For IQ four, we used the same methodology as in IQ three. However, our data was divided into four subdivisions to reflect differences in populations of undergraduate GPA and the three separate exams. Our four tests were between the graduate GPAs of students who required waivers for: undergraduate GPA and GMAT scores; undergraduate GPA and GRE-V scores; undergraduate GPA and GRE-Q scores; and undergraduate GPA and both GRE-V and GRE-Q scores. Our hypotheses for each of the four are:

H_0: $(\mu_1 - \mu_2) = 0$

H_a: $(\mu_1 - \mu_2) > 0$, or $(\mu_1 - \mu_2) < 0$

where μ_1 is the mean of GMAT waiver students' graduate GPA, GRE-V waiver students' graduate GPA, GRE-Q waiver students' GPA, and GRE-V and GRE-Q waiver students'

graduate GPA respectively for each of the four tests; and μ_2 is the mean of undergraduate GPA waiver students' graduate GPA. The standard deviations and test statistics will be configured as follows:

$$\text{Large Sample TS} = \frac{(\text{Xbar}_1 - \text{Xbar}_2) - 0}{\sqrt{[(\sigma_1^2 / n_1) + (\sigma_2^2 / n_2)]}}; \quad \text{Small Sample TS} - \frac{(\text{Xbar}_1 - \text{Xbar}_2) - 0}{\sqrt{[S_p^2 * (1/n_1 + 1/n_2)]}}$$

where $S_p^2 = \dfrac{[(n_1 - 1) * S_1^2 + (n_2 - 1) * S_2^2]}{n_1 + n_2 - 2}$

n = sample size;

Xbar = sample mean; and

S or σ = sample standard deviation.

Due to the small sample size for three of the four tests (N ‹ 30), our test statistic will be measured against a z-value based on $n_1 + n_2 - 2$ degrees of freedom (McClave et al., 2001; 362). Assumptions are the same as in IQ three.

Model Validity

To test the validity of our regression model, a random twenty-five percent of the data will be removed before developing out model. Once the model is complete, we will run the models with the twenty-five percent to see if our results still hold. The desired outcome is for the R^2 value to be as good as it was for the reduced kernel model once the new data is entered. This will indicate a percentage up to 100% of the variance of graduate success (indicated by graduate GPAs) is explained by the independent variables (undergraduate GPA, test scores, gender, etc.) of our reduced models.

Restrictions and Limitations

The main restrictions and limitations of this research study are the restriction in range of student GPAs and test scores and the accuracy of the data.

The restriction in range is common in predictability studies for graduate success (Kuncel et. al, 2001). The issue is that GPAs and test scores are taken for students who are accepted into the school and, in AFIT's case, graduate from the school. It is difficult to determine how many, if any, students were turned down for AFIT eligibility, and the data for students who did not meet the admissions criteria is not available. The impact of range restriction is somewhat limited due to the fact that AFIT grants waivers into its programs. This means that we have a larger (and acceptable) range for our study, of undergraduate GPAs and test scores than if anyone who did not meet the criteria were automatically rejected from admissions. Similarly, graduate GPAs collected are for students who completed the program on time and graduated from AFIT. For the time covered in this study, only six students did not complete the program, though we do not have complete data for any of the five students and therefore cannot use them in the study. Only one of the five withdrew due to academic reasons and one passed away before completion of AFIT. However, due to the small number of students who did not complete the program, the missing data should not statistically affect the outcome of the research.

Data accuracy could also be a limitation to this research. The data was compiled from two separate databases and does not match up completely. Several students in one database are not included in the other and vice versa. The registrar's office at AFIT has been trying to correct this problem for several years and the last three years of data is

more accurate than any thus far (Baker, 2004). Missing data points could reduce our population for the study, though we still expect to have a significant representation of all programs within the institution.

Summary

This chapter has explained the methodology which will be used in this study. It discussed the data collection methods, research design, success criteria, and predictor variables to be used in regression analysis. This chapter also covered the specific hypothesis testing used to answer investigative questions three and four. Investigative questions were reiterated in statistical terms which will be the focus of this study. Finally, this chapter discussed model validity methodology and the restrictions and limitations of this research effort. The following chapter will be a compilation of the data analysis.

IV. Analysis and Results

Chapter Overview

The purpose of this chapter is to analyze the data from the statistical analysis described in the previous chapter and present the results in relation to investigative questions one through four. This chapter reviews the objectives of this study and the investigative questions individually along with the results of the analysis for each question. The multiple regression models developed for IQ one and two will be discussed as well as the hypothesis testing for IQ three and four. The chapter will conclude with a brief summary of the results, leading into the conclusion of this study.

Multiple Regression Modeling

Regression modeling was used for IQ one and two. Once the data was scrubbed for accuracy, a histogram of the dependent variable, graduate GPA, was plotted and determined to be relatively continuous in nature and the process was stochastic (Figure 2, Table 2).

When we developed models for all students based upon admission requirements and other variables, we did not come up with very significant findings. Therefore, we divided the data between the two schools of study at AFIT, Science & Engineering and Management. Three different baseline models were developed: The GRE Model for Scientists and Engineers; The GRE Model for Managers; and The GMAT Model for Managers. Due to multicolinearity and correlations of some independent variables to each other, program code and work experience were eliminated from the full and reduced

models. GRE-A was omitted from the baseline models because the models were used to determine the predictability of admission requirements. GRE-A is not currently an admission requirement and greatly reduced the number of data points which could be used for each model. For IQ one and two, graduate GPA was the dependent variable and combinations of the other independent variables were tried. Our focus was on GMAT, GRE-V, GRE-Q, and undergraduate GPA as predictor variables. However, various combinations were tried to include prior enlisted time, number of household members, gender, rank, and AFSC.

Figure 2. Graduate GPA Distribution Histogram

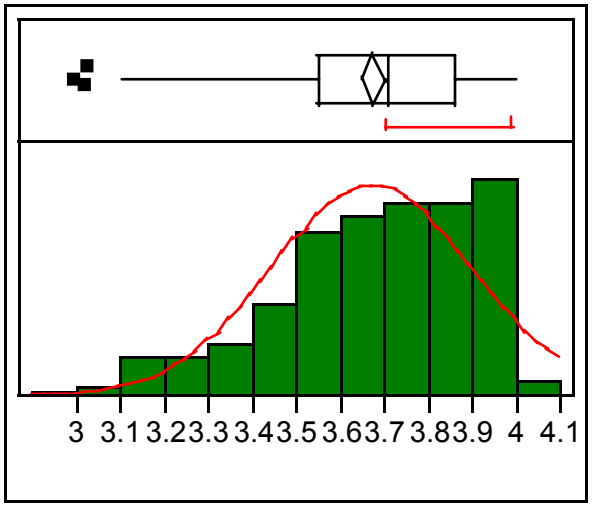


Table 2. Graduate GPA Goodness-of-Fit Test: Shapiro-Wilk W Test

W	Prob<W
0.942967	<.0001

GRE Baseline Model for Scientists & Engineers

The full model for Scientists & Engineers using GRE scores to predict graduate GPA included data from 112 students for the independent variables: undergraduate GPA; GRE-Q scores; GRE-V scores; Rank/Grade; prior enlisted; AFSC Code; Gender; and number of members in household. Eight data points were determined to be influential through the Cook's Distance Influential diagnostics and removed from the full and reduced model. The parameter estimates are shown in Table 3. All other diagnostics are included in Appendix B. The full model had an adjusted R^2 value of .1871 indicating approximately 19% of the variability in graduate GPA can be attributed to the independent variables used in this model.

Table 3. Parameter Estimates: Full Model GRE for Scientists & Engineers

Term	Estimate = β	Std Error	t Ratio	Prob>|t|
Intercept	2.2802035	0.302292	7.54	<.0001
UGPA	0.1913769	0.056618	3.38	0.0011
GRE-Q	0.0008058	0.000348	2.32	0.0228
GRE-V	-0.000094	0.000263	-0.36	0.7208
Rank/Grade	0.0539065	0.02944	1.83	0.0704
Prior Enlisted	-0.118499	0.04742	-2.50	0.0143
AFSC	0.0098429	0.008049	1.22	0.2245
Gender	0.1127232	0.094629	1.19	0.2367
In Household Desc COUNT	-0.005994	0.022332	-0.27	0.7890

Then, independent variables were removed through forward stepwise regression, one at a time, to determine the most robust, parsimonious, reduced model. The reduced model has an adjusted R^2 value of .1931, an increase of less than one percent from the full model. However, all p-values for the independent variables included in the model are below .1, our boundary indicated in stepwise regression model building.

The reduced model for Scientists & Engineers contained four independent variables: undergraduate GPA, GRE-Q scores, prior enlisted, and rank/grade, with approximately 19% variability in graduate success attributed to these variables. The

parameter estimates are given in Table 4. Additional diagnostics are displayed in Appendix F.

Table 4. Parameter Estimates: Reduced Model GRE for Scientists/Engineers

Term	Estimate = β	Std Error	t Ratio	Prob>|t|
Intercept	2.3155586	0.294445	7.86	<.0001
UGPA	0.1976235	0.053893	3.67	0.0004
GRE-Q	0.0009257	0.000335	2.77	0.0068
Rank/Grade	0.0467071	0.027664	1.69	0.0946
Prior Enlisted	-0.127741	0.045292	-2.82	0.0058

All p-values for the independent variables are less than the standard .05, indicating good predictability, except Rank/Grade. However, deleting another variable greatly reduced the overall predictability of the model and increased the possibility of over-fitting the model to the data. When our model was validated, entering the 25% data points taken out during model building, the R^2 value dropped to .1732, only a 2% drop, indicating the model is robust and does not over-fit the data used during model building. Diagnostics on the validated model are included in Appendix H.

The F-test was used to indicate whether a positive difference in the reduced model exists by measuring the value of the additional variables in the full model. Our F-test indicated the reduced model was more parsimonious than the full model and appears to provide better predictions of graduate GPA than the full model.

GRE Baseline Model for Managers

Only sevan independent variables used in the GRE baseline model for scientists and engineers were used in the GRE baseline model for managers. Gender was eliminated due to an insufficient number of females in the study. The sample size was 48 students. The parameter estimates are shown in Table 5. All other diagnostics are included in Appendix C. The full model had an adjusted R^2 value of .5170 indicating

approximately 52% of the variability in graduate GPA can be attributed to the independent variables used in this model.

Table 5. Parameter Estimates: Full Model GRE for Managers

Term	Estimate = β	Std Error	t Ratio	Prob>|t|
Intercept	2.6068535	0.364757	7.15	<.0001
UGPA	0.2096701	0.052857	3.97	0.0003
GRE-Q	0.0016187	0.000287	5.65	<.0001
GRE-V	-0.00107	0.000388	-2.75	0.0088
Rank/Grade	0.0248257	0.039389	0.63	0.5321
Prior Enlisted	-0.000046	0.043189	-0.00	0.9992
In Household Desc COUNT	0.016003	0.017308	0.92	0.3607
AFSC	-0.014725	0.006683	-2.20	0.0334

Nine data points within the full model were shown to be influential according to the Cook's Distance Influence diagnostics and were removed from the model. Then, independent variables were removed according forward stepwise regression techniques, one at a time, to determine the most robust, parsimonious, reduced model. Interestingly, the GRE-V variable indicates a negative correlation to graduate GPA, bringing into question the importance of the GRE-V test to incoming students. The reduced model has an adjusted R^2 value of .5356, approximately 2% above the full model.

The reduced model for managers contained four independent variables: undergraduate GPA, GRE-Q scores, GRE-V scores, and AFSC, with approximately 54% variability in graduate success attributed to these variables. The parameter estimates are given in Table 6. Additional diagnostics are displayed in Appendix F.

Table 6. Parameter Estimates: Reduced Model GRE for Managers

Term	Estimate = β	Std Error	t Ratio	Prob>|t|
Intercept	2.8509723	0.245969	11.59	<.0001
UGPA	0.1978809	0.045503	4.35	<.0001
GRE-Q	0.0015296	0.000252	6.07	<.0001
GRE-V	-0.001148	0.000372	-3.09	0.0035
AFSC	-0.015771	0.006416	-2.46	0.0181

All p-values for the independent variables are less than the standard .05, indicating good predictability. When our model was validated, entering the 25% data points taken out

during model building, the R^2 value surprisingly dropped to -.3894. The p-values for all variables increased considerably and the beta estimates (our practical significance) for GRE-Q, GRE-V, and AFSC reversed signs for this data set. The sample size was only 13, as six data points were removed due to influencing the model too much, although the difference in the models is too great to be explained only by the smaller sample set. Diagnostics on the validated model are included in Appendix I.

Despite the negative validation results, the F-test indicated the reduced model was more parsimonious than the full model and appears to provide better predictions of graduate GPA than the full model.

GMAT Baseline Model for Managers

The full model for Managers using GMAT scores to predict graduate GPA included data from 21 students for the independent variables: undergraduate GPA; GMAT scores; Rank/Grade; prior enlisted; AFSC; and number of members in household. Gender was not included in the full model because the sample was 100% male. The parameter estimates are shown in Table 7. All other diagnostics are included in Appendix D. The full model had an adjusted R^2 value of .7877 indicating approximately 79% of the variability in graduate GPA can be attributed to the independent variables used in this model.

Table 7. Parameter Estimates: Full Model GMAT for Managers

Term	Estimate = β	Std Error	t Ratio	Prob>|t|
Intercept	2.9852362	0.287084	10.40	<.0001
UGPA	0.03616	0.040428	0.89	0.3862
GMAT	0.0010989	0.000287	3.83	0.0018
Rank/Grade	0.1085052	0.042573	2.55	0.0232
Prior Enlisted	-0.131235	0.033339	-3.94	0.0015
AFSC	-0.019662	0.005373	-3.66	0.0026
In Household Desc COUNT	0.0108721	0.015436	0.70	0.4928

Three data points within the full model were shown to be influential according to the Cook's D Influence diagnostics and were removed from the model. Then, independent variables were removed according to forward stepwise regression techniques, one at a time, to determine the most robust, parsimonious, reduced model. Independent variables were removed until the variables left in the model displayed a p-value less than 1.0 and the R^2 value ceased increasing. The reduced model has an adjusted R^2 value of .7910, less than 1% higher than the full model.

The reduced model for managers contained four independent variables: undergraduate GPA, GMAT scores, and prior enlisted, and rank/grade, with approximately 79% variability in graduate success attributed to these variables. The parameter estimates are given in Table 8. Additional diagnostics are displayed in Appendix G.

Table 8. Parameter Estimates: Reduced Model GMAT for Managers

Term	Estimate = β	Std Error	t Ratio	Prob>|t|
Intercept	3.0852446	0.266415	11.58	<.0001
GMAT	0.0011681	0.000278	4.20	0.0007
Rank/Grade	0.1128572	0.041022	2.75	0.0142
Prior Enlisted	-0.122582	0.032441	-3.78	0.0016
AFSC	-0.021002	0.005207	-4.03	0.0010

When our model was validated, entering the 28% data points taken out during model building, the R^2 value decreased to .6916, though still indicating a robust model. The validation model was a very small sample of only eight datapoints and none were removed due to being over-influential. Diagnostics on the validated model are included in Appendix J.

Once again, the F-test indicated the reduced model was better as a whole than the full model and appears to provide better predictions of graduate GPA than the full model.

Investigative Question 1

Investigative Question 1 states "Do current measures of capability, such as the GRE or GMAT standardized tests, have any predictive capability on AFIT student performance?" The hypothesis for this question was that GRE tests have low to moderate predictive capability on AFIT student performance and we would be unable to determine whether or not the GMAT had any predictive capability due to the low number of students who take the GMAT exam.

The GRE/GMAT exams have been shown to have predictive capability in previous studies outlined in Chapter II. However, the correlation typically show less than 30% of variation of graduate GPA is due to GRE/GMAT test scores. The GRE tests for general cognitive ability. However, it does not take into account motivation of students, unforeseen events in a student's life (death in family, marriage, birth of a new child, etc.), devote professors to help a student through a program, specific knowledge a student may require for a degree in a specific field, and many other factors which contribute to graduate school performance. At the master's level, studies are not as general as they were in undergraduate programs and a student must begin to think and process information in a more specific manner. Therefore, students could receive an excellent GRE score, but not be able to adjust to a master's curriculum and do poorly, or vice versa. The GMAT test measures general cognitive ability, but in relation to business ideas and practices. Though it does not take into account many of the items listed above which also have to do with graduate performance, we believe it will be a better predictor of success for students entering the management programs at AFIT.

The sample used for this study can be categorized according to the pre-entrance exams they each student took (Table 9). Scores from students who took the GRE tests showed mixed correlations to graduate GPAs when used alone (Figures 3 and 4, Appendix K and L). However, when used in conjunction with undergraduate GPA and other variables, the correlations were typically stronger. The GRE-V scores showed a moderate correlation within the GRE baseline model for managers, with good statistical significance levels (p-values) and positive practical significance (beta estimates). The GRE-Q scores showed a much higher correlation to graduate success in both models developed. The adjusted R^2 values for the models developed using GRE scores for scientists & engineers and managers were .1931 and .5356 respectively. This indicates the GRE scores are more predictive of the managers' success than the scientists and engineers.

The admissions office at AFIT requires minimum scores of 600 on the GRE-Q and 500 on the GRE-V for eligibility to attend AFIT. However, every one of the students in this data set attended AFIT and graduated with a GPA of 3.0 or higher. From the results of this data, the admission requirement for GRE-V scores to be used at all should be questioned, especially when they indicate predictive capabilities for management students only, and the GMAT proves to be a much better predictor of success for management students from this study.

Table 9. Entrance Exams of Pre-Validation Sample

Missing Data	GRE-V; GRE-Q	GRE-A	GMAT	GMAT, GRE-V, GRE-Q	TOTAL
66	223	95	33	11	311

Figure 3. Bivariate Fit of GGPA by GRE-Q

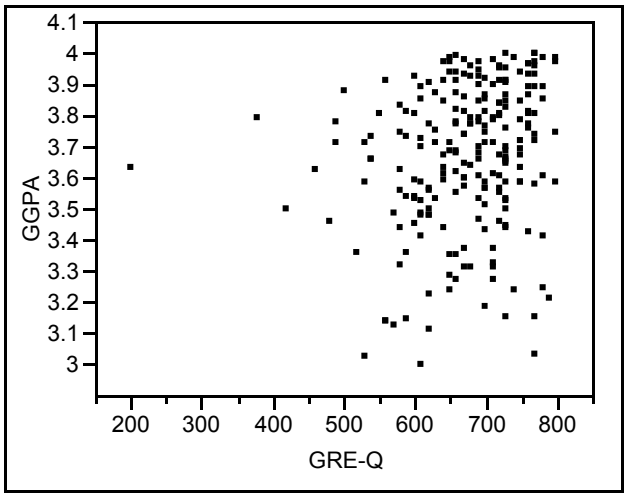
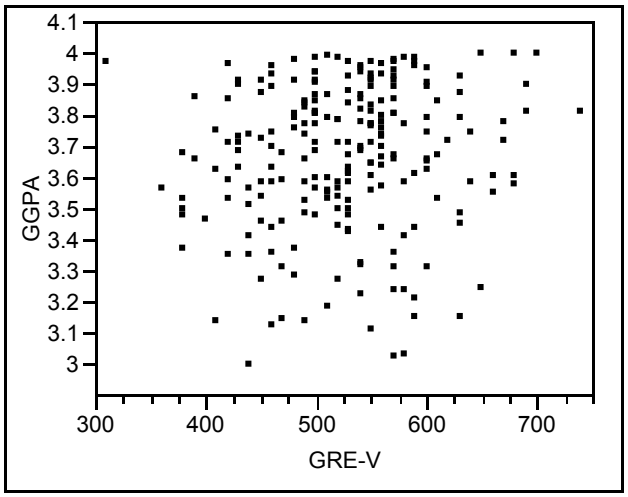


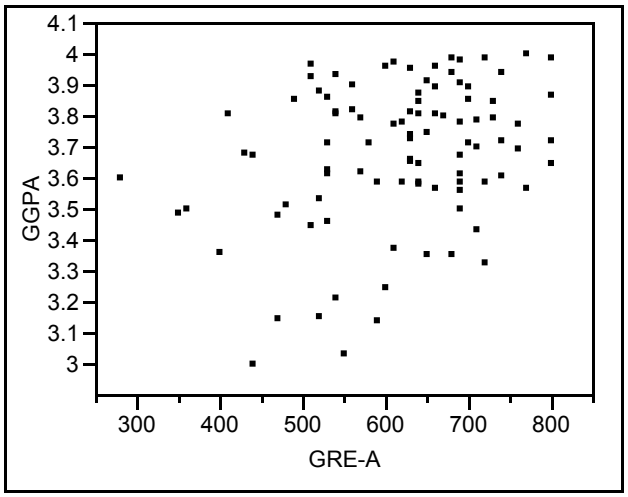
Figure 4. Bivariate Fit of GGPA by GRE-V



Of the 95 students who took the GRE-A exam, a small correlation could be seen between the GRE-A and graduate GPAs (Figure 5). The correlation is stronger for scientists and engineers ($p = .0014$) than for management students ($p = 1048$). Also, the GRE-Analytical exam is not required for entrance into AFIT and therefore has no real bearing on the admissions process to determine eligibility. The trend in the data,

however, suggests that more students are taking the analytical test as they take the verbal and quantitative portions of the GRE.

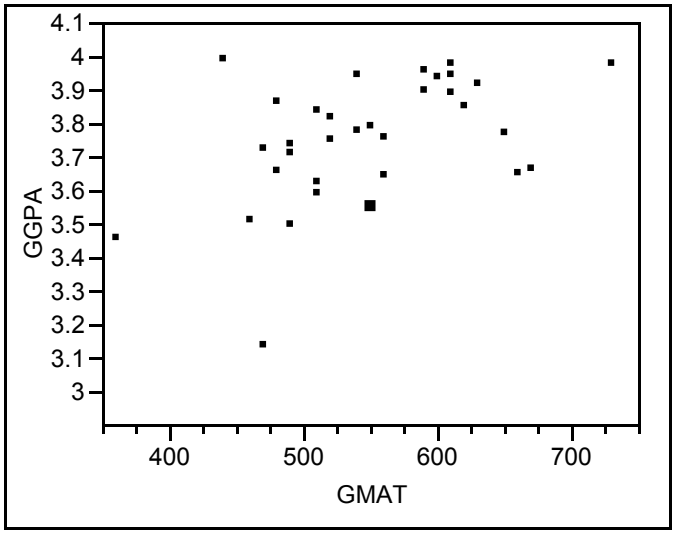
Figure 5. Bivariate fit of GGPA by GRE-A



The required score for students who take the GMAT exam is 550. Of the 33 students who took the GMAT, 18 were in the GAQ program, 4 in GIR program, 7 in the GLM program, 3 in the GCA program, and only 1 outside of the school of management, in the GAP program. The data point larger than the others in Figure 6 highlights the student's information from the GAP program.

The reduced baseline model for managers using GMAT scores showed a predictive capability of $R^2 = .7910$. The p-value for GMAT was also lower than .05 when used alone, indicating good predictive capability. Although the sample size for students who took the GMAT was low, the results indicate the GMAT is statistically a better predictor of success for managers than the GRE scores.

Figure 6. Bivariate fit of GGPA by GMAT



Our hypothesis proved false. The analysis showed significant correlations of GRE-V and GRE-Q scores to graduate GPAs for management students, particularly GRE-Q scores with a p-value of ‹.0001. GRE-Q scores were found to be significant for scientist and engineering students as well with a p-value of .0068 in our baseline model. The GRE-Q scores seem to be a good predictor alone and with other variables. Similarly, we found a strong correlation of GMAT scores to graduate GPAs, though the results could be called into question due to the low sample size. Overall, the GMAT proved to be a better predictor graduate GPA than GRE scores for management students at AFIT.

Investigative Question 2

Investigative Question 2 states "Do current measures of past performance, such as undergraduate GPAs, have any predictive capability on AFIT student performance?" The hypothesis for this question is that the undergraduate GPA will have little to no correlation to graduate GPA performance.

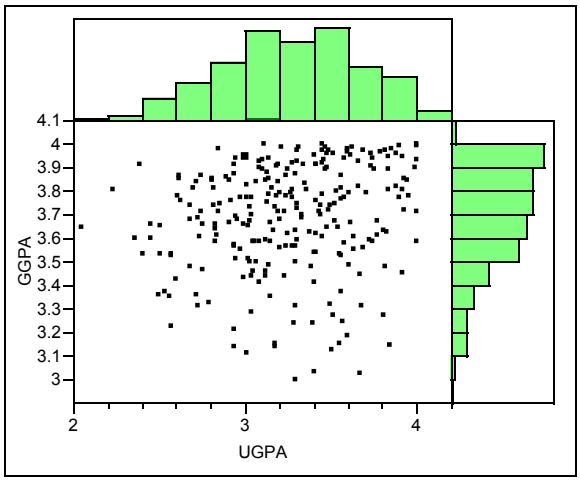
Many researchers believe past performance predicts future performance, especially in similar circumstances such as an academic setting. However, the early career of an Air Force officer does not necessarily follow the same pattern as individuals not in the military. A person can become an officer one of three ways: receive a commission through the Air Force Academy, Air Force Reserve Officer Training Core, or Officer Training School. If one enters through officer training school, he/she already received their bachelor's degree prior to entrance and typically has a higher undergraduate GPA than an ROTC or Academy student. Students who attend ROTC and the Air Force Academy know all they need to do to enter the Air Force as an officer is to graduate. Most schools will award a bachelor's degree with only a 2.0 GPA. Students have the motivation to finish school with higher than a 2.0 GPA, higher only if they are driven from within or another external force. Therefore, many officers do not have exceptional undergraduate GPAs: students did not need them; students had job security with a 2.0 GPA. I propose another reason for low undergraduate GPAs is that students are often young when receiving their bachelor's degree and are not of the same maturity of those attending AFIT. They do not have the importance of their careers in mind yet (since they have yet to start them) and often make choices to participate in other activities rather than study.

However, when a person enters AFIT, he/she typically has at least one job tour (typically 1-3 years) of service completed. This job initiates the officer into the adult world of business. Though jobs are secure, students have a new understanding that job security is based largely upon performance, which can have an impact on them and their

families. Typically, by the time an airmen enters AFIT, they perform better academically than they did at an undergraduate institution.

Our results verify this claim. Of 311 students, 247 had their undergraduate GPA's in one of the two databases. This information can be deleted once a student graduates or is often replaced by the new graduate GPA upon graduation from AFIT. Figure 7 shows the visual correlation of undergraduate GPA to graduate GPA as well as the histograms showing the relativity of number of students to GPAs. Students with prior service typically had higher undergraduate GPAs than those without prior service.

Figure 7. Bivariate Fit of UGPA by GGPA



The statistical significance of undergraduate GPA to graduate GPA is .1392 for scientists and engineers and .0037 for managers. Undergraduate GPA came up as a variable in every regression model built and was included in each of our three baseline models with p-values less than .001 in all baseline models. This indicates undergraduate GPA is a better predictor with other variables (such as test scores) than when used alone, supporting the claims of the Educational Testing Service. Our hypothesis about undergraduate GPA was incorrect. The correlations of undergraduate GPA to graduate

GPA are statistically significant, especially when combined with other factors such as GRE-Q and GMAT scores.

Investigative Question 3

Investigative question 3 states, "3. Is there a difference in performance between students who meet all admissions requirements and those who require a waiver?" The hypothesis for this question is yes, there is a positive difference in performance between students who meet the requirements and those who require a waiver.

As the results of IQ one and two indicated, past performance indicates some level of future performance. It is therefore logical to assume if a student receives a poor undergraduate GPA or performs poorly on standardized tests, he/she will also struggle with their studies at AFIT. Of course, this cannot be generalized to the entire population at AFIT, but on average, students who perform poorly prior to AFIT should not perform as well as those who do.

The data showed 248 prospective students submitted at least one of the following to the AFIT admissions department: undergraduate GPA, GRE scores, or GMAT scores. 139 students, or 56%, required a waiver of at least one admission criterion (Table 10). 36 students, or 14.5%, required admission requirements to be waived in more than one area (i.e. 2 test scores, UGPA and test scores, etc.)

Table 10. # of Students Who Required a Waive of Admission Criteria

	UGPA	GRE-V	GRE-Q	GMAT	At least 1 waiver
# Students who received Waiver	64	71	32	17	139
Data Points	247	223	223	33	248
Percentage (%)	25.91	31.84	14.35	51.52	56.05

Using a large sample test of hypothesis, our first sample was the students who did not receive a waiver of admission criteria. Our second sample was the students who did require a waiver. Our null hypothesis is that the differences in graduate GPA are equal. Our alternative hypothesis is that the graduate GPAs of students who do not require a waiver receive higher graduate GPAs on average. The test statistic for this calculation is 3.29, $z_{.05} = 1.658$, which is less than the test statistic and falls within the rejection region for the sample. Therefore, we can reject the null that the two graduate GPAs are the same and can reasonably assume the graduate GPAs of students who meet all admission criteria receive higher GPAs. However, it is important to note, that based upon the differences in mean graduate GPAs of each sample (3.73 and 3.64,) the means are very close and do not practically indicate much of a difference. If we had chosen a smaller alpha and took a higher risk of making a type I error (we reject the null when it is true,) the results would be different. If we chose an alpha of .0005, for example, our test statistic would not have fallen in the rejection region and we would say there was no difference in the graduate GPAs of the two populations. This is important to realize because although the statistical difference in mean graduate GPAs, the practical difference between the two is not by very much (Table 11).

Table 11. Mean and Standard Deviation for our Random Samples (N=109)

Sample	Identifier	GPA Mean	Standard Deviation
1	Non-Waiver Students	3.7312	0.2335
2	Waiver Students	3.6353	0.2212

Investigative Question 4

Investigative question 4 states, "Is there a difference in performance depending on which admission requirement is waived (GRE/GMAT scores or undergraduate GPA)?" This question is divided into four subdivisions, divisions of samples as follows: GMAT scores and undergraduate GPA; GRE-V scores and undergraduate GPA; GRE-Q scores and undergraduate GPA; and both GRE scores and undergraduate GPA. Our hypothesis is that yes, there is a difference in performance in all four subdivisions. We propose the graduate GPAs of students who required a waiver for any test scores will be higher than those of students who required a waiver for undergraduate GPA.

Many students who attend AFIT graduated from undergraduate institutions at least three years prior to entrance into AFIT. Though not much time has elapsed from the completion of their undergraduate education, the test scores are generally more current than undergraduate GPAs. Also, the standardized exams reflect what they can recall from undergraduate education; undergraduate GPAs measure what students know at the time of the courses in undergraduate education. Therefore, the standardized test scores reflect what a prospective AFIT student knows at the time of application and entrance into AFIT and will better predict how well a student will perform in graduate education.

Data was selected for use in the different categories based upon waivers for that particular discipline. For example, several students received waivers for both undergraduate GPA and test scores. However, none of the students were included in the hypothesis testing. Students who received a waiver for undergraduate GPA were included if they did not have a waiver for the test it was being tested against. Table 6 shows how many students required waivers for each exam and undergraduate GPA.

Using large and small sample tests of hypothesis for each of the four pairs of samples, the results are shown in Table 12.

Table 12. Results of 4 Sub-tests of Hypothesis

Hypothesis Test (sample 1, sample 2)	N	Hypothesis	Test Statistic	Rejection Region (based on α = .05)	Result
GMAT, undergraduate GPA	11/58	H_0: $(\mu_1 - \mu_2) = 0$ H_a: $(\mu_1 - \mu_2) > 0$	2.00	1.67	Reject H_0
GRE-V, undergraduate GPA	57/50	H_0: $(\mu_1 - \mu_2) = 0$ H_a: $(\mu_1 - \mu_2) < 0$	-0.9769	1.679	Fail to Reject H_0
GRE-Q, undergraduate GPA	23/55	H_0: $(\mu_1 - \mu_2) = 0$ H_a: $(\mu_1 - \mu_2) < 0$	-1.9199	1.671	Reject H_0
GRE-V and GRE-Q, undergraduate GPA	12/45	H_0: $(\mu_1 - \mu_2) = 0$ H_a: $(\mu_1 - \mu_2) < 0$	-2.58	1.671	Reject H_0

By rejecting H_0 for three of the four tests, it can be concluded that there is statistical evidence to suggest a difference exists between the graduate GPAs of students who require a waiver for insufficient undergraduate GPAs and students who require a waiver for insufficient test scores on the GMAT, GRE-Q, and both GRE tests. We can also conclude there is no statistical evidence to suggest the graduate GPAs of students who receive a waiver for GRE-V scores are different than graduate GPAs of students who receive a waiver for undergraduate GPA. However, it is important to note that practically, no difference exists. When we examine the mean graduate GPAs of students in each group as well as their standard deviations, the difference is so small as to be practically negligible (Table 13).

Table 13. Mean and Standard Deviations of Waiver Samples

Samples	Mean Graduate GPA	Standard Deviation
GMAT/ Undergraduate GPA	3.7621/ 3.6403	.1716/ .1872
GRE-V/ Undergraduate GPA	3.6197/ 3.6536	.2349/ .1815
GRE-Q/ Undergraduate GPA	3.5503/ 3.6488	.2539/ .1839
GRE-V and GRE-Q/ Undergraduate GPA	3.4916/ 3.6548	.2405/ .1817

Overall statistically, the data suggests the following: students who receive a waiver for GMAT test scores, on average, perform better than students who receive a waiver for undergraduate GPAs; students who receive a waiver on either the GRE-Q test score or both the GRE-V and GRE-Q test scores, on average, perform worse than students who receive a waiver for undergraduate GPAs; and students who receive a waiver for GRE-V scores perform the same as students who receive a waiver for undergraduate GPAs. Combining this data with the data from IQ one, we could assume the difference in graduate performance is not seen as clearly in students who receive a waiver for the GRE-V scores because they are not a much a contributor to graduate success. Thus, our prediction for the outcome of the hypothesis was correct for only three of the four sub-division hypotheses tests.

Overall practically, there is very little difference in performance based upon the waiver given, except perhaps students who require a waiver for more than one test score.

Summary

This chapter presented and analyzed the results of our data analysis. There is statistical evidence to suggest the GRE-V and GRE-Q test scores have little correlation to

graduate success as measured by graduate GPA. The GMAT test has a moderate correlation to graduate success. Undergraduate GPA has little correlation to graduate success when used alone. However, when combined with other variables, particularly GRE-Q, it has a moderate correlation to graduate success. This chapter also analyzed the importance of issuing waivers to students for admission into AFIT. Statistical evidence suggests a very slight difference in graduate GPAs exists between students who meet admission criteria and those who do not. Also, the type of waiver given (i.e. for undergraduate GPA, GRE-V, GRE-Q, GMAT, or two GRE scores) is not significant if the waiver is given for only a GRE-V score, GRE-Q score, GMAT score, or undergraduate GPA. However, it is important when giving waivers for more than one test, such as for both the GRE-Q and GRE-V tests, to realize the undergraduate GPA waiver students have been shown to have higher success.

Chapter five will discuss the results of the tests. It will present the big picture meaning for the results and how they can impact AFIT selection procedures. Also, chapter five will suggest future research topics based upon the research in this study and wrap up the research effort.

V. Conclusion

Chapter Overview

This chapter discusses the results from the analyses shown in chapter four, what conclusions we can draw from the results, and how our results pertain to the objectives of this study. This chapter will also cover the limitations of the research, additional areas of interest, and future research ideas pertaining to the predictive factors of graduate success. We will conclude with a final summary of the research effort as a whole.

Conclusion of Research Objectives

The problem the Air Force Institute of Technology and the Air Force is facing is a conflict in personnel placement. The Air Force has a mission to achieve and needs airmen to place around the world for the accomplishment of that mission. At the same time, the Air Force has identified a need to educate more airmen at AFIT to improve our warfighting capabilities. Though AFIT has a standard set of admission criteria, more than 50% of its applicants fail to meet the criteria, yet are admitted mainly to maintain given quotas.

Nearly 100% of AFIT students graduate with greater than a 3.0 graduate GPA and a master's degree in the science and engineering fields or management fields. When all students graduate, despite failing to meet set admission criteria, the question about whether or not AFIT needs admission criteria becomes important to consider. The main criteria AFIT considers for admission of prospective students are undergraduate GPA, GRE-Verbal test scores, GRE-Quantitative test scores, and GMAT scores. When a waive

of admissions is required, department directors must take the time to examine student records and make the decision about whether or not to waive the requirements and allow the student attend.

The purpose of this research was to determine if current admission criteria have any predictive capability of a student's graduate success and if students do not meet the eligibility standards, whether they perform more poorly than students who meet all standards. The research in this study indicates changes in the admissions policy should be changed; mainly, if over 50% of students require a waiver to attend AFIT, perhaps there shouldn't be admission criteria at all.

Investigative Question 1

Students are required to take either the GRE-V and GRE-Q exams, or the GMAT exam for entrance into AFIT. The GMAT is an exam specifically used for schools of management and business and has a good predictability rate for graduate success. Roughly 69-79% of the variability of graduate GPA for management students can be explained in part by test scores from the GMAT exam as opposed to only 20-50% variability explained in part by GRE test scores. The results are similar to those found in the literature (Nilsson, 1995; Hoefer and Gould, 2000, Garwood, 2002). The management programs at AFIT do not require this exam for entrance, however. One explanation for the higher correlation of GMAT scores could be that students who take the GMAT are taking it, not for AFIT, but for entrance into a business master's program elsewhere, and reused the score for AFIT eligibility. Students in the management programs sometimes have other master's degrees before entrance into AFIT. Therefore,

perhaps some of their success could be attributed to previous experience in a master's curriculum.

The GRE-A exam showed to have a high correlation to graduate success with a strong beta weight for the science and engineering students, indicating those who do well on the GRE-A exam will do well in graduate school. Similar results showed up for the management students, though not quite as strong a correlation exists.

Results for the GRE-V exam were moderate to low in the models examined, supporting the research done by Garwood (2002). GRE-Q exams showed a significant correlation for both science and engineering students as well as management students. This is not surprising since the majority of students at AFIT has a technical background and typically performed well on the GRE-Q exams. The ETS recommends the GRE scores be used in conjunction with undergraduate GPA, which this research supported. In each model developed, the GRE/GMAT scores and undergraduate GPAs' predictability increased when combined.

The overall conclusion of this study is that though the GRE-V exam has some predictability on graduate success for management students, it does not contribute to the success of science and engineering students. Also, the GMAT is a much better predictor of success for management students. The GRE-A exam, however, does have good predictability for science and engineering students, and should perhaps replace the requirement for GRE-V scores for entrance into AFIT. Also, several AFIT theses have concluded the whole school should not be assessed by the same criteria for entrance. I disagree with that assessment. Although, models built when using the entire sample from AFIT yielded much different results (the GMAT exam was the only variable which had

any predictability, due to the fact it was mainly management students who took the exam) the school can still be assessed as a whole. The data must be divided, however, between science and engineering students and management students. The results for each school are similar in regards to the predictability of test scores and undergraduate GPA. However, the additional independent variables, such as prior enlisted, number of members in household, rank, etc. alter the data and create less than ideal results. It appears as though additional factors other than academic performance, have a different impact on students from each school, thought the reason for this is unclear.

Science and engineering students should continue to take the GRE-Q/GRE-A exam prior to entrance and waivers assigned to GRE-A exams on a case-by-case assessment. GRE-Q admission standards should also be lowered due to the high number of waivers given for this exam. The GRE-V exam, if left in the admissions criteria should not have a limit for eligibility at all. The predictive value of GRE-V is insignificant and more waivers are given for the GRE-V exam than any other waiver. Scores can be an indicator to directors about how much time and personal attention a student might require to successfully complete the program. Similar studies for AFIT (Garwood, 2002, Zitzmann, 2002) came to the same conclusion, although other studies within the literature reviews disagree (Kuncel et al., 2001). While this recommendation might not be universally applicable, each school should conduct their own study. A student's writing habits will not changed based on the curriculum at AFIT, yet program directors will be able to assess the writing capabilities of students based on the GRE-A exam scores. This way, directors will be able to understand how much time a student

might require to accomplish the thesis and how much editing/revision time the student will need to do well in writing assignments.

Students in management programs should be required to take the GMAT exam prior to entrance into AFIT. The GMAT exam includes a writing assessment test within the exam which can indicate writing capabilities for students. While quantitative abilities are important to the management students as well as the science and engineering students, they are far less important within the management programs and the GMAT exam will capture what students have the potential to accomplish in all aspects of a management program. Scores for the GMAT exam should be examined and assessed to determine the appropriate standard for admissions.

Investigative Question 2

Undergraduate GPA was a significant predictor of graduate success when used alone and when combined with other variables. However, over 25% of students required a waiver who did not have adequate undergraduate GPAs for admissions. In many cases, this could be attributed to the "2.0 and go" phenomenon of undergraduate students who have secured a job in the Air Force upon completion of their undergraduate degree. This can also be attributed to immaturity of an undergraduate student. This research shows the majority of students who enter into AFIT have an undergraduate GPA lower than 3.5, yet graduate from AFIT with a GPA higher than 3.5. Undergraduate GPA should be used as a guideline for directors granting waivers for test scores only and the cut-off of 3.0 undergraduate GPA should be eliminated from the admission criteria.

Investigative Question 3

What we now know about AFIT that we did not know before, is that program directors give out a very high number of waivers to students for entrance into AFIT. Many students receive more than one waiver. A few students receive waivers for every admission criteria set by AFIT. The research in this study concluded there is a slight, though nearly negligible difference in graduate GPAs of students who receive waivers and students who do not. The implications of this finding are huge. The results indicate the admission criteria do not play much part in admissions of students to AFIT. The results also give a certain freedom to program directors upon issuing waivers in the future if admission criteria are not changed.

Investigative Question 4

Similar to the results in IQ three, the types of waivers given does not have much influence upon a student's performance. If program directors are concerned about whom to give waivers for, it could be suggested not to give multiple waivers, such as for both a GRE-V and GRE-Q score. It might be wiser to give a waiver to a student with an inadequate undergraduate GPA than two inadequate test scores. It might also be wiser to give a waiver to a student with inadequate GMAT or GRE-Q scores than an inadequate undergraduate GPA. However, in the big picture, the statistical evidence in this research shows there's not much difference in performance no matter which waiver is given, and the practical evidence suggests there is not a difference at all.

Limitations

There were three main limitations to this research study. First, the use of databases proved to be a limitation due to the inaccuracy and incompleteness of the data within each database. The database included 311 subjects, presumably all full-time Air Force officers who were assigned to AFIT from 1999-2001, 2000-2002, and 2001-2003. However, upon closer inspection, not all subjects were assigned to AFIT during that time, all the individuals assigned to AFIT were in the database, and not all academic and military data were included in both databases. Therefore, it might have been a better choice to manually review all hard-copy records of AFIT students attending AFIT during the times described to gather more accurate data.

Along the same lines of inaccurate data, interviews with professors in each department should have been a standard part of this research, particularly in the science and management programs, to gain a better understanding of individual waiver assignment processes and perspectives.

And last, civilians and other members of the armed services who attend AFIT were not included in this study. The purpose of eliminating them from this study was due to the fact the study was focused on the Air Force situation of assigning people to AFIT when they are perhaps needed in other parts of the world. However, many civilians and members of other services attend AFIT full time at government expense. Also, the recommendation of eliminating certain, if not all, admission requirements could bring repercussions to the institution when considering civilian applicants, either as full-time students or as part-time students.

Suggestions for Future Research

I believe it is essential for all graduate institutions to assess their admission criteria on a regular basis. Given that, a similar study should be conducted within the next five years on the entire school, perhaps separated into science and management programs and management programs.

Another research topic closely related to this one is what factors of motivation influence graduate success. Consistently, test scores and undergraduate GPA account for roughly 15-20% of the variance of graduate success, but research should be conduced to find out what accounts for the final 80-85%. McCloy, Campbell, and Cudeck (1994) believe performance is based on declarative knowledge, procedural knowledge and skill, and motivation. This study showed 20% of performance is declarative knowledge. The other areas of McCloy et al.'s formula are worth looking into at AFIT.

Walpole and others (2002) examined different criteria of success as deemed by graduate professors and staff at graduate institutions. AFIT has two main avenues of success criteria: graduate GPA and thesis grades. Cumulative exams for programs might be a great indicator for AFIT to use before completion as a determinant of learning at the institution. Currently, the Acquisition Management program (a.k.a. Strategic Purchasing) is incorporating a cumulative exam through an affiliate organization, which upon successful completion, awards a Certified Purchasing Manager certification to students. The exam is comprehensive of all classes taken during the 18-month period at AFIT. A good research direction would be to determine whether or not cumulative exams add value to the school and programs and whether or not they truly measure learning for the students at the institution.

Summary

This research is based on the conflict the Air Force and AFIT have of balancing mission requirements of personnel needed throughout the world and training airmen in technical fields to remain the world's most technological force. AFIT must find available, eligible airmen to train in their master's degree programs. Currently, over 50% of AFIT students do not meet the set admission requirements to attend AFIT and require a waiver of admissions to attend. The purpose of this research was to examine current admission criteria to determine its predictability on graduate success as well as determine whether or not the granting of a waiver has an impact on student performance.

The literature review for this research indicated many mixed results as to the predictability of undergraduate GPAs and standardized test scores, although the AFIT thesis continue to show a familiar trend that the requirements are sufficient, but not adequate. This validity study used multiple regression model building and hypothesis testing to show admission requirements are no longer adequate. GRE-Q exam scores should continue to be used as an admission requirement, but the standard "cut-off" score should be lowered. GRE-V scores should not be used as an admissions requirement at all. GRE-A scores should be added as a requirement with and appropriate standard developed. The GMAT exam should be required for admissions by all management students. And undergraduate GPA should be required submittal factor for admissions, but used only as an additional guideline to determine the granting of waivers and not have a "cut-off" standard, since it is rarely adhered to anyway. Additional factors, particularly prior enlistment, should be examined when granting waivers as well.

When waivers are granted, directors should not be overly concerned with the type a student requires, particularly if it is for a GRE-V score. However, they should be cautious of granting waivers for inadequate scores in every admission criterion. Overall, AFIT's admission criteria are not adequate predictors of graduate success and should be reexamined in lieu of the number of waivers granted to incoming students, particularly with the increased number of students AFIT expects to educate in the coming years.

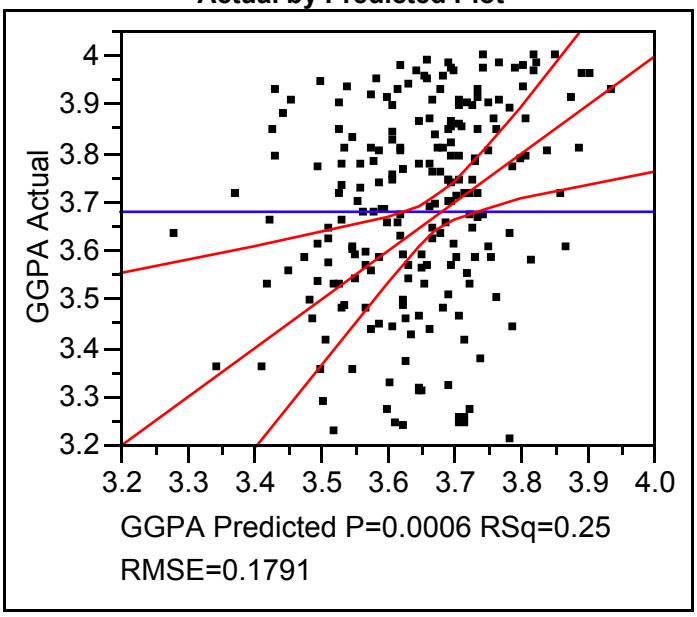
Appendix A: Program and AFSC Codes

AFIT Program	Code
Astronautical Engineering (GA)	0
Aeronautical Engineering (GAE)	1
Aerospace and Information Operations (GAI)	2
Applied Physics (GAP)	3
Acquisition Management (GAQ)	4
Computer Engineering (GCE)	5
Computer Systems (GCS)	6
Electrical Engineering (GE)	7
Engineering and Environmental Management (GEE)	8
Electro-Optics (GEO)	9
Information Resource Management (GIR)	10
Logistics Management (GLM)	11
Meteorology (GM)	12
Nuclear Engineering (GNE)	13
Operations Research (GOR)	14
Space Operations (GSO)	15
Cost Analysis (GCA)	16

AFSC Description	AFSC	Code
Pilot	11xx	0
Navigator	12xx	1
Space, Missile, and Command and Control	13xx	2
Intelligence	14xx	3
Weather	15xx	4
Logistics	21xx	5
Civil Engineering	32xx	6
Communications and Information	33xx	7
Biomedical Specialist	43xx	8
Scientific	61xx	9
Developmental Engineering	62xx	10
Acquisition	63xx	11
Contracting	64xx	12
Finance	65xx	13

Appendix B: Full GRE Baseline Model for Scientists and Engineers

Actual by Predicted Plot



Summary of Fit

RSquare	0.252827
RSquare Adj	0.187142
Root Mean Square Error	0.179064
Mean of Response	3.67987
Observations (or Sum Wgts)	100

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	8	0.9873291	0.123416	3.8491
Error	91	2.9178242	0.032064	Prob > F
C. Total	99	3.9051533		0.0006

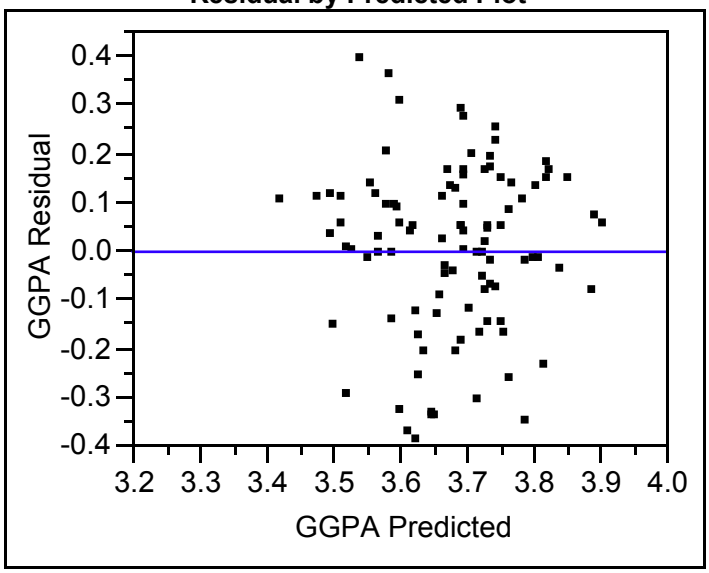
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.2802035	0.302292	7.54	<.0001
UGPA	0.1913769	0.056618	3.38	0.0011
GRE-Q	0.0008058	0.000348	2.32	0.0228
GRE-V	-0.000094	0.000263	-0.36	0.7208
Rank/Grade	0.0539065	0.02944	1.83	0.0704
Prior Enlisted	-0.118499	0.04742	-2.50	0.0143
AFSC	0.0098429	0.008049	1.22	0.2245
Gender	0.1127232	0.094629	1.19	0.2367
In Household Desc COUNT	-0.005994	0.022332	-0.27	0.7890

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
UGPA	1	1	0.36634268	11.4254	0.0011
GRE-Q	1	1	0.17192764	5.3620	0.0228
GRE-V	1	1	0.00412040	0.1285	0.7208
Rank/Grade	1	1	0.10750637	3.3529	0.0704
Prior Enlisted	1	1	0.20022588	6.2446	0.0143
AFSC	1	1	0.04795353	1.4956	0.2245
Gender	1	1	0.04549792	1.4190	0.2367
In Household Desc COUNT	1	1	0.00231012	0.0720	0.7890

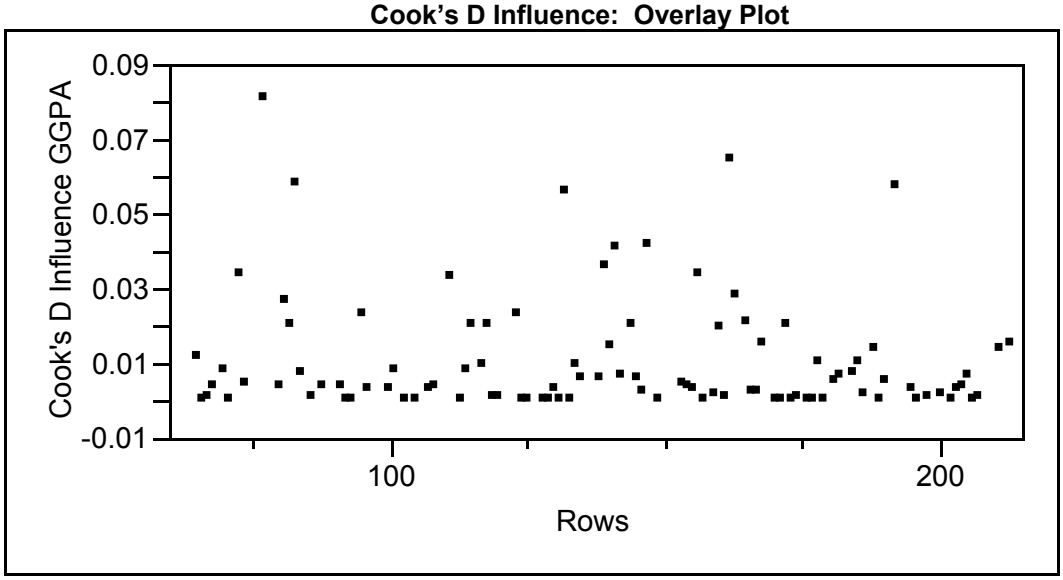
Residual by Predicted Plot



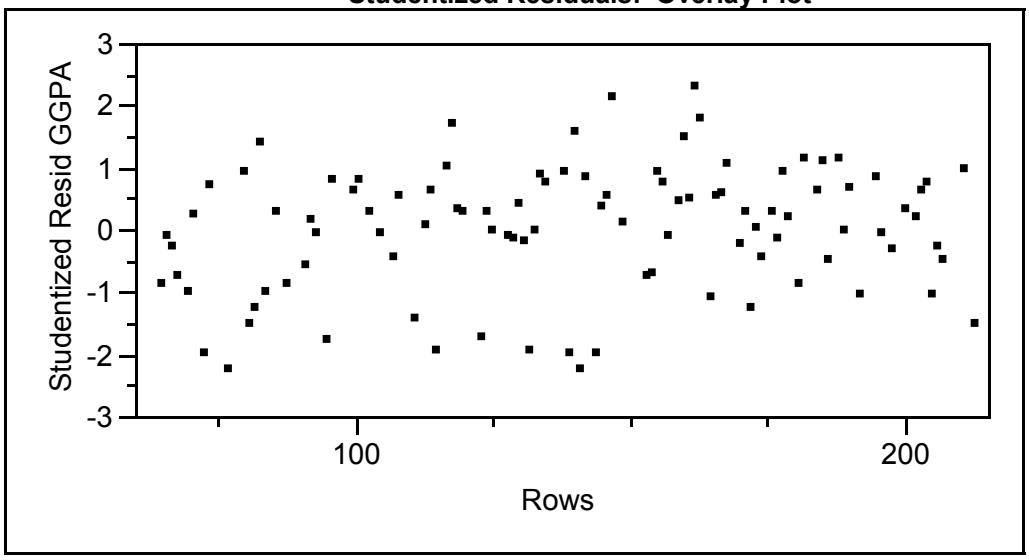
Durbin-Watson

Durbin-Watson	Number of Obs.	AutoCorrelation
1.4481067	100	-0.0732

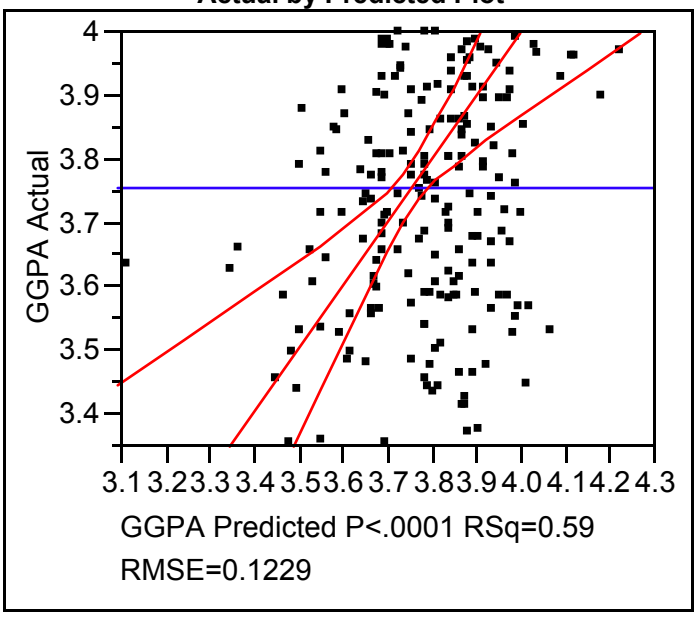
Cook's D Influence: Overlay Plot



Studentized Residuals: Overlay Plot



Appendix C: Full GRE Baseline Model for Managers



Summary of Fit

RSquare	0.588943
RSquare Adj	0.517008
Root Mean Square Error	0.122946
Mean of Response	3.755625
Observations (or Sum Wgts)	48

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	0.8662870	0.123755	8.1871
Error	40	0.6046323	0.015116	Prob > F
C. Total	47	1.4709193		<.0001

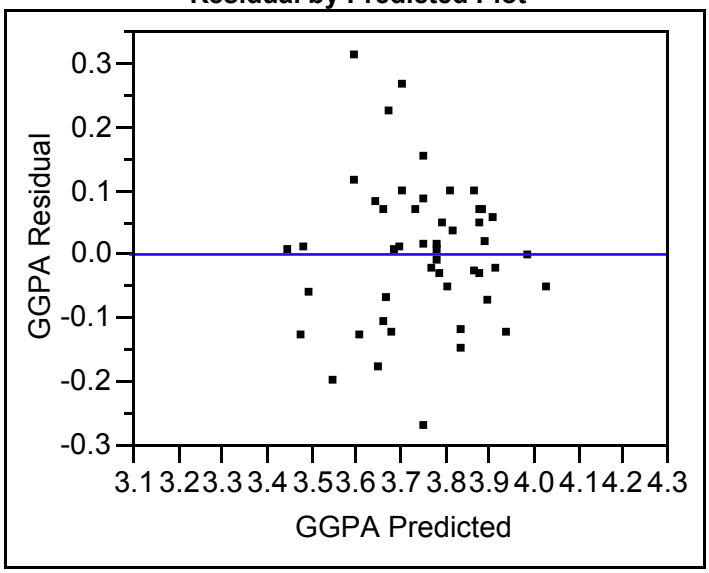
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.6068535	0.364757	7.15	<.0001
UGPA	0.2096701	0.052857	3.97	0.0003
GRE-Q	0.0016187	0.000287	5.65	<.0001
GRE-V	-0.00107	0.000388	-2.75	0.0088
Rank/Grade	0.0248257	0.039389	0.63	0.5321
Prior Enlisted	-0.000046	0.043189	-0.00	0.9992
In Household Desc COUNT	0.016003	0.017308	0.92	0.3607
AFSC	-0.014725	0.006683	-2.20	0.0334

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
UGPA	1	1	0.23785080	15.7352	0.0003
GRE-Q	1	1	0.48186497	31.8782	<.0001
GRE-V	1	1	0.11469670	7.5879	0.0088
Rank/Grade	1	1	0.00600453	0.3972	0.5321
Prior Enlisted	1	1	1.71658e-8	0.0000	0.9992
In Household Desc COUNT	1	1	0.01292302	0.8549	0.3607
AFSC	1	1	0.07337926	4.8545	0.0334

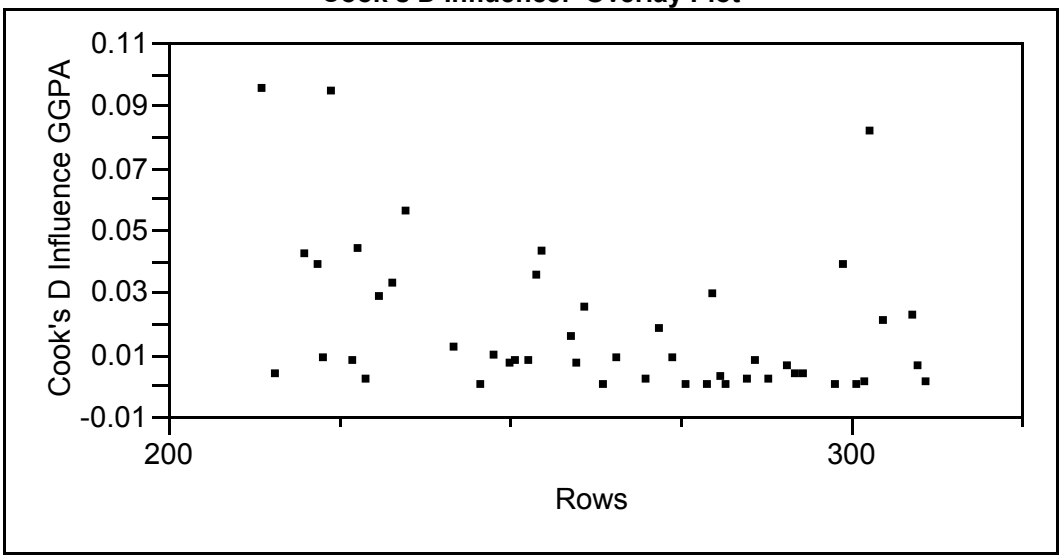
Residual by Predicted Plot



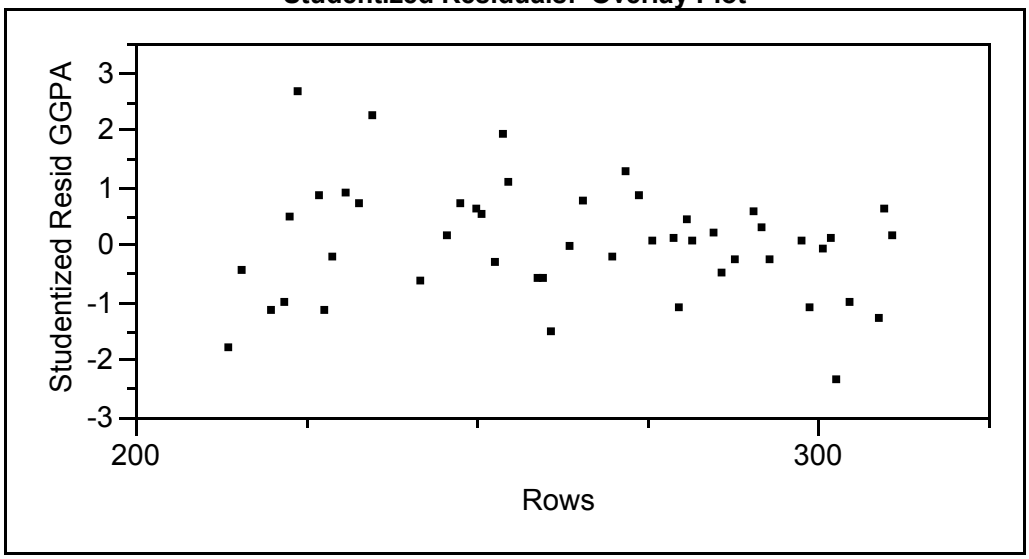
Durbin-Watson

Durbin-Watson	Number of Obs.	AutoCorrelation
0.7514523	48	0.0320

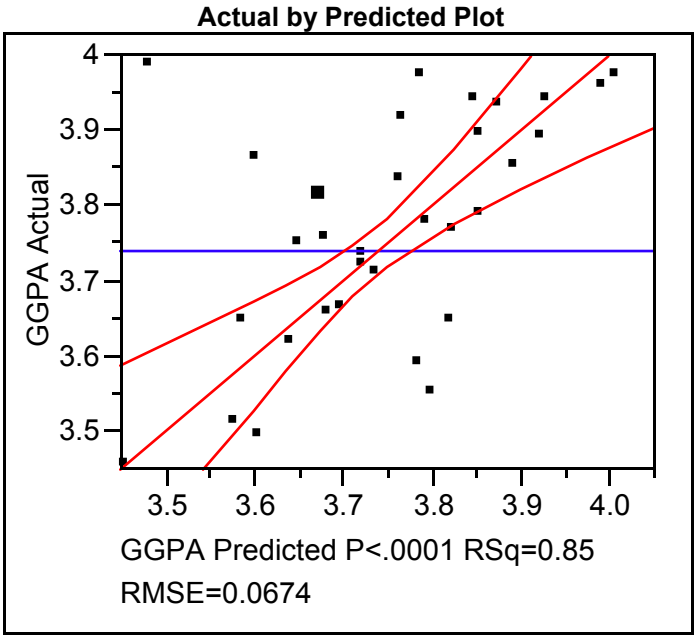
Cook's D Influence: Overlay Plot



Studentized Residuals: Overlay Plot



Appendix D: Full Baseline GMAT Model for Managers



Summary of Fit

RSquare	0.85139
RSquare Adj	0.787699
Root Mean Square Error	0.06744
Mean of Response	3.740238
Observations (or Sum Wgts)	21

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	6	0.36478964	0.060798	13.3677
Error	14	0.06367417	0.004548	Prob > F
C. Total	20	0.42846381		<.0001

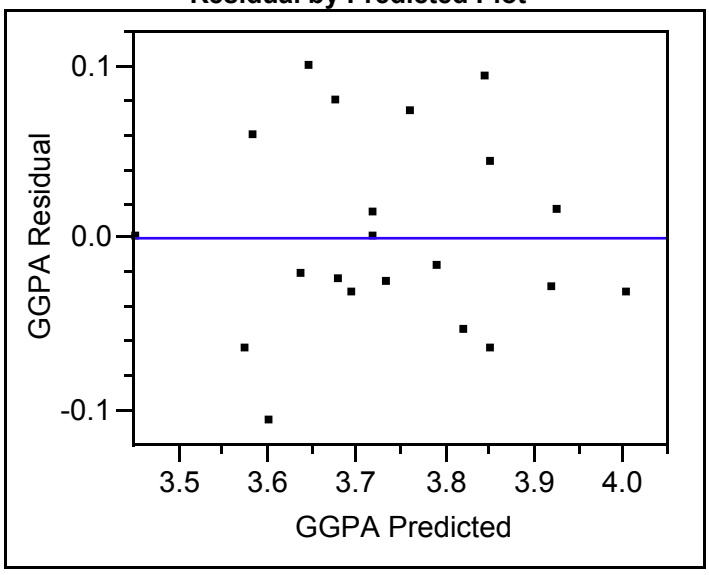
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.9852362	0.287084	10.40	<.0001
UGPA	0.03616	0.040428	0.89	0.3862
GMAT	0.0010989	0.000287	3.83	0.0018
Rank/Grade	0.1085052	0.042573	2.55	0.0232
Prior Enlisted	-0.131235	0.033339	-3.94	0.0015
AFSC	-0.019662	0.005373	-3.66	0.0026
In Household Desc COUNT	0.0108721	0.015436	0.70	0.4928

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
UGPA	1	1	0.00363861	0.8000	0.3862
GMAT	1	1	0.06661828	14.6473	0.0018
Rank/Grade	1	1	0.02954346	6.4957	0.0232
Prior Enlisted	1	1	0.07047324	15.4949	0.0015
AFSC	1	1	0.06091082	13.3924	0.0026
In Household Desc COUNT	1	1	0.00225623	0.4961	0.4928

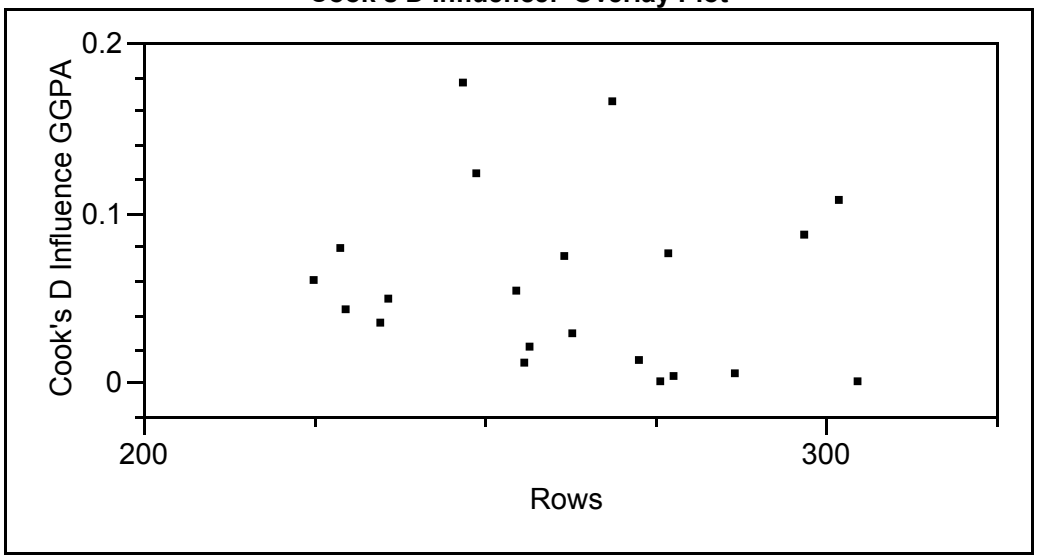
Residual by Predicted Plot



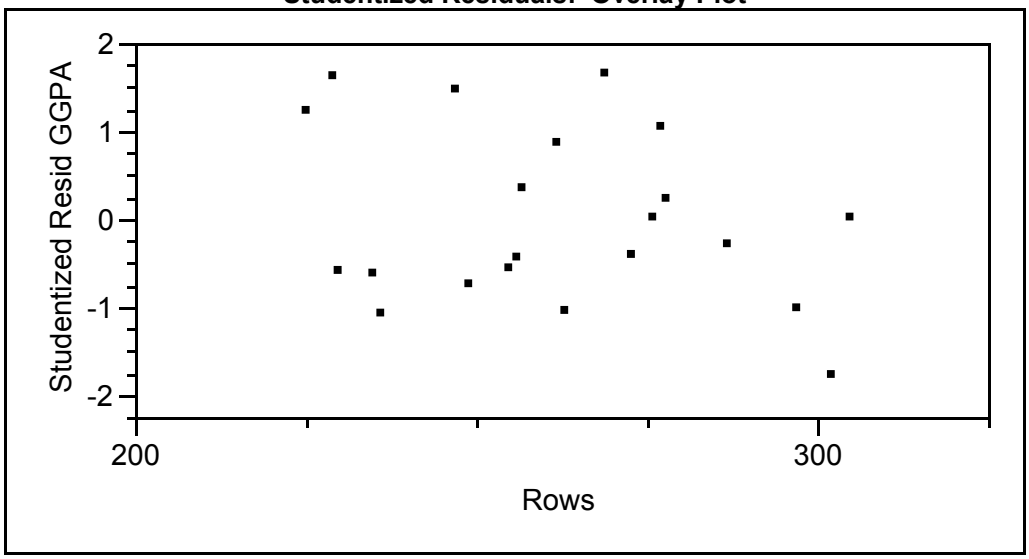
Durbin-Watson

Durbin-Watson	Number of Obs.	AutoCorrelation
0.5718382	21	-0.0401

Cook's D Influence: Overlay Plot

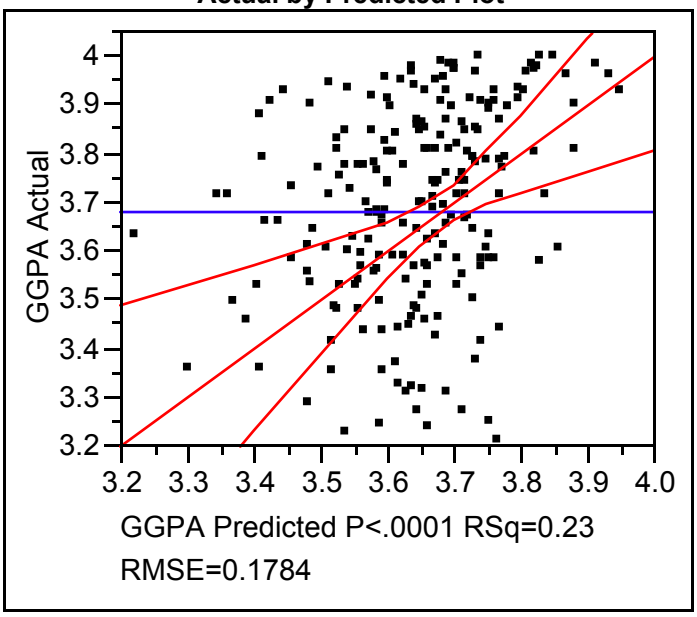


Studentized Residuals: Overlay Plot



Appendix E: Reduced GRE Baseline Model for Scientists/Engineers

Actual by Predicted Plot



Summary of Fit

RSquare	0.22574
RSquare Adj	0.19314
Root Mean Square Error	0.178402
Mean of Response	3.67987
Observations (or Sum Wgts)	100

Analysis of Variance

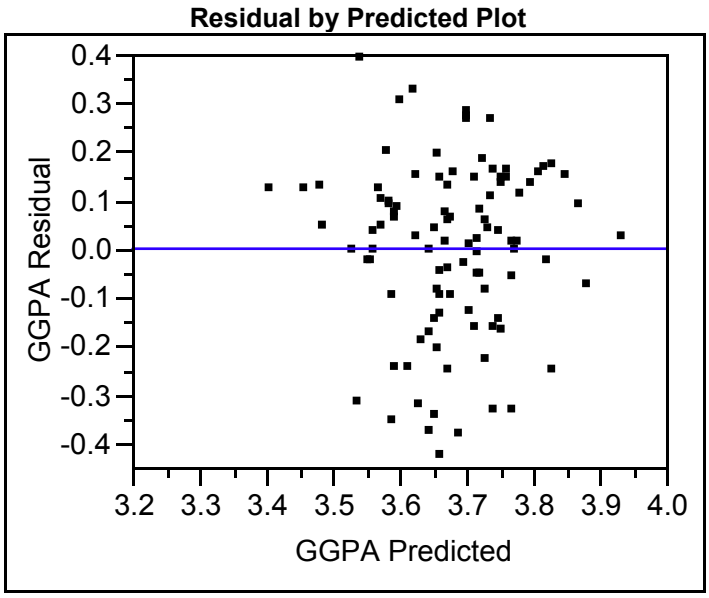
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	0.8815492	0.220387	6.9244
Error	95	3.0236041	0.031827	Prob > F
C. Total	99	3.9051533		<.0001

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.3155586	0.294445	7.86	<.0001
UGPA	0.1976235	0.053893	3.67	0.0004
GRE-Q	0.0009257	0.000335	2.77	0.0068
Rank/Grade	0.0467071	0.027664	1.69	0.0946
Prior Enlisted	-0.127741	0.045292	-2.82	0.0058

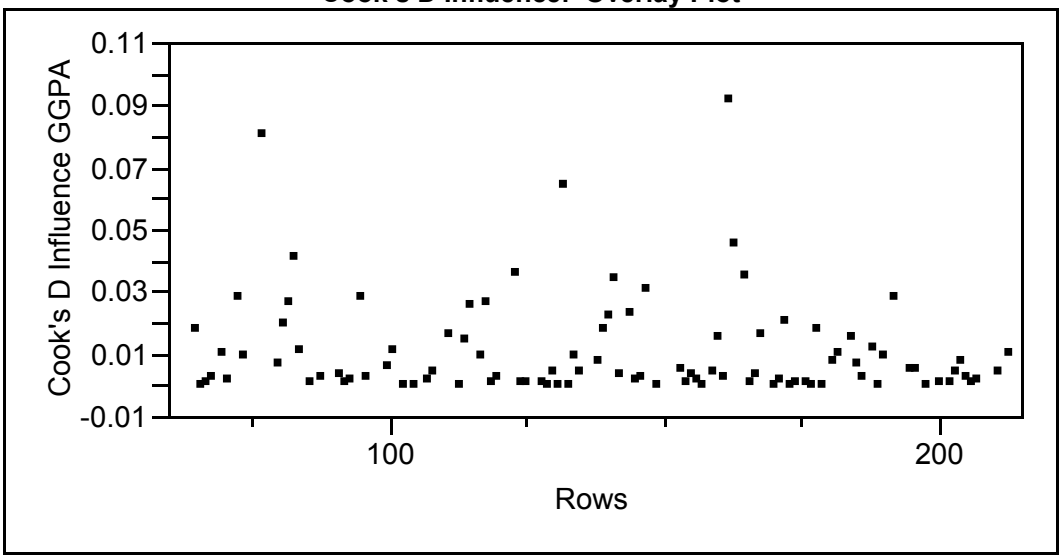
Effect Tests

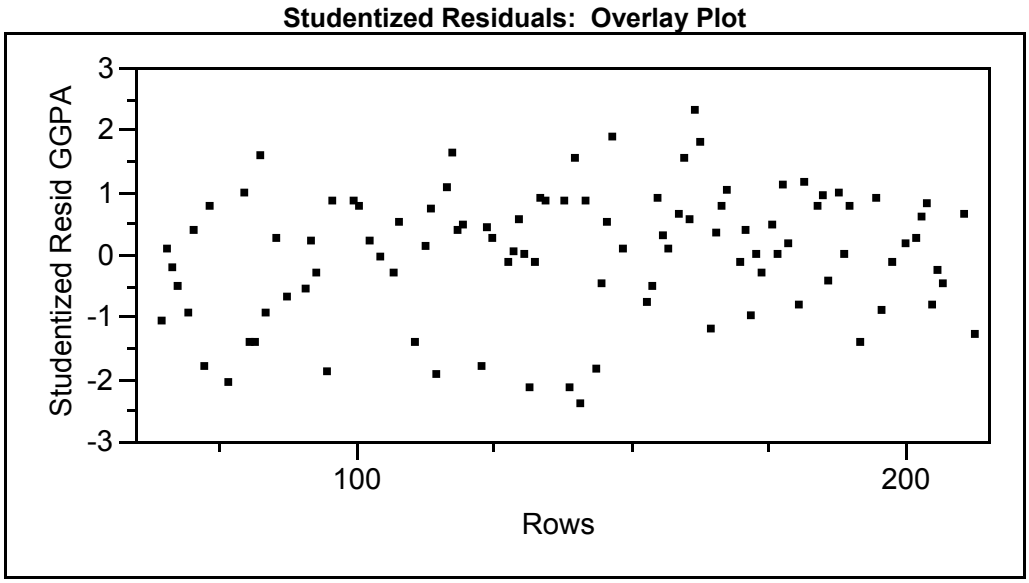
Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
UGPA	1	1	0.42796514	13.4464	0.0004
GRE-Q	1	1	0.24371090	7.6573	0.0068
Rank/Grade	1	1	0.09072919	2.8507	0.0946
Prior Enlisted	1	1	0.25317437	7.9546	0.0058



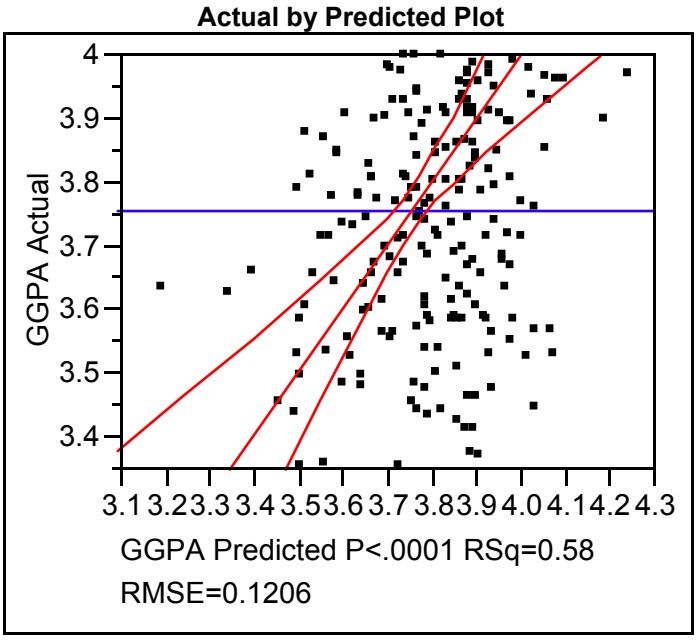
Durbin-Watson

Durbin-Watson	Number of Obs.	AutoCorrelation
1.480186	100	-0.0771




Studentized Residuals: Overlay Plot
Studentized Resid GGPA
3
2
1
0
-1
-2
-3
100
200
Rows

Appendix F: Reduced GRE Baseline Model for Managers



Summary of Fit

RSquare	0.575099
RSquare Adj	0.535573
Root Mean Square Error	0.12056
Mean of Response	3.755625
Observations (or Sum Wgts)	48

Analysis of Variance

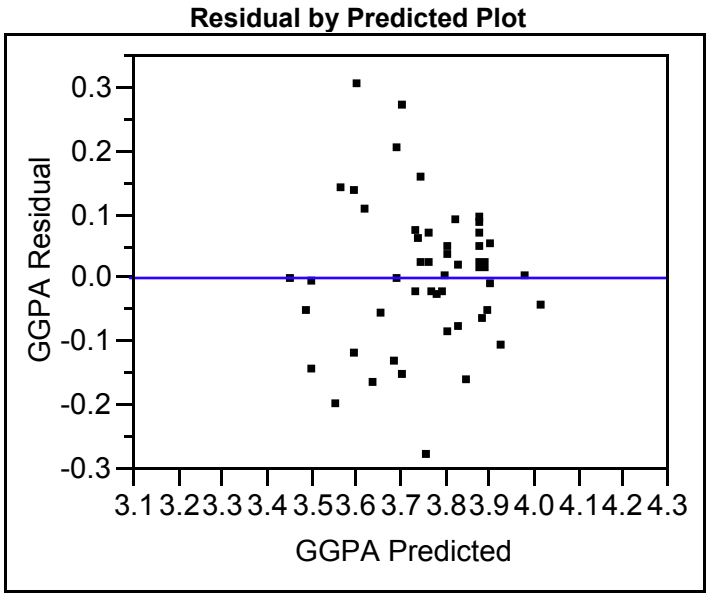
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	0.8459238	0.211481	14.5500
Error	43	0.6249954	0.014535	Prob > F
C. Total	47	1.4709193		<.0001

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.8509723	0.245969	11.59	<.0001
UGPA	0.1978809	0.045503	4.35	<.0001
GRE-Q	0.0015296	0.000252	6.07	<.0001
GRE-V	-0.001148	0.000372	-3.09	0.0035
AFSC	-0.015771	0.006416	-2.46	0.0181

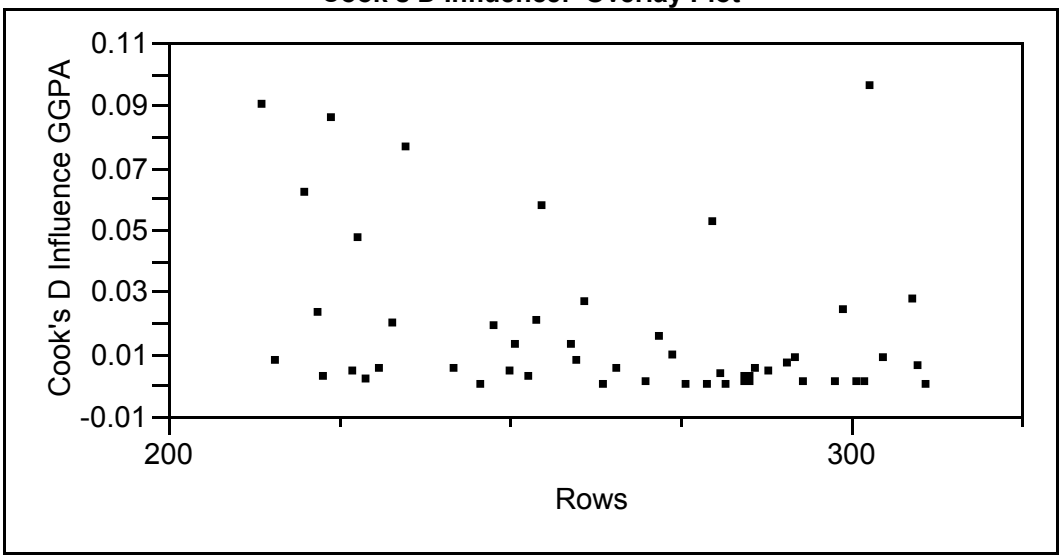
Effect Tests

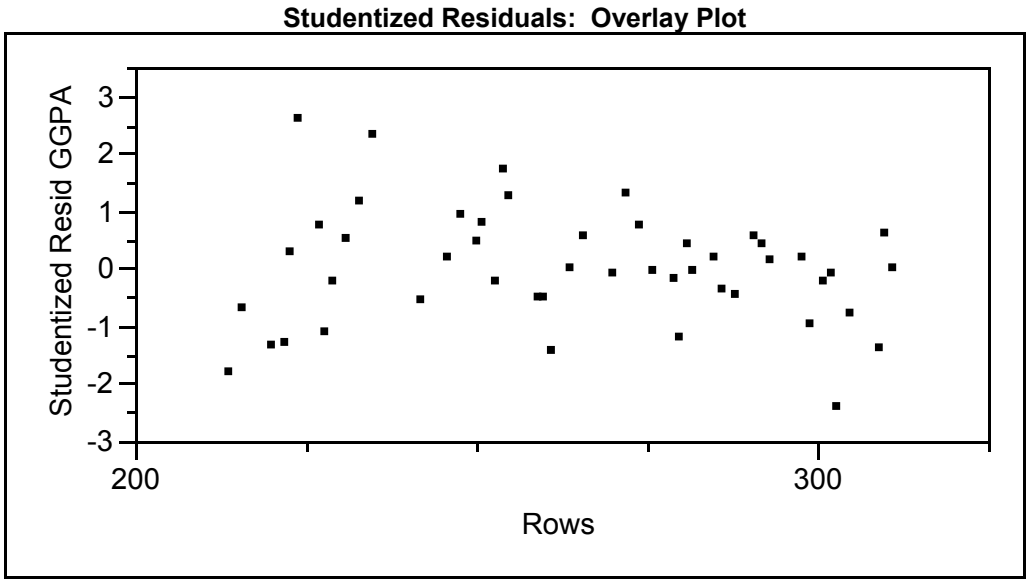
Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
UGPA	1	1	0.27487161	18.9113	<.0001
GRE-Q	1	1	0.53572473	36.8581	<.0001
GRE-V	1	1	0.13853804	9.5315	0.0035
AFSC	1	1	0.08781018	6.0414	0.0181



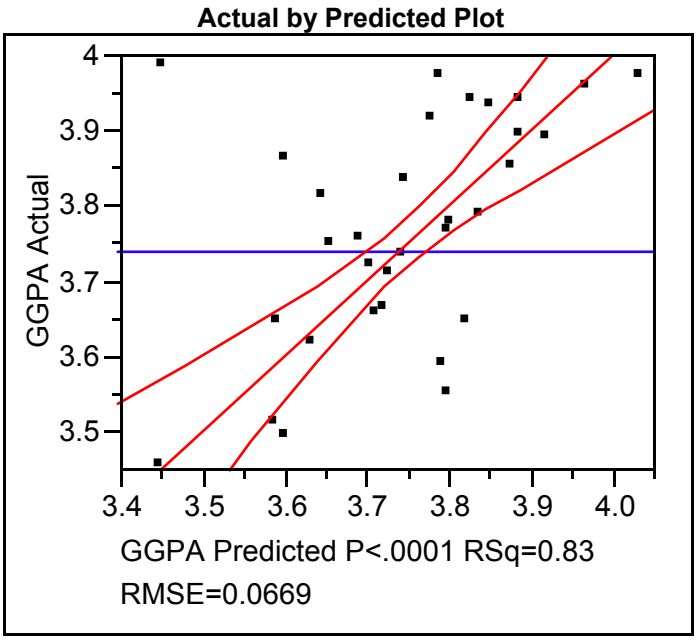
Durbin-Watson

Durbin-Watson	Number of Obs.	AutoCorrelation
0.69285	48	0.0430




Studentized Residuals: Overlay Plot
Studentized Resid GGPA
3
2
1
0
-1
-2
-3
200
300
Rows

Appendix G: Reduced GMAT Baseline Model for Managers



Summary of Fit

RSquare	0.832764
RSquare Adj	0.790955
Root Mean Square Error	0.066921
Mean of Response	3.740238
Observations (or Sum Wgts)	21

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	0.35680934	0.089202	19.9183
Error	16	0.07165447	0.004478	Prob > F
C. Total	20	0.42846381		<.0001

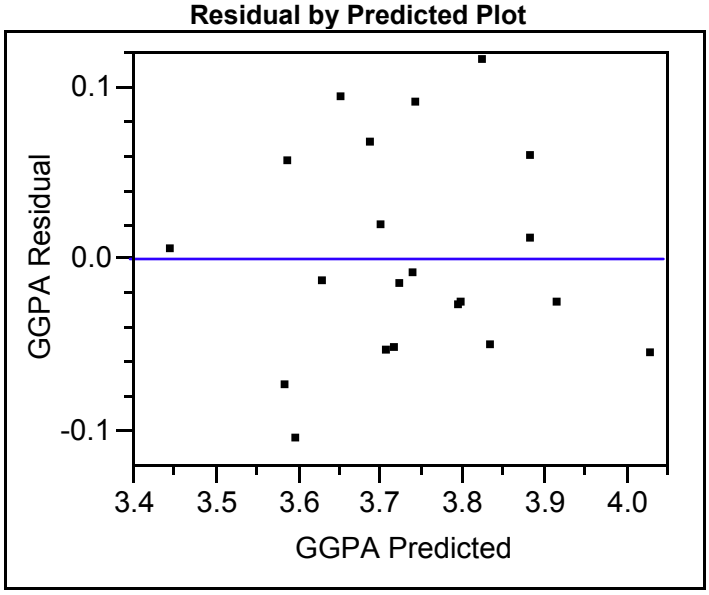
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	3.0852446	0.266415	11.58	<.0001
GMAT	0.0011681	0.000278	4.20	0.0007
Rank/Grade	0.1128572	0.041022	2.75	0.0142
Prior Enlisted	-0.122582	0.032441	-3.78	0.0016
AFSC	-0.021002	0.005207	-4.03	0.0010

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
GMAT	1	1	0.07918037	17.6805	0.0007
Rank/Grade	1	1	0.03389555	7.5687	0.0142
Prior Enlisted	1	1	0.06394206	14.2779	0.0016
AFSC	1	1	0.07286101	16.2694	0.0010

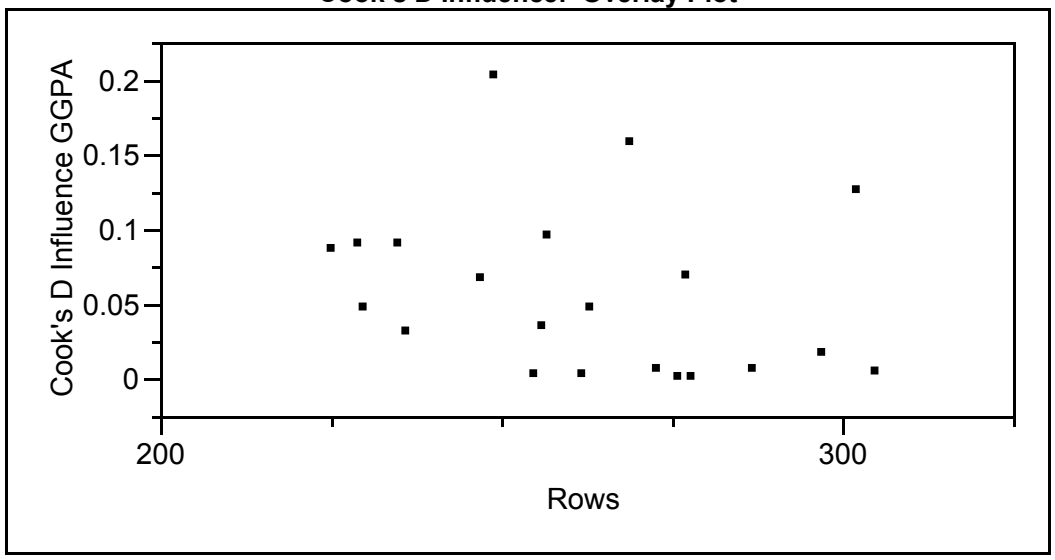
Residual by Predicted Plot

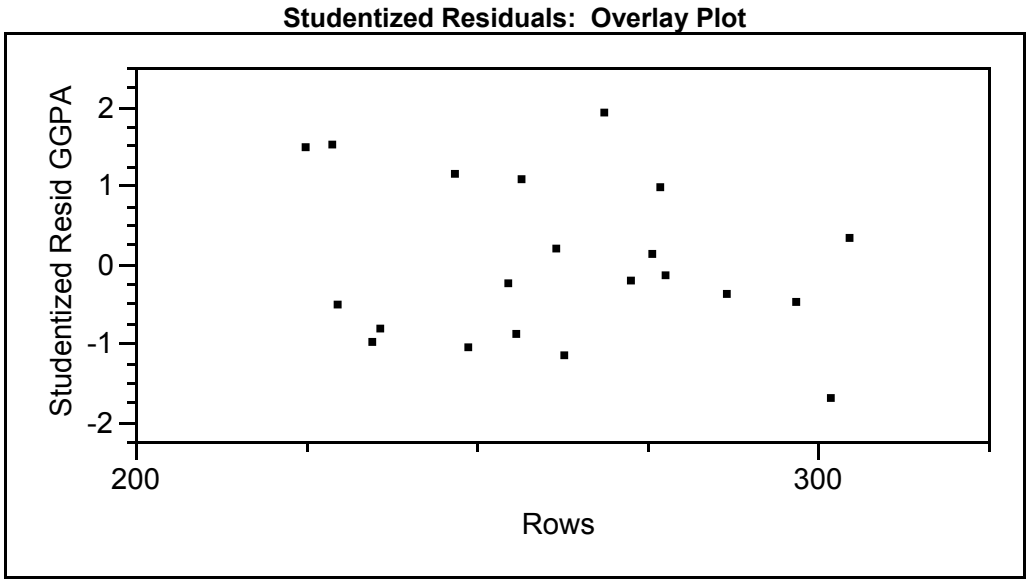


Durbin-Watson

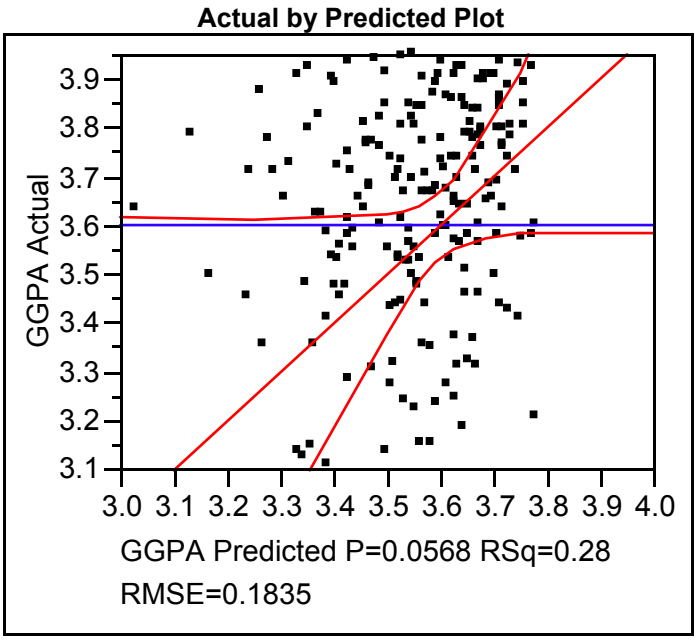
Durbin-Watson	Number of Obs.	AutoCorrelation
0.5897497	21	-0.0409

Cook's D Influence: Overlay Plot




Studentized Residuals: Overlay Plot
Studentized Resid GGPA
2
1
0
-1
-2
200
300
Rows

Appendix H: Validation GRE Baseline Model for Scientists and Engineers



Summary of Fit

RSquare	0.279876
RSquare Adj	0.173191
Root Mean Square Error	0.183536
Mean of Response	3.600625
Observations (or Sum Wgts)	32

Analysis of Variance

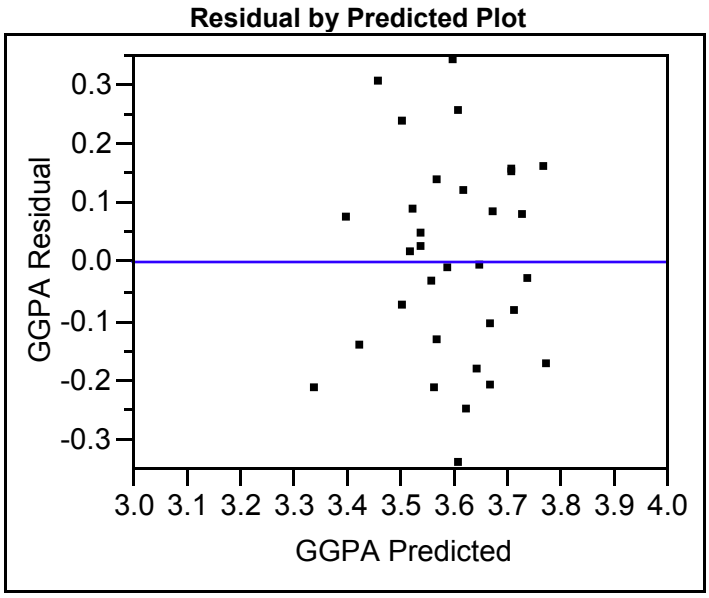
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	0.3534779	0.088369	2.6234
Error	27	0.9095036	0.033685	Prob > F
C. Total	31	1.2629815		0.0568

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.6384303	0.48006	5.50	<.0001
UGPA	0.0317524	0.086758	0.37	0.7172
GRE-Q	0.001246	0.000609	2.04	0.0508
Rank/Grade	0.0198851	0.064043	0.31	0.7586
Prior Enlisted	-0.15675	0.074531	-2.10	0.0449

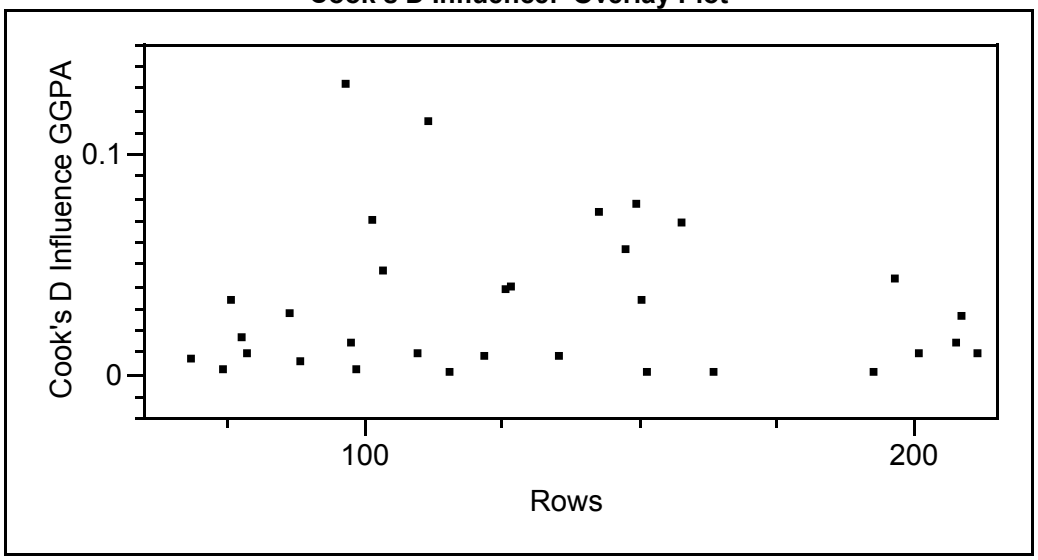
Effect Tests

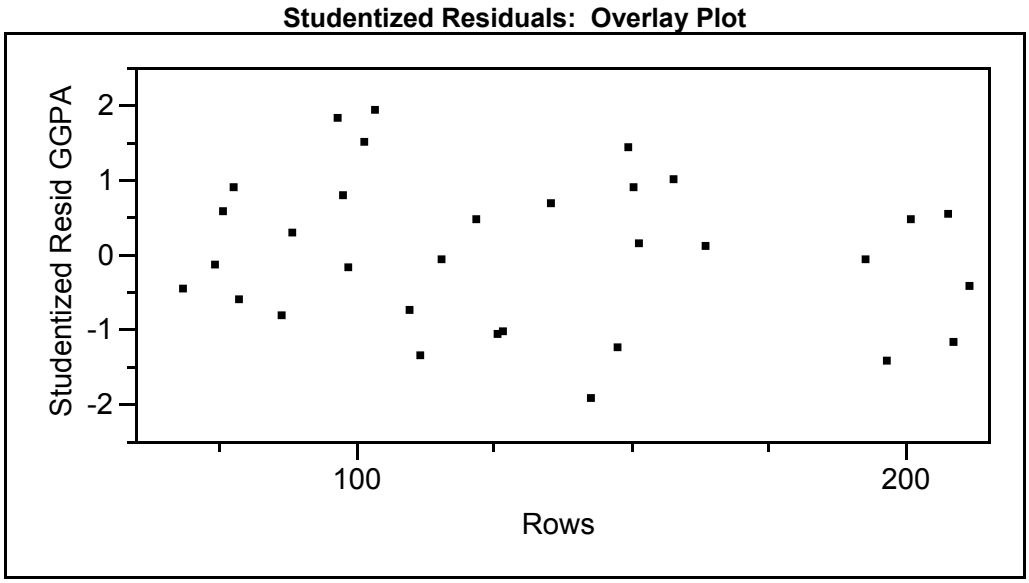
Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
UGPA	1	1	0.00451204	0.1339	0.7172
GRE-Q	1	1	0.14078491	4.1794	0.0508
Rank/Grade	1	1	0.00324749	0.0964	0.7586
Prior Enlisted	1	1	0.14899688	4.4232	0.0449



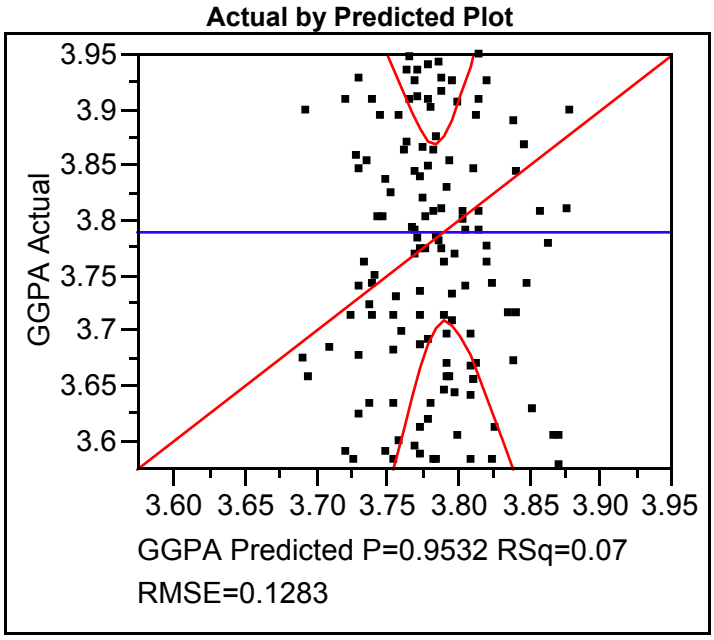
Durbin-Watson

Durbin-Watson	Number of Obs.	AutoCorrelation
0.2773592	32	0.0768




Studentized Residuals: Overlay Plot
Studentized Resid GGPA
2
1
0
-1
-2
100
200
Rows

Appendix I: Validation GRE Model for Managers



Summary of Fit

RSquare	0.073762
RSquare Adj	-0.38936
Root Mean Square Error	0.128281
Mean of Response	3.788692
Observations (or Sum Wgts)	13

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	0.01048405	0.002621	0.1593
Error	8	0.13164872	0.016456	Prob > F
C. Total	12	0.14213277		0.9532

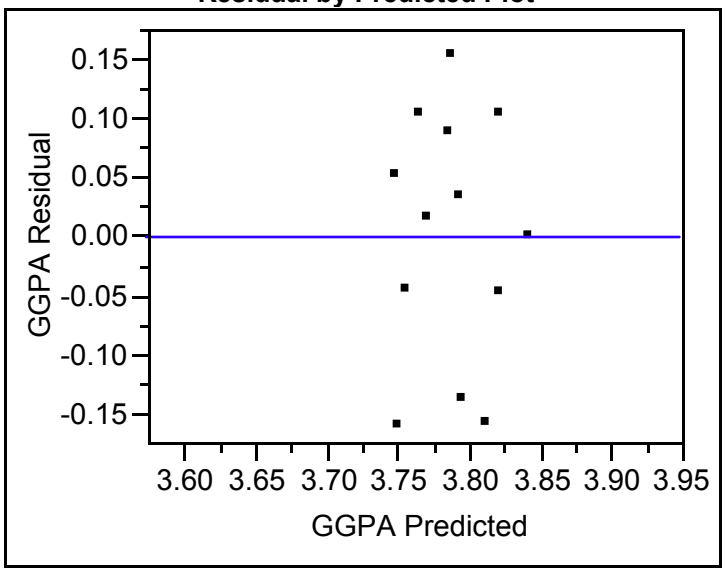
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	3.4734728	0.721965	4.81	0.0013
UGPA	0.0035586	0.111454	0.03	0.9753
GRE-Q	-0.000041	0.000448	-0.09	0.9303
GRE-V	0.0005359	0.000815	0.66	0.5293
AFSC	0.0053646	0.014164	0.38	0.7147

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
UGPA	1	1	0.00001678	0.0010	0.9753
GRE-Q	1	1	0.00013423	0.0082	0.9303
GRE-V	1	1	0.00711351	0.4323	0.5293
AFSC	1	1	0.00236053	0.1434	0.7147

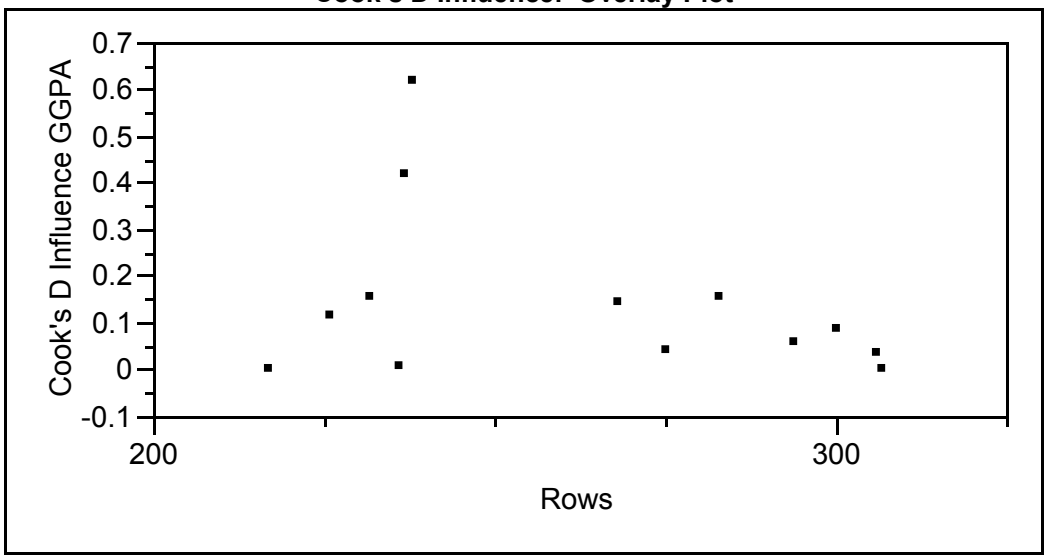
Residual by Predicted Plot

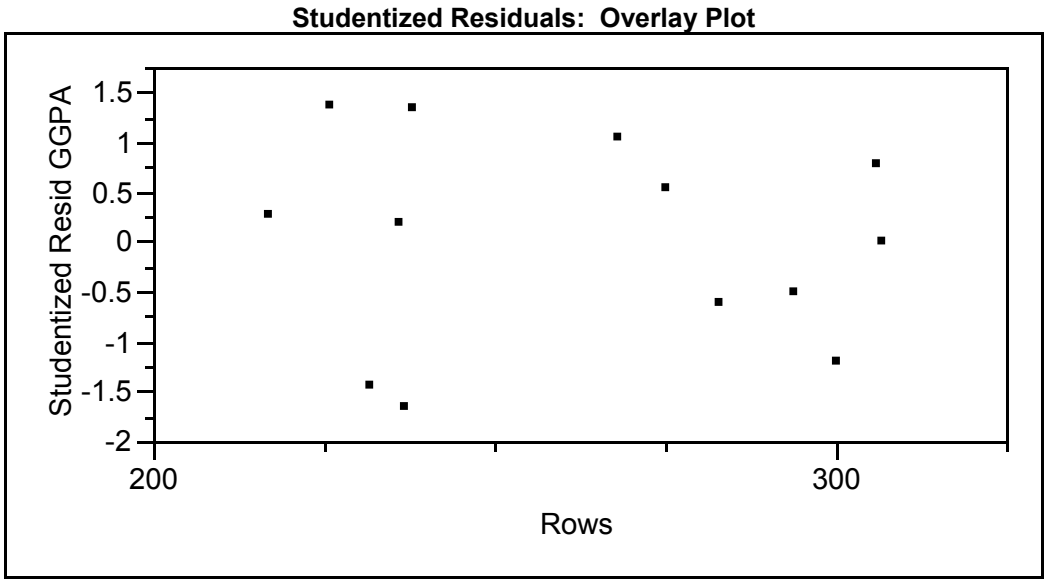


Durbin-Watson

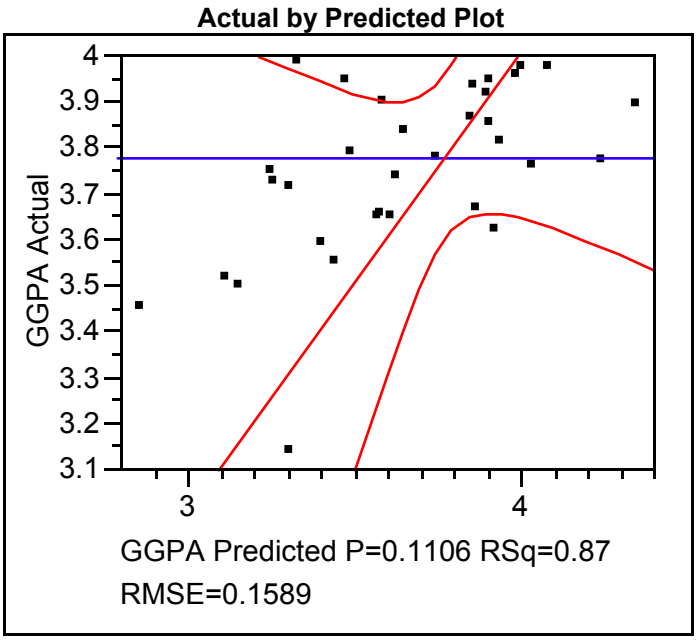
Durbin-Watson	Number of Obs.	AutoCorrelation
0.8292008	13	-0.1458

Cook's D Influence: Overlay Plot




Studentized Residuals: Overlay Plot
Studentized Resid GGPA
1.5
1
0.5
0
-0.5
-1
-1.5
-2
200
300
Rows

Appendix J: Validation GMAT Model for Managers



Summary of Fit

RSquare	0.867828
RSquare Adj	0.691599
Root Mean Square Error	0.158923
Mean of Response	3.778
Observations (or Sum Wgts)	8

Analysis of Variance

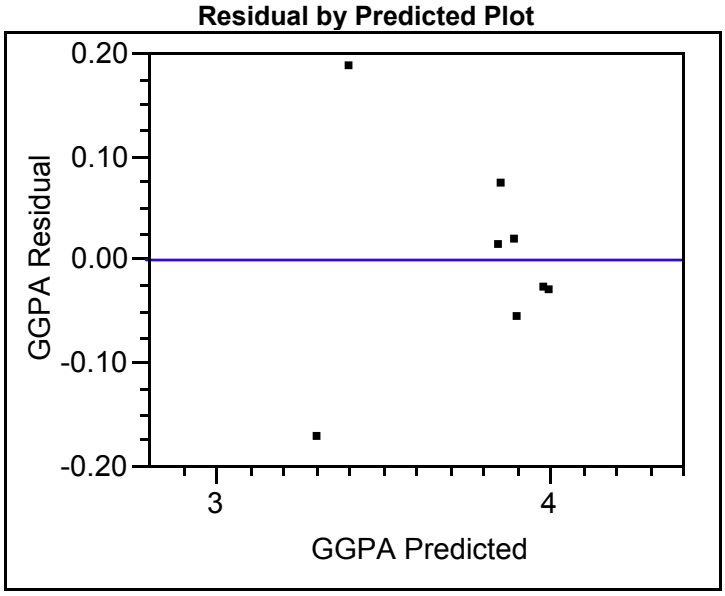
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	0.49749467	0.124374	4.9244
Error	3	0.07576933	0.025256	Prob > F
C. Total	7	0.57326400		0.1106

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	3.5988772	0.700884	5.13	0.0143
GMAT	0.0023116	0.000826	2.80	0.0679
Rank/Grade	-0.267153	0.148373	-1.80	0.1696
Prior Enlisted	-0.448834	0.187918	-2.39	0.0969
AFSC	-0.024859	0.02901	-0.86	0.4545

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
GMAT	1	1	0.19788436	7.8350	0.0679
Rank/Grade	1	1	0.08188056	3.2420	0.1696
Prior Enlisted	1	1	0.14408159	5.7047	0.0969
AFSC	1	1	0.01854580	0.7343	0.4545



Durbin-Watson

Durbin-Watson	Number of Obs.	AutoCorrelation
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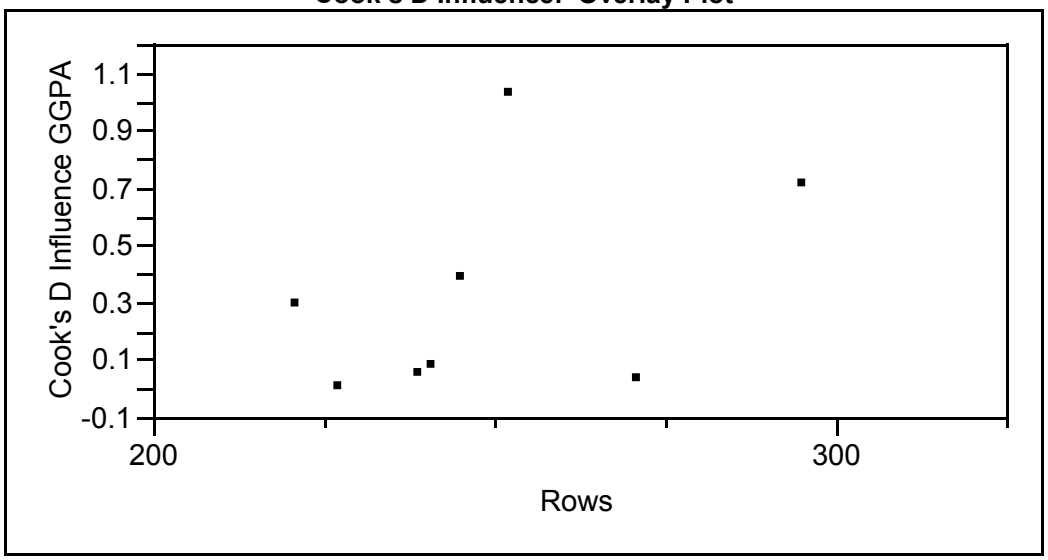

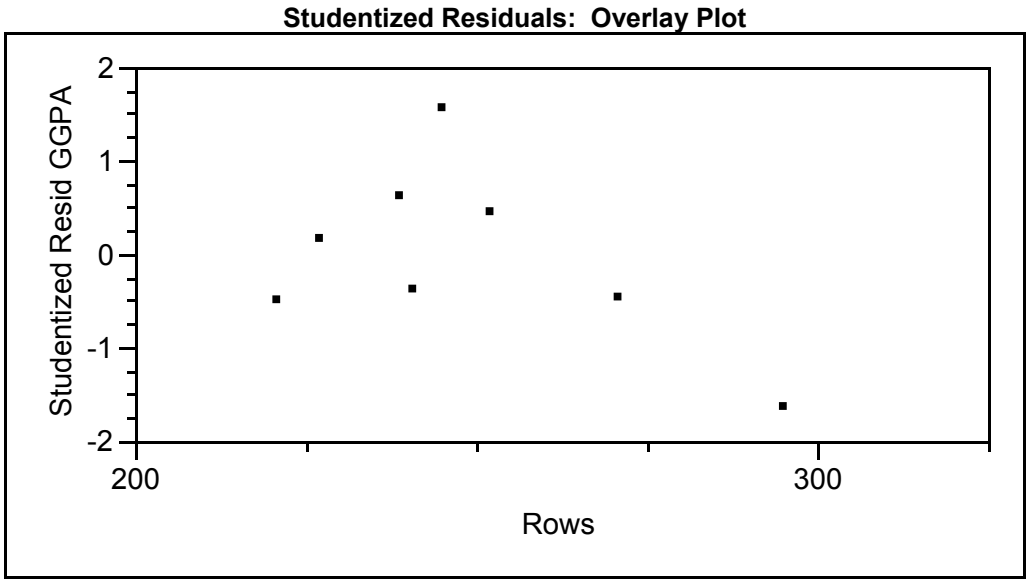
Studentized Residuals: Overlay Plot
Studentized Resid GGPA
2
1
0
-1
-2
200
300
Rows

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14. ABSTRACT

This research is based on the Air Force and AFIT balancing mission requirements of personnel needed for duty and training airmen in advanced studies. Currently, over 50% of AFIT students do not meet AFIT entrance requirements. The purpose of this research was to examine criteria to determine its predictability of graduate success, as measured by graduate GPA, as well as determine whether performance is different for students who require criteria to be waived. Current AFIT eligibility criteria include undergraduate GPA, GRE test scores, or GMAT test scores. Other variables examined in this study include: GRE-Analytical test scores; rank/grade; prior enlistment; AFSC; gender; and number of members in household.

This research found GMAT scores were a better predictor of success than GRE scores for management students. GRE-Q scores were good predictors for all students, while GRE-V scores were moderately good predictors for management students only. GRE-A scores should be added as a requirement with an appropriate standard. Undergraduate GPAs should be used as a guideline, not eligibility criteria into AFIT. Waivers should not be given for multiple deficiencies when possible, though there was little difference in the performance of students who met the criteria and those who did not. There was also little difference in the performance of students depending upon the type of waiver given.

15. SUBJECT TERMS
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