A REVIEW OF GRADUATE STEM DEGREES

BY GENDER IN THE CONTEXT

OF THE GREAT RECESSION

by

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ABSTRACT

The purpose of this study was to review the graduate gender divide in STEM fields in the context of the recent Great Recession. The rationale for this study was a continuation of the pipeline paradigm at the graduate level. The goal was also to examine the gender divide in STEM across select institutional types, such as land-grant institutions, as well as degree levels comparing master's and doctoral. Additionally, geographic differences were addressed by examining data related to the Academic Common Market. Trends for data were reviewed in an effort to discern degree production changes. Different ANOVA's and Ordinary Least Squares Regression were used to review IPEDS data from academic years 2005 through 2010.

The dependent variable was the ratio of female graduate degrees out of total graduate degrees at the CIP (Classification of Instructional Program) level. Overall, there were not significantly different findings across years or trends across years. There were select differences between master's and doctoral degree levels within STEM field. Select differences also existed between institutions on the basis of land-grant status and Academic Common Market status. Select independent variables were statistically significant for each of the STEM CIP fields under review.

Results indicate a gender divide in STEM fields. Using the pipeline paradigm, these differences were more noticeable at the doctoral than master's level. Variation existed in the extent of the gender divide across STEM fields. Results can be used to further expand research

concerning policies and practices of the gender divide in STEM fields at the graduate level in the United States.

LIST OF ABBREVIATIONS AND SYMBOLS

α	Probability of making a Type I error
ANOVA	Analysis of variance
β	Probability of making a Type II error
b^*,	Standardized beta weights
df	Degrees of freedom
F	F distribution
M	Mean
Mdn	Median
n	Number of cases (subsample)
N	Number of cases total
OLS	Ordinary Least Squares
p	Probability value
r	Pearson product-moment correlation coefficient
r^2	Coefficient of determination
R	Multiple correlation
R^2	Multiple correlation squared
SD	Standard deviation
SE	Standard error

χ^2	Chi-square statistic
$\hat{Y}$	Estimated value of y
ε	Error
$<$	Less than
$>$	Greater than

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INTRODUCTION

Introduction

For the United States, according to the National Bureau of Economic Research, the dates for the start and end of the recent severe economic downturn known as the Great Recession were December 2007 and June 2009, respectively (American Association of University Professors [AAUP], 2011). In response to this economic environment, select degree programs have been emphasized nationally. These degree programs are STEM (Science, Technology, Engineering, and Math) fields (Burke & McNeill, 2011; Obama, 2011).

Part of this push at the national level has been a refocus at the secondary school level. This is evidenced in President Obama's 2011 State of the Union address, which highlighted STEM field teacher replacement at the high school level, saying..."and over the next ten years, with so many baby boomers retiring from our classrooms, we want to prepare 100,000 new teachers in the fields of science and technology and engineering and math." Another example of a recent national push for STEM fields is a number of national initiatives, such as President Obama's *Educate to Innovate*. *Educate to Innovate* is a program that seeks to combine efforts across several sectors, including federal intervention as well as private corporate efforts (Burke & McNeill, 2011). One example of collaboration occurs via the STEM Education Coalition, which seeks to combine efforts across education and business to promote STEM fields (STEM Education Coalition, 2012). Despite these national initiatives, there are still critiques of ongoing efforts. Critics are quick to point out that national initiatives overlook local influence and sidestep the stumbling blocks of an already dilapidated national educational system (Burke & McNeill, 2011).

There are ambitious campaigns currently underway which seek to promote STEM fields, specifically for females. The private sector seeks to increase the number of females in STEM fields via social marketing efforts. An example of a process used by the private sector is to raise awareness via social media methods (YouTube), as well as providing highlights of data that provide evidence for the continued gender divide online. Such efforts provide rich context for the current emphasis on STEM fields (Change the Equation, 2012).

Fields similar to STEM fields have been promoted in the past. For example, the National Defense Education Act (NDEA) of 1958, in response to the Soviet Union launching the Sputnik satellite in 1957, renewed focus on science fields as part of the space race (Burke & McNeill, 2011; Thelin, 2004). The current status of such science fields, now denoted as STEM fields, has critically declined since the national push from NDEA decades ago (Burke & McNeill, 2011). However, STEM fields are once again in the national spotlight.

Additionally, having enough graduates in STEM fields has been a constant matter of discussion for the past two decades. In 1992, there was discussion and call for solutions regarding the need to increase engineering graduates domestically (Bakos, 1992). There are current marketing efforts via the private sector (Change the Equation, 2012) that call for new STEM graduates. At times, there has been a seemingly greater demand for STEM fields and more opportunities in the workforce for STEM fields than there are STEM graduate degrees being produced (National Science Foundation Division of Science Resources Statistics, 2010a).

One way to meet this demand for STEM graduates is by finding ways to facilitate degree attainment for populations that are traditional minorities in STEM degree attainment.

Finding ways to ensure equitable degree attainment for all students regardless of their demographic background is key in order to meet this workforce demand, especially during a severe economic recession such as the one recently experienced in the United States. The first step in reviewing the current status of select minorities in STEM fields is to review degree production to discern the current status of differences by select demographic backgrounds.

Statement of Problem

Analyses of gender differences have historically shown males with higher degree attainment in STEM fields (Hagedorn, Nora, & Pascarella, 1996; Huang, Taddese, Walter, National Center for Education Statistics, & Synectics for Management Decisions, 2000; National Academy of Sciences National Research Council, 1991). While there have been gains in select STEM fields, gender differences still exist (Dave et al., 2010; Hanson, 2011). Research which focuses on gender is abundant regarding STEM baccalaureate degree attainment and, to a lesser extent, STEM associate degree attainment. However, there is not much analysis on graduate STEM degree attainment in the United States that focuses on gender. This includes the time period of the recent Great Recession in the United States.

This focus on the gender divide in STEM is also part of a larger context of gender equity in education. Efforts to address the gender divide in STEM fields mirror overall efforts to address the greater accountability movement in education to increase standards and provide an equitable educational setting. A specific case which frames this gender equity movement and accountability movement applied to STEM fields is the Science and Engineering Equal Opportunities Act of 1980 which called for the promotion of students in the sciences regardless of demographic background (Lynch, 2011; National Science Foundation, 1980).

Purpose

The purpose of this study was to compare the differences in graduate degree attainment by gender within the context of the Great Recession. This study is national in scope. Land-grant universities will be one focus of this dissertation due to their historical emphasis on the applied disciplines, such as STEM fields (Thelin, 2004). The Southeastern US will also be addressed as a region by using a regional cooperative, the Academic Common Market, as a comparison group (Southern Regional Education Board, 2010).

Research Questions

The following is a list of the research questions. For the following questions, the dependent variable is ratio of female degrees for select STEM fields at the CIP level out of the total number of degrees for the STEM CIP field.

1. Is the gender divide greater among master's degrees compared to doctoral degrees for STEM;
2. Are there differences in graduate degree production for land-grant vs. non land-grant institutions;
3. Are there gender differences in each STEM field by two-digit CIP code for academic years 2005-2010;
4. Are there differences in graduate STEM degree production comparing the Academic Common Market vs. non-ACM institutions;
5. Are there trends in graduate degree attainment by gender across academic years 2005-2010; and
6. What institutional factors can be indicators of female graduate STEM degree attainment for academic years 2005-2010?

Significance

While there is an abundance of research that focuses on undergraduate degrees, graduate degree attainment is not as well studied. Reviewing the impact of the Great Recession on graduate degree attainment by gender can provide new data on gender differences at the graduate level. Understanding factors, which provide a context for moving forward with finding ways to create equitable education environments, can be critical in effectively weathering future economic recessions, and in improving educational opportunities for students (especially females) in graduate STEM fields.

Differences in degree attainment by gender during an economic downturn can affect the future direction of policy and practices regarding gender and equity in STEM fields. The intent of the study is to provide data regarding potential gender divide in STEM fields at the graduate level, which can be useful in future insight for efforts at promoting an equitable degree attainment process. On an individual level, this aids students who seek to pursue graduate degrees in STEM fields to do so without being hindered due to their gender. On an economic level, such policies and practices could facilitate the development of the economy to help ensure a sense of economic vitality and competitiveness for an American economy that has been lagging. This is especially true, given that increased equity can be theoretically linked to greater competition in the labor pool and, consequently, to greater productivity as a result of having more qualified individuals (females) in the STEM workforce (Leslie, McClure, & Oaxaca, 1998).

A focus on equity is also linked to a focus on the accountability movement regarding the gender divide in STEM fields. This focus on gender equity in education can be linked to prior policies that focus on equity in educational and social contexts. Such equity policies include the

1972 Title IX (formally Title IX of the Education Amendments of 1972), which mandated equal access to federally funded education activities (United States Congress, 1972), likewise in 1983 the National Science Foundation increased its focus on equity by including emphasis on quality for all participants through its Educating Americans for the Twenty-First Century (Lynch, 2011). There were also annual reports published by the NSF that focus on females and minorities in science and engineering (Lynch, 2011; National Science Foundation Division of Science Resource Statistics, 2011). The Education and Human Resources Directorate (one of the six main Directorates of NSF) has, as one of its main goals, increasing participation in STEM fields. This increased participation includes diversity at every level of education (Earle, 2011), such as gender equity at the graduate level.

On a regional level, findings from this study can be critical during a recession for a geographic area with a regional compact which seeks to promote access by addressing affordability (Southern Regional Education Board, 2010). Additional findings, which can be significant, are gender differences on a national scale versus those of a select region, the Southeastern United States, which includes states participating in the Academic Common Market (Southern Regional Education Board, 2010). Significant differences in these states can reveal the extent to which gender differences in a region can promote gender equity among fields, which are being promoted nationally.

The Academic Common Market (ACM) is a regional compact in the Southeastern United States, which seeks to increase access to select types of degrees. The compact allows for out-of-state students to pay in-state rates. The long-standing regional compact represented by ACM allows for the investigation of the current status of the regional cooperation (Southern Regional Education Board, 2010).

The ACM is relevant due to its emphasis on increasing access in a time of economic hardship (Harcleroad & Eaton, 2005). The additional benefit of having a regional comparison becomes apparent when the national agenda is promoted. The regional cooperation of ACM is unique since the context for the inception of the ACM was an economic downturn (Southern Regional Education Board, 2010). Reviewing the extent to which degrees are awarded nationally as compared to within the ACM can be a way in which this regional compact can revisit the compact's mission during a time of economic downturn.

Hiring trends continually show that select majors, such as engineering, continue to be in demand (Michigan State University Collegiate Employment Research Institute, 2006). However, degree production for STEM is at best remaining even, and at worst declining. There are also indicators of lessened degree output given the amount of funding expended on STEM education. Finally, the overall retention rates in STEM are low (American Institutes for Research, 2012).

Being aware of geographic significance, geographic savvy, for select industries is also growing in importance in a global economy. A regional economic outlook in the US couched within a global marketplace framework has recently been promoted (Michigan State University Collegiate Employment Research Institute, 2006). Geographic savvy can be critical during the recent Great Recession, as well as the southeastern U.S.

There is also the potential for this study to provide data relevant to the status of graduate-level females who pursue STEM degrees in general. Given a severe economic downturn, the status of females in STEM fields is of particular interest. The potential gender difference in the impact of the Great Recession could provide more data concerning the representation of females in STEM fields.

This study, focusing on the graduate level and institutional type, is a novel approach in the general STEM and gender literature, which historically has focused on the pipeline paradigm at pre-graduate education levels. The literature from the pipeline paradigm framework deals mostly with primary and secondary schools, and postsecondary undergraduate levels to a lesser extent. An example of a review of gender and STEM in postsecondary institutions has been conducted previously (Berryman & Rockefeller Foundation, 1983). Graduate degrees are not studied as much as earlier education levels regarding gender and STEM fields. This study provides a new perspective on equity at the post-baccalaureate level.

Definitions

Classification of Instructional Programs (CIP) - CIP codes refer to academic fields. These include STEM fields. A CIP code has a full range of identifying numeric data. There are numerous levels of CIP codes. For example, a two-digit CIP code may refer to a general field (i.e. engineering) while a longer (4 to 6 digit) CIP code may refer to a more specific subfield (aerospace engineering). For purposes of this study, two-digits CIP codes will be used (National Center for Education Statistics, 2012a). A more thorough explanation of which CIP codes were used is contained in Delimitations and Chapter III: Methods.

Gender - For purposes of this study gender means a biological identification for male and female. This is consistent with the identification of gender in IPEDS (National Center for Education Statistics, 2012b).

Graduate Degree - A graduate degree is a full degree beyond the four-year bachelor's level. A graduate degree does not include graduate certificates. Master’s degrees as well as doctoral degrees will be the focus in this study (National Center for Education Statistics, 2012b).

Great Recession - The Great Recession is the severe economic downturn across the United States during the latter part of the 2000-2010 decade. For the United States, the Great Recession will be defined according to the National Bureau of Economic Research, which places the dates for the start and end of the Great Recession as December 2007 and June 2009, respectively (AAUP, 2011).

Integrated Postsecondary Education Data System (IPEDS) - A database of annual surveys administered by the National Center for Education Statistics (NCES). IPEDS is mandatory for all postsecondary institutions, which participate in federal student aid programs. This includes a range of data, such as financial practices, faculty and staff, enrollment and retention, to name a few (National Center for Education Statistics, 2012b).

National Center for Education Statistics (NCES) - NCES is a federal office in the US Department of Education, which collects and stores a range of US education data (National Center for Education Statistics, 2012c).

Land-Grant Institution - The land-grant institution is an institution with a select federal designation to serve as an institution within states, as identified in IPEDS. Land-grant institutions traditionally emphasize technical and applied disciplines, which include STEM fields (Thelin, 2004). There are three types of land-grant institutions. The first type, 1862 land-grant institutions, are institutions that serve the state in which they were founded. The second type, 1890 land-grant institutions, are noteworthy for including institutions, which are designated Historically Black Colleges and Universities (HBCUs) as land-grant universities (Thelin, 2004). The third type, 1994, gives land-grant status to Native American Tribal Colleges (National Center for Education Statistics, 2012b).

STEM - Science, Technology, Engineering, and Math. There is no universal definition of which fields are considered STEM fields. STEM was a term first used en masse during the early 1990s (Bybee, 2010). For purposes of this study, STEM fields will refer to a predetermined set of disciplines in IPEDS by using two-digits CIP codes (Hardy & Katsinas, 2010; Starobin & Laanan, 2008), as well as the addition of one CIP code to address the technology part of STEM fields.

Assumptions

The current study was undertaken based upon the following a priori assumptions:

1. Doctoral research institutions are engaged in the curriculum leading to the reward of master's and doctoral degrees;
2. There is complete data in IPEDS; and
3. There is accurate data in IPEDS.

Delimitations

The current study was conducted with the acknowledgement of a priori delimitations:

1. The study involved only degrees produced in the following STEM-related classification of instructional programs (CIP) codes: *computer and information sciences and support services, engineering, engineering technologies and related fields, biology and biomedical sciences, mathematics and statistics, physical sciences,* and *science technologies/technicians* (National Center for Education Statistics, 2012b);
2. Only master's and doctoral degrees in these CIP codes were considered for review;

3. Only IPEDS date for academic years 2005-2006 through 2010-2011 were analyzed;
4. Only data from the following surveys in IPEDS were used: Institutional Characteristics, Completions, 12-Month Enrollment, Finance and Human Resources; and
5. Institutions not part of the 50 United States or Washington DC in IPEDS were not included for review. Those institutions located in US territories and protectorates were not included.

Limitations

The current study was completed with the acknowledgement of a priori Limitations:

1. The quality and completion of IPEDS data may lack consistency;
2. The focus of the study was on only graduate degree production. Thus, results are not generalizable to undergraduate degrees;
3. There are select factors outside of those studied which may affect the independent and dependent variables; and
4. There cannot be generalization to non-degree credentials.

Organization of the Study

This study is organized into five chapters. They are as follows: Chapter I: Introduction**;** Chapter II**:** Literature Review; Chapter III: Methods; Chapter IV: Results; and Chapter V: Conclusion. An overview of each chapter follows.

Chapter I introduces the topic and provides a rationale for conducting the study through the problem and purpose. A brief background and significance of the study provide support and context. Limitations, assumptions and delimitations of the study are also addressed.

Chapter II provides a relevant literature review. There are three main sections: economic, education, and social. Chapter Two begins with a review of the current economic context with a focus on the Great Recession and related environmental factors. Contextual factors with overlapping areas to this dissertation are discussed as well, including STEM jobs and the changing workforce related to STEM.

The following section of Chapter II addresses the educational context. A review of institutional characteristics, which can act as a background for choosing variables to serve as predictors of STEM degree production, is presented as well. Discussion of community college and undergraduate levels is presented as a contextual lead-in to the graduate level. An in-depth discussion of land-grant universities concludes section two.

The third and final section presents Gender Equity and the greater social context of STEM fields as related to higher education. Emphasis is placed on females in STEM fields. The third section ends with the presentation of two models, which provide paradigms for reviewing females in STEM fields. These two models provide the conceptual framework for the methodology.

Chapter III of the study provides a methodological explanation for statistical review of the data along with the process and rationale for this approach. Research questions are presented. Statistical analysis is explained. Database sources are presented, followed by ethical considerations and researcher positionality.

Chapter IV provides results of the data analysis. Results are displayed in a question-by-question format. Descriptive statistics are presented as needed, followed by relevant data highlights in the text of Chapter IV. Full data tables and data references are included as needed in the body of the text as well as in the Appendices.

Chapter V provides the conclusion to the study. Interpretation of results and implications for policy and practice are discussed. Recommendations for future research initiatives are considered as well.

CHAPTER II:

LITERATURE REVIEW

Context is paramount throughout this dissertation. An overview of the literature is presented with three main contextual themes. The three main themes for review are economic, education, and social.

The focus on the Great Recession and related contextual factors is emphasized in the economic context. Following the discussion of the economic context is an overview of the educational context with discussion of institutional characteristics related to degree production. These institutional characteristics are reviewed in order to provide an overview of possible variables and rationale for the methodology section. Institutional type focuses on land-grant institutions and their relation to STEM. The social context of gender equity concludes Chapter II.

Economic Context: The Great Recession

In the later years of the 2000-2010 decade, the economy of the United States underwent a severe economic downturn known as the "Great Recession." The Great Recession will be defined, for the purposes of this study, according to the economic guidelines put forth by the National Bureau of Economic Research as mentioned in a recent faculty salary report. The formal dates for the Great Recession as put forth in the National Bureau of Economic Research are from December 2007 through June 2009 (AAUP, 2011). The financial impact due to the Great Recession will provide context during which STEM degree attainment will be examined.

Overall, the Great Recession had a significant negative impact on the United States economy (Hoynes, Miller, & Schaller, 2012). Select employment indicators show how this economic recession has been the worst since the Great Depression (Goodman & Mance, 2011). Additional workforce factors show how the Great Recession is different than comparable severe recessions (Elsby, Hobijn, & Sahin, 2010). From a workforce perspective, the recent Great Recession had the severest impact on younger males with lower levels of education (Hoynes et al., 2012).

There was an economic gender divide revealed during the recent Great Recession. Workforce reviews reveal males doing better at finding jobs since the end of the recession in 2009 (Kochhar, 2011). Also, the higher education industry and females in the overall workforce were not as negatively impacted due to the recent Great Recession (Hoynes et al., 2012).

At the same time as the Great Recession, there has been a new emphasis placed on STEM fields nationally (Obama, 2011). Although national efforts have been criticized (Burke & McNeill, 2011), STEM fields remain valued disciplines. One manner in which this value is highlighted is through higher pay, including faculty salaries (AAUP, 2011).

Defining STEM

There is no consistently used definition of STEM fields. The early 1990s revealed the first large-scale use of the term "STEM" as an acronym (Bybee, 2010). While traditional fields such as chemistry or physics can easily be recognized as STEM fields, there are newer fields being developed within the technology sectors, which are not so readily or easily identified as STEM fields.

With the rapid expansion of the field of technology, the development of fields can be constantly changing which makes defining the technology in STEM difficult. The second reason Technology can be so difficult to classify is that there is ongoing debate on how the "T" in

STEM will be defined and conceptualized given its dynamic, seemingly pervasive quality to be such an integral part of the educational process (Kelley, 2010). Additional evidence for the inability to define STEM fields includes the overemphasis on science and math without the inclusion of engineering and technology (Bybee, 2010).

Elucidation of the STEM concept can help articulate a conceptual framework for STEM fields in order to facilitate advancement within the disciplines (Bybee, 2010). In order to promote or study a group of disciplines, agreeing on the disciplines to include would be a first step. Consequently, for the purposes of this paper, a definition of STEM fields will be used which has been used in prior research (Hardy & Katsinas, 2010; Starobin & Laanan, 2008), along with one CIP code (11-Computer and Information Sciences and Support Services) (National Center for Education Statistics, 2012b) to address the technology part of STEM fields.

Great Recession and STEM

Recession and war are factors that can be related to increased degree production. The use of the modern day GI Bill could contribute to increased degree production (Smith, 2008). It remains to be seen if returning soldiers from current foreign missions seek STEM degrees in the same way that veterans of World War II did (Thelin, 2004). This includes continuing education into graduate studies (Smith, 2008), and gender differences that may occur in the use of the GI Bill.

While the Great Recession is a unique economic event, there are potential similarities with smaller recent recessions. There are also possible links between lower economic conditions with lowered enrollment. However, the opposite remains true for graduate degree enrollments during the Great Depression (Edwards, 1932). There was a marked decrease in the overall rates of students obtaining quantitative doctorates during this era in the 1970. The number of females obtaining quantitative doctorates increased alongside a general increase in females obtaining doctorates during the 1970s, a period that included a recession (Berryman & Rockefeller Foundation, 1983). Similarities to past recessions include the recession of the early 1980s as well as the turn of the twentieth century (Smith, 2008). Unemployment rates for SEM (Science, Engineering, and Math), occurred at a time when there were also higher rates of degree completion. In conclusion, the economic context is related to degree production (Ampaw & Jaeger, 2011).

The social context of this data must be considered given the difference in time (Edwards, 1932; Smith, 2008). The recessions of the early 1970s, 1990s and 2000s all revealed graduate enrollment growth. Recessions are linked with higher numbers of students in graduate school (Smith, 2008). How these factors combine with STEM fields and the traditional gender divide is of interest. There is the possibility that the Great Recession had similar effects as past recessions.

Graduate studies cemented themselves as part of land-grant universities during the 1930s. Enrollment during the Depression continued to grow through the post-WWII expansion. This could be due in part to the promotion of research and national funding from federal sources (Eddy, 1957). Perhaps the manner in which the ascension of the research university (Thelin, 2004) and funding mechanisms (National Science Foundation) has influenced the manner in which (land-grant) universities get funded effects the gender divide.

Overall growth in STEM is expected to continue at least until 2014 (Pantic, 2007). Efforts are also being made by businesses to significantly increase (double) the number of STEM graduates by year 2015 (Tapping America's Potential, 2008). However, lower rates of females in STEM fields remains the status quo (Hanson, 2011).

Since 1995, the overall number of bachelor's degrees has risen. This includes growth in non-white science and engineering undergraduate students. Reviewing data from 2000, females have earned about 50% of undergraduate degrees in science and engineering. However, in recent years the number of females in select STEM fields has declined (National Science Foundation Division of Science Resources Statistics, 2010b).

The gender divide in select STEM fields still exist as well. Biology is one field where females seem to consistently earn more degrees than males. There has also been a marked increase in females obtaining degrees in chemistry. Fields that reveal a majority of degrees being granted to males include engineering, physics, and computer sciences (National Science Foundation Division of Science Resources Statistics, 2010b).

Physics can provide an example of STEM field trends prior to the Great Recession. During the 2006 and 2007 academic years, physics bachelor's degrees had reached their highest rate since 1971. Also, during these years, there was a marked discrepancy in physics enrollment by gender. About 79% of bachelor's degrees awarded went to males, and 21% of bachelor's degrees awarded went to females (down from 23% in 2004) (Mulvey & Shindel, 2010).

Master’s degree awards for females mirror overall degree production growth since the early 1990s. In 2007, there was a record number of doctorate degrees awarded across science and engineering fields. Degree production for science and engineering fields is highest at research institutions, including 70% of doctoral degrees in science and engineering (National Science Foundation Division of Science Resources Statistics, 2010b).

Policies related to the sciences and graduate degree attainment reveal the manner in which funding is distributed. The percent of overall undergraduate enrollment attributed to research universities is 13% (National Science Foundation Division of Science Resources

Statistics, 2010b). The extent to which a university-type, such as land-grant institutions, includes this research-intensive focus could have more influence when reviewing degrees at the graduate level than at the undergraduate level.

For nearly 30 years there has been growth in science and engineering fields at a rate faster than that of the workforce at large. However, from 2000 to 2007, this rate of growth was smaller compared to the decades prior (National Science Foundation Division of Science Resources Statistics, 2010a). Graduate degrees grew at a faster rate than undergraduate degrees from 1980 to 2000 in science and engineering (except for math and computer science) (National Science Foundation Division of Science Resources Statistics, 2010a). The highest ever graduate enrollment in science and engineering in the United States occurred just before the Great Recession, in 2006 (National Science Foundation Division of Science Resources Statistics, 2010b). There appears to be a discrepancy between the economic vitality of the United States and science and engineering degree awards (National Science Foundation Division of Science Resources Statistics, 2010a).

There has been steady growth in the number of females in science and engineering fields who hold doctorate degrees (National Science Foundation Division of Science Resources Statistics, 2010a). Doctorates in science and engineering are more prone to enter the workforce in the same fields for which they obtained their degrees compared to bachelor's degrees in science and engineering. In general, the higher the advanced degree, the more likely a graduate will end up in a position more closely tied to their degree (National Science Foundation Division of Science Resources Statistics, 2010a).

Tracking graduate degrees may be easier in relation to the broader economic context. Only 7% of the science and engineering workforce included doctorates, and about 18% master's degrees (National Science Foundation Division of Science Resources Statistics, 2010a). Current national efforts to address the gender divide in STEM fields are portrayed as localized institutional efforts with mixed results and limited generalization, yet facilitated via federal funding (Layne, 2011).

Higher expected earnings were indicative of higher degree completion. For a prior study, labor market conditions did not reveal gender differences upon degree completion. However, only one institution in the southeastern United States was included for review (Ampaw & Jaeger, 2011).

Perhaps the greater earning potential that may come with graduate degrees (even doctorate vs. master's) can be a positive motivator for degree completion. The question remains, what would be the expected earnings upon graduating in this economic recession? Perhaps this is intuitively a rationale for remaining in a degree program and graduating.

Educational Context: Institutional Characteristics and STEM Degree Production

Institutional Characteristics

Research which has focused on STEM fields and graduate studies focuses more on the ways in which the gender divide in STEM fields has been revealed at select types of institutions, such as HBCUs. However, the focus of a recent study focused on the undergraduate level at an HBCU in the southeastern United States (Francis, 2013). There are also recent studies which focus more on the choice to pursue a STEM degree in the current economic context (Mau, 2013; Niu, 2013; Garibay, Hughes, Eagan, & Hurtado, 2013), however, once again, these studies focus more on the undergraduate level than the graduate level. In these studies (Mau, 2013; Niu, 2013; Garibay et al., 2013), gender was aligned with students not going into STEM fields at the undergraduate level. For two of these studies, (Niu, 2013; Garibay et al., 2013), research which focused on the institutional level of review, i.e. institutional type, was explicitly cited as an area which needed future research.

There is also recent research that focuses on the individual level student choice to pursue graduate STEM degrees. This research provides a logical transition from focusing on the undergraduate STEM degree production to the graduate STEM degree focus of the current study. The Garibay et al. (2013) study used multi-level modeling, or HGLM (Hierarchical General Linear Model). The three dependent variable outcomes in the study were graduate STEM degree pursuit, STEM workforce, and non-STEM future (meaning a student has chosen a job outside of the STEM pipeline). The only institutional level predictor included in the study that focused on student choice to transition to the graduate STEM degrees was the IPEDS characteristics of institutional control or affiliation. The study found that private not-for-profit institutions for undergraduate study were indicators of graduate STEM degree pursuit (Garibay et al., 2013).

A recent dissertation focused on institutional level characteristics with relevance to the current dissertation. The focus of the dissertation was on institutional characteristics which could act as predictors of graduate degree production for traditionally underrepresented groups in engineering, including females. The date ranges for the recent dissertation included 2005-2009 (National Center for Education Statistics, 2012b). This dissertation (Ostreko, 2012) has overlap with the current study that focuses on the broader STEM fields and the economic context of the Great Recession.

Descriptive findings of the dissertation reveal regional emphasis with higher rates of engineering graduates, specifically the South/Southeastern United States (Ostreko, 2012). This can be critical when reviewing the Academic Common Market (Southern Regional Education

Board, 2010). Further review of data would be necessary when considering the generalization from engineering to STEM fields.

Variables under review for the past dissertation (Ostreko, 2012) included a range of university-wide demographics. Faculty demographics of the academic engineering unit (college, school, etc.), student demographics, population demographics of states where institutions were located, and ratio of acceptance were also significant institutional characteristics. Number of students enrolled in master's programs was also a significant institutional characteristic indicative of higher graduation rates for Black, Hispanic and Native American minority populations (Ostreko, 2012).

The research emphasis of an institution has been revealed in two ways. The first was through membership in a group of universities in the United States and Canada, which emphasize research, known as the Association of American Universities (Association of American Universities, 2012). The second way was through a significant institutional level predictor variable for the yearly mean money spent on research, or research expenditures. This predictor came from a regression equation for higher graduation rates for graduate degrees for traditionally underrepresented ethnic student groups in engineering (Ostreko, 2012).

Ostreko's (2012) findings supported select racial minority status (Black, Hispanic and Native American) for graduate engineering degree attainment rates was closely associated with institutional types, which were not as focused on research. However, the opposite was found with females in engineering. Female graduation rates in engineering were closely associated with institutional types, which emphasized research.

Additionally, institutional characteristics, which focus on critical mass or enrollment ratios for underrepresented minority students at public institutions, have been positive predictors in OLS Regression for graduating racial minorities (Black, Hispanic and Native American) in STEM fields. Emphasis on research grants has also been shown to be a positive predictor using this same statistical approach (Hubbard & Stage, 2010). While the Hubbard and Stage (2010) study focused on underrepresented minorities, enrollment ratios and emphasis on research grants can be used when focusing on gender.

Other select factors from Ostreko's (2012) dissertation are noteworthy as well. The ratio of females residing in the state was new. Twenty percent was deemed a high rate for select minorities in the population. Smaller classes seemed to be significant predictors for doctoral degree rates for females in engineering.

There also has been research conducted which reveals a gender divide in perspectives of resources needed to complete doctoral studies. However, these are individual level characteristics reviewed by gender in aggregate (Barnes & Wells, 2009). These viewpoints, especially one response item related to less agreement by females to males on feeling financially supported (Barnes & Wells, 2009), can be used to highlight resources which could become institutional characteristics needed to complete degree completion in the graduate STEM degrees. One perception of relevance was that female tended to agree more with a question regarding the perception that their program emphasized recruitment of qualified candidates from underrepresented populations (Barnes & Wells, 2009).

There is potential for institutions that emphasize research to display higher graduation rates for females in graduate STEM fields. Emphasizing technical, applied fields (Thelin, 2004) which focus on research can be an inherent means by which (land-grant) universities focus on research. Since land-grants are emphasized in the current study, there is the potential for land-grants to display higher rates of females obtaining graduate degrees in STEM fields.

However, the degree to which land-grant universities emphasize research remains to be seen. While there are select land-grant institutions which are also part of the American Association of Universities (AAU) (Association of American Universities, 2012), numerous AAU universities are not land-grant institutions. A significant difference lies in private institutions that are AAU members, such as Johns Hopkins, Duke or Emory (Association of American Universities, 2012). There are public AAU members that emphasize STEM fields, which are not land-grant institutions. In the Integrated Postsecondary Education Data System, select institutions are classified as STEM-dominant when referring to type of graduate offerings (National Center for Education Statistics, 2012b).

A recent research project focused on university selectivity in relation to bachelor's degree attainment in STEM fields. Results indicate that even though institutions, which are more selective have higher graduation rates in general, racial minorities have lower graduation rates in STEM fields at such selective institutions. The study reported undergraduate research efforts and STEM retention efforts were positive indicators of STEM degree completion (Eagan, Hurtado, & Chang, 2010).

Being able to review a broader range of institutions may provide insight into the ways in which emphasis of research at institutions can be related to STEM graduate degree production for the Great Recession. This can be achieved by having a set of universities, which offer graduate studies along with land-grant universities. Special emphasis can also be placed on the types of research emphasized. A broader spectrum of universities must be considered when reviewing graduate STEM degree production for females. A broader range of university type includes university’s that may offer graduate degrees in STEM, yet not traditionally be known as leaders regarding research in STEM. The potential review of such universities may enable a generalization of results to institutional type.

Institutional level. In order to review graduate degree production, reviewing institutional level factors that influence STEM degree production at community college and undergraduate schools is needed. A brief review of institutional characteristics, which influence degree production for females in STEM fields, may provide insight to graduate degree production in STEM fields. Given the sparse rates of females in competitive research universities (May, Moorhouse, & Broussard, 2010), reviewing factors that influence degree attainment at related STEM institutional contexts is beneficial as well.

Community college and undergraduate level. Overall, there has been a lack of females in STEM fields on the associate level from 1985 to 2005 (Hardy & Katsinas, 2010). However, community colleges are known for positively impacting degree production for females in STEM fields (Starobin & Laanan, 2008). Within this population, the proportion of females in science and engineering fields has grown since 1993 (National Science Foundation Division of Science Resources Statistics, 2010b).

One strongpoint of community colleges that has been cited is their diversity of student composition. This may allow for students to focus on their studies in place of non-academic factors, which may negatively influence their academic performance. One example is being female in a field with more males (Starobin & Laanan, 2008). This community aspect (Starobin & Laanan, 2008) of demographic minorities is postulated as a means by which select minorities in engineering may enter into an institutional type, which provides a diverse community on an undergraduate level.

Overwhelmingly the majority of degrees awarded in science and engineering (STEM) are given at the bachelor's level (70%) (National Science Foundation Division of Science Resources Statistics, 2010b). The number of females in undergraduate studies can be a negative indication of institutionalized discrimination, as are the presence of females in top administrative roles and the presence of female's studies programs (Kulis, 1997). Gender has been used in regression equations to create more accurate models of student attrition and degree attainment. Studies have found that being female predicts higher attrition and lower degree attainment for undergraduates compared to traditional white male students in STEM fields. This remains true when controlling for financial background (Whalen & Shelley, 2010), and additional individual level demographic characteristics such as socioeconomic status and additional demographic variables (Gayles & Ampaw, 2011). Liberal arts colleges and institutions with higher selectivity were also positive indicators of degree completion for females at the undergraduate level in STEM fields (Gayles & Ampaw, 2011).

Undergraduate gender differences by disciplines are less than in the working population (Hagedorn et al., 1996). Perhaps years spent in the workforce prior to entering a graduate STEM degree could be an indicator related to STEM degree attainment. Years spent in an environment that was more gender divided than academia could exacerbate gender differences prior to students entering their STEM graduate studies.

Focus groups have revealed factors, which effect retention on undergraduate levels include ratio of females in a field, self-concept, sociocultural views of female, and family support. Family support can be critical when combined with cultural values and expectations for female, especially for a university sample which had a commuter orientation where females may have worked (Burke, Sunal, & Sunal, 2011). Efforts addressed at retention for first and second year students related to STEM fields exist with successful results (Caudill, Hill, Hoke, & Lipan, 2010). One study even revealed how participation in a co-op program after the first year increased retention by five times (Jaeger, Eagan, & Wirt, 2008).

Given the degree to which community colleges positively impact the rate of female graduates in STEM areas (Starobin & Laanan, 2005), factors in community colleges which can be shown to facilitate degree attainment for female students might be more related to graduate degree attainment in STEM fields than undergraduate degrees. Community colleges and bachelor's granting institutions must be considered as a backdrop to graduate STEM institutional characteristics for females.

Regression equations which seek to use merit-based aid on state levels to try and determine undergraduate degree production for STEM fields reveal clinically significant data that merit-based aid programs increase undergraduate STEM degree production. However, this data does not achieve statistically significant results, and varies by state. This could be a result of merit-based aid programs increasing overall degree production on the undergraduate level (Zhang, 2011).

Merit-based aid might be more difficult to maintain in a STEM field than a non-STEM field, so STEM retention becomes an issue, especially when focusing on the undergraduate population (Zhang, 2011). However, the presence of such merit-based aid programs has mixed results on undergraduate degrees for females in STEM fields as compared to males. This can be a result of disproportionately females choosing non-STEM fields. Again, this may be due in part to a focus of merit-based aid on all degree programs, not just STEM fields (Zhang, 2011).

Graduate level. Select factors in undergraduate STEM fields may differ in influence at the graduate level. Prior research has revealed that continuation into graduate studies in general for females can be related to the size of the undergraduate institution attended (Ethington & Smart, 1986). Perhaps institution size can be a correlate for graduate studies despite the more tailored approach of graduate coursework in STEM fields.

Qualitative studies at research intensive universities reveal the complex interaction of doctoral student efforts to persist and finish their dissertation to obtain their degrees. An environmental context for individuals achieving success is considered (Lovitts, 2008). Discussion of the success of select minorities in a case study in California provided anecdotal evidence for student success in obtaining STEM degrees. There is not as much evidence readily available for faculty commentaries from female and minority viewpoints (Yohannes-Reda, 2010).

Assistantships are a main funding mechanism for science and engineering graduate studies. Federal funding can impact graduate school funding, as shown by federally funded projects displaying more research assistantships compared to teaching assistantships. The two main federal organizations providing this funding are National Institute of Health (NIH) and National Science Foundation (NSF). This assistantship trend is reversed for non-federally funded projects that reveal more teaching assistantships than research assistantships. Also, gender differences exist for funding, as males obtain more research assistantships and personal resources are used more by females (National Science Foundation Division of Science Resources Statistics, 2010b).

In a single university review of SEM (Science, Engineering, and Math) disciplines, at one time point, males were observed to hold 22% more research assistantships than females (38 and 16 percent respectively). This is significant in light of data that support a 67% growth towards degree production for SEM students who hold a research assistantship (Ampaw & Jaeger, 2011).

Prior research indicates select assistantships and fellowships have been granted equally among male and female students in the 1970s in select STEM fields at a single university (Illinois-at Urbana Champaign) (Tidball, 1976). Previous findings reveal a slight gender divide related to persistence (Liseo, 2005).

Land-grant universities. Land-grant universities were originally developed in order to address land expansion in the United States through the Morrill Act of 1862. From their inception, land-grant universities have emphasized the practical fields, which include STEM fields (Thelin, 2004). Land-grant universities can be a lens to view the degree production of STEM fields because land-grant universities can be an institutional type that offers a baseline measure of STEM degrees through degree offerings.

Land-grant universities are one of America's major contributions to the structure and philosophy of higher education through their emphasis on select applied arts relevant to the American people (Eddy, 1957; Ross, 1942). The pragmatism of land-grant universities is synonymous with an American sense of pragmatism. Current organizations go so far as to maintain land-grant colleges can be considered the benchmark for the development of modern mass education (Association of Public and Land-Grant Universities [APLU], 2012a).

History of Land-Grant Universities, 1840-1862. A sense of duty to provide education was at the backdrop of the movement towards land-grant universities for a half of a century preceding the official announcement of land-grant universities. Part of this movement towards a duty of service through education included providing increased access and equity, including access for females. Land-grant universities can be seen as the culmination of these influences, as well as the culmination of grassroots movements to increase access (Eddy, 1957).

The Morrill Act of 1862 formally created the land-grant colleges. The Morrill Act of

1862 provided a means to develop a select type of practical institution. Noteworthy are the attempts to develop independent institutions resembling land-grant institutions that imploded due to finances in the years immediately before 1862 (Eddy, 1957). National policy allowed for the development and continuation of land-grant universities.

The development of land-grant institutions was, first and foremost, a by-product of policies seeking geographic expansion of the United States. Institutional development for the applied, agricultural and mechanical disciplines was a secondary objective (Thelin, 2004). Even in their development processes, land-grant universities have elements of pragmatism through national, federal efforts. Funding mechanisms and federal support can be critical to such universities. Consequently, fields, which land-grant universities emphasize, including STEM fields, are impacted as well.

During the 1840s, there was a "frontier" mentality, which promoted the American sense of individualism with the continued expansion of the country. It was difficult to develop national, federal means to play an active hand in the development of both the nation and education (Ross, 1942) during the decades before the Morrill Act of 1862. This Morrill Act of 1862 (Ross, 1942) can be seen as a solution for federal influence finding a way to affect state policy. Federal influence found a way into state policy related to trends in geographic expansion and education.

There was a sense of growth in science as a discipline, as well as growth in technical training, and class divisions (laborer and farmer), which also immediately preceded the announcement of the Morrill Act of 1862. At the roots of the land-grant institution were class consciousness and equity. Both class consciousness and equity were influential in the development of land-grant institutions. However, these equity elements were subjugated by political desires for expansion and political motivations. An example of the manner in which land-grant universities are a product of the people's institution are the political representatives which initially promoted the universities-Congress, or representatives of the people (Eddy, 1957).

Additional increases in science and practical training for vocations arose (Eddy, 1957). This trend in the rise of applied disciplines can be seen as encompassing political movements of the Populist sentiment, which promoted the training of farmers, or technical training geared towards farmers. This was in contrast to the government's training of soldiers and engineers (Ross, 1942).

Trends for training of farmers provides more evidence for the manner in which a movement for equity was in place, which lead to the development of land-grant universities. The emphasis of the land-grant university as a practical institution, which emphasized a sense of equity for those who previously had no formal training is significant (Ross, 1942). The farmer class can be congruent with the traditionally underserved class females have represented in the applied, STEM fields.

Morrill Acts of 1862 and 1890. The Morrill Act formally brought land-grant institutions into being in 1862 (Thelin, 2004). The Morrill Act of 1862 provided no authoritative means for imposing federal will on states outside of a narrow reporting structure by which states were expected to provide data to the federal government regarding ongoing advancements at select institutions (Ross, 1942). This could have set up one system of reporting for land-grants, which may have differed from that of non-land-grant institutions.

Land-grant universities seem to be set up with a degree of state self-determination as to the exact manner in which practical disciplines (Ross, 1942) (STEM fields) would be studied.

After the development of the land-grant universities, there were periods when land-grant universities varied in the extent to which they would allow for studying technical disciplines, and only technical, applied disciplines and sciences (Ross, 1942). The modern terminology for the extent to which STEM is emphasized could be "STEM-dominant" (National Center for Education Statistics, 2012b). Consequently, land-grant universities which emphasize different disciplines can come to reflect the gender divide which is reflective of the gender divide of these select disciplines, again, STEM fields.

Expansion of land-grant universities in the Second Morrill Act of 1890 effectively extended land-grant status to, among other institutions, African American institutions (Thelin, 2004). The Second Morrill Act of 1890 is a continuation of the equity framework of the applied disciplines, which made a turning point where land-grant universities became established.

One such philosophical ideal is equity, especially as it relates to gender. Movements for equity, which influenced the early stages of land-grant institutions, mirror emphasis for equity today. There are similarities between gender equity leading up to the development of land-grant institutions and the modern accountability movement in STEM fields at all education levels which started in the 1980s (Lynch, 2011).

Institutional culture can influence equity. The degree to which each land-grant universities sought to emphasize the applied disciplines (Thelin, 2004), or even which disciplines would be emphasized, could have influenced the organizational culture which developed at the institutions. Gender equity could be lessened in land-grant universities due to a result in the degree to which organizational cultures were promoted across the university and within disciplines. If there was a heavy emphasis on select applied disciplines (STEM), then the culture of such disciplines could influence gender equity. This gender equity could impact degree production by gender.

The Great Depression and land-grant universities. Federal influence for land-grant institutions had given way to state influence. One outward sign of this was the renaming of land-grant universities as “state” institutions (Ross, 1942). During the early decades of the twentieth century before the Great Depression, land-grant funding shifted significantly in a dissipating amount of federal funding to state funding. Funding was directly tied to levels of control. As such, control, accountability, and the reach of the extension arm of land-grant universities seemed to emphasize a sense of homage to one's state, where revenues funded institutions (Eddy, 1957).

The Depression also significantly and negatively impacted land-grant institutions as a result of their state-level of funding. A noteworthy development during the Depression was large-scale federal funding efforts to promote research. Federal funding increased significantly during the Great Depression to alleviate a lack of state funding for research for land-grant institutions (Eddy, 1957). Effective, long-term solutions were not reached during the Depression, nor have effective solutions been achieved today regarding state funding and control mechanisms.

Additional federal influence occurred regarding secondary school teachers. The Smith-Hughes Act of 1917 promoted the training of secondary teachers in applied arts. These were the same applied arts, which land-grant universities emphasized (Eddy, 1957). This parallels a current call for secondary STEM teachers (Obama, 2011).

Engineering was a flagship degree program at land-grant institutions. In the early twentieth century, land-grant colleges were seen as the mechanism by which engineers would be produced. Also, the degree of specialization within engineering, and the business-savvy skill set in an engineering degree curriculum were called into question as a result of the Great Depression (Eddy, 1957).

Today these same questions are resulting in combined programs in STEM bachelor's degrees and MBA programs. One such program is offered through the Honors program at the University of Alabama (University of Alabama Manderson Graduate School of Business, 2012). These types of degrees are part of growing national trends as well. The formal term for programs combining STEM with an applied business focus is referred to as Professional Science Master’s (Professional Science Masters, 2012).

Such programs seek to reconcile the specialized STEM field with the realities of the business world. The economic environment in which engineers found themselves in the Great Depression impacted their preparation and degree attainment. Similar efforts and reactions to promote STEM fields in the current Great Recession have similarities with situations experienced during the Great Depression (Eddy, 1957).

The modern land-grant university. During World War II, the research part of the university was found to be a significant contributor to the war effort. The research endeavors carried out through the scientific expertise of university professors and researchers enabled military advancements, which would carry over into the post-war era (Thelin, 2004). For land-grant universities, production of agriculture and export of farm products were methods to contribute to war efforts. After the war, there was a boom in all types of research, basic and applied (Eddy, 1957).

Upon returning from the war, practical degrees were emphasized by veterans who chose to make use of their GI Bill benefits (Thelin, 2004). Practical, applied fields included STEM fields. In 1950 the National Science Foundation (NSF) was founded (Earle, 2011). Two years, later, in 1952, below 1% of females received NSF fellowships (Lynch, 2011).

Today land-grant universities continue to be the people's institution by emphasizing the practical disciplines. Prior efforts to maximize the extent to which land-grant universities realize this potential occur through national cooperative extension efforts (Association of Public and Land-Grant Universities, 2012b). A review of the Association of Public and Land-Grant Universities (APLU) reveals how much research is emphasized in STEM fields among member institutions (APLU, 2012a).

Recently, there has also been a third development in land-grant universities. This is the development of Native American tribal colleges in 1994. The first two land-grant institutions result from the Morrill Act of 1862, which designated land-grant universities in general, as well as the Second Morrill Act of 1890, which allowed for land-grant status for, among other institutions, select historically black colleges and universities. The 1994 land-grants emphasize Native American colleges (APLU, 2012a). The more recent third level land-grant university denotes the continuing development in recognition of inclusion to the land-grant university.

Graduate education and degree production. Efforts at retaining female students seem to be smaller and localized, such as at the program or institutional level. However, recently, there are efforts made to address the gender gap in STEM fields through a large-scale approach. Project ADVANCE seems to summarize the cumulative efforts to bring numerous aspects of females in STEM to the forefront. This is achieved by focusing on institutional factors addressing the gender divide in STEM fields at select types of institutions. However, there still is an institution-specific manner in which such efforts are implemented (Layne, 2011).

Graduate degree production is a complex process, which cannot be directly tied to bachelor's degrees production. A range of additional factors must be considered and the exact interaction between increased bachelor's degree production and graduate degree production remains to be seen on a large scale. While this principle may remain intact that growth in undergraduate degrees leads to growth in graduate degrees, this exact manner and process by which this occurs remains to be seen (Smith, 2008).

A three-decade meta-analysis of graduate student persistence reveals that any type of financial aid can be seen as a significant contributor to graduate student persistence for degree attainment. Data were drawn from several national survey databases. Assistantships were found to decrease persistence when they were the only form of income (Gururaj, Heilig, & Somers, 2010). Snapshots of graduate enrollment by STEM degree discipline, along with full time or part time student can be found through reports provided by NSF (National Science Foundation Division of Science Resource Statistics, 2011).

A comparison of doctoral degrees awarded in the US from 1970 to 2003 reveals slight changes in which STEM doctorates received the highest number of degrees. Engineering and biology grew while physical sciences and chemistry fell. Overall, there were not significant changes in graduate degree production rankings by discipline (first through tenth) at both the master’s and doctoral levels (Smith, 2008).

Differences in general graduate degree attainment models have been found between master’s and doctoral students. Types of funding engagement processes (shown through assistantships and fellowships) seemed to have a greater influence on retention for doctoral students, as did performance on select qualifying experiences. Grades were more important for master’s level degree recipients (Girves & Wemmerus, 1988). This educational model is relevant for the more specific STEM pipeline given the different rates at which females drop out of graduate school in general (Berryman & Rockefeller Foundation, 1983).

Cooperation favors gender equity. One of the means by which land-grant institutions gained public support was through an overall atmosphere of cooperation in place of competition. This sense of cooperation surfaced in student culture via gender equity as well as through select by-products of the land-grant universities. These by-products were projects synonymous with public works (Eddy, 1957). The spirit of cooperation is cited as advantageous for all parties during the early years of the development of land-grant universities (Ross, 1942).

An example is an extension focus placed on works directly applicable to select economic endeavors, such as agriculture. One specific instance was the Smith-Lever Act, which allocated funds for agriculture by way of land-grant institutions. The movement to promote agriculture bolstered the movement of the land-grant institution in the early nineteen hundreds (Eddy, 1957).

Increased access to students who would otherwise have been unable to go to college (including female students) was also a hallmark of land-grant institutions in their developing years. The developing years saw a race for equality for females, including informal student activities. This parallels the modern female's movement in STEM fields. Also, coeducation was emphatically embraced. Females performed every bit as well as males. Graduation ceremonies and awarding of degrees revealed equality of genders in land-grant universities (Ross, 1942).

These early days of land-grant institutions can be seen as a contrast to the current gender divide of STEM fields within land-grant institutions (Ross, 1942). The manner in which female students were enrolled in proportion to male students in land-grant universities in these developing years could provide more insight into the manner in which female involvement in land-grant universities started out and changed over time. There are also question, which arise regarding the degree to which a spirit of cooperation, not competition, remains to be the spirit of land-grant universities.

Sociological Context: Gender Equity in STEM and Higher Education

Gender Equity History

The modern movement towards gender equity started during the early 1980s. This is also a period where there has been a marked growth in graduate degrees (Smith, 2008). The gender equity movement (including the equity movement in STEM) is comparable to an accountability movement in education nationally. One example, which can provide a starting point for the current accountability movement in STEM, is the Science and Engineering Equal Opportunities Act of 1980, which called for the promotion of students in the sciences regardless of demographic background (Lynch, 2011; National Science Foundation, 1980).

A continuation of the accountability trend in education on a national scale is portrayed in a report published in 1983, *A Nation at Risk*, highlighting the dire situation of education in the US (Gardner, National Commission on Excellence in Education et al., 1983). *A Nation at Risk* essentially criticized the education system on a national level. *A Nation at Risk* can be seen as starting the modern movement towards accountability across education (Gardner, National Commission on Excellence in Education et al., 1983). This accountability in education seeks to provide an equitable education environment and to increase standards across all educational fields.

A Nation at Risk criticizes the poor conditions of the educational system in the United States (Gardner, National Commission on Excellence in Education et al., 1983). Additional findings of *A Nation at Risk* note how STEM fields were devalued. Shortages of teachers in STEM fields were highlighted as well as low teacher salaries and the under qualified nature of approximately 50% of new teachers in select STEM fields at the secondary level (Gardner, National Commission on Excellence in Education, et al., 1983).

The growth in accountability for science (STEM) fields paralleled national accountability movements. Evidence for the accountability movement in STEM fields on a national level is contained in special reports. One example is a special report that focused on females and minorities and the sciences was produced via the Rockefeller Foundation (Berryman & Rockefeller Foundation, 1983). Additional evidence for the beginnings of the STEM accountability movement includes the introduction of annual reports on females and minorities in science and engineering through the National Science Foundation (NSF) (Lynch, 2011; National Science Foundation Division of Science Resource Statistics, 2011).

Physics provides a STEM field case example for trends possibly linked to the accountability movement. Since the mid-1980s, there has been a steady growth in the number of high school students enrolled in physics courses (White & Tesfaye, 2010). Perhaps this growth is a response to the accountability movement emphasized during the early 1980s. In addition to the increase of overall number of students in high school physics classes, there has been a growth in the percentage of females enrolled in these courses. The rate of growth for female students in high school physics courses is faster than that for males (White & Tesfaye, 2011). There is also an increase in the number and percent of female high school instructors teaching physics (White & Tesfaye, 2010).

The accountability movement continued through the 1990s (National Academy of Sciences National Research Council, 1991). Today, the accountability movement, inclusive of the gender equity movement, is occurring at the same time as a focus on accountability among land-grant universities (Association of Public and Land-Grant Universities, 2012c). The gender equity movement is currently emphasized nationally. One way this is evident is through the Education and Human Resources Directorate (one of the six main Directorates of NSF), which has a main goal to increase participation in STEM fields (Earle, 2011). An example of a national overlapping study inclusive of land-grant universities and the gender equity movement includes the ADVANCE NSF grant funded project for the 2000 decade (Layne, 2011).

Timeline for Equity Policies

There are numerous ways in which underrepresentation in STEM fields can be approached. The aspect included in this paper is gender. Gender is especially relevant in STEM degree production because of the social implications which might come into play which might not readily be available while focusing on only degree production without reviewing degree production by gender (Eagan, 2010). This is a reminder that gender policies are part of a social context, and as such, policies can influence gender in STEM fields. The following are select events that have influenced gender as related to STEM fields.

In 1972 Title IX was passed (formally Title IX of the Education Amendments of 1972), which mandated equal access to federally funded education activities (United States Congress, 1972). In 1983, NSF furthered a focus on equity by including emphasis on quality for all participants through Educating Americans for the Twenty-First Century (Lynch, 2011). State level assessments in education (including STEM fields) grew as a result of the accountability movement as well, as shown in the publications of math standards for states by the 1989 National Council for Teachers of Mathematics (Lynch, 2011).

The growth in standards encompassing equity and quality can be found in the 1990s as well in national standards such as the 1996 *National Science Education Standards* National Academy of Sciences National Research Council, 1996). International comparisons were also developed as benchmarks for the performance levels of US students, such as the Third International Mathematics and Science Studies, with undesirable (lower than expected) scores for US students at select grade levels (Lynch, 2011). There was also a report that magnified how twenty years of efforts to promote equity and quality in STEM fields revealed standards had yet to show any real improvement. Highlights revealed how science and math education in K-12 (STEM pre-cursors) were still in a dismal state (National Commission on Mathematics and Science Teaching for the 21st Century, 2000).

These are just a few of the highlights from a 20 year period during which an accountability movement in the science and math K-12 education fields has grown from state to international prominence. This includes equity policies that promote equal treatment at all levels, K-12 through graduate education. While these examples emphasize the K-12 level, the approach remains true at all levels of STEM education.

Motivations to Enter STEM Fields

STEM degree production is inherently tied to student motivation to enter STEM fields**.** Part of the rationale for finding out why students seek to enter STEM fields revolves around the current atmosphere, which promotes higher STEM graduation at all levels of education for both genders. There are also critics who cite underdevelopment of STEM fields as providing a rationale for motivating new generations to enroll in STEM disciplines (Deemer, Mahoney, & Ball, 2012).

In order to find ways to attract new students, specifically females, motives for entering STEM fields can be significant. Motivations for entering select STEM disciplines can also provide insight into the gender divide in select STEM fields. Gender differences for motivations to enter STEM fields exist. There is a markedly higher desire for females to enter STEM fields as a result to take on a helping, supporting role (Deemer et al., 2012).

Similar data was found in a single university population of select STEM students. Generalizations may be limited (Mellion, 2010). This may influence differences by STEM subfields. For example, there are comparable numbers of female and male students in biology graduate studies while in engineering there are a significantly more males (National Science Foundation, Division of Science Resource Statistics, 2011).

In faculty roles, females are noticeably less satisfied with their career work in STEM fields (Deemer et al., 2012). Perhaps dissatisfaction during graduate training can be a rationale for why so few females progress in STEM fields. Select instruments have been developed which focus exclusively on STEM graduate students. Such instruments have been applied to faculty roles and reveal differences in reward systems (internal and external) by gender for faculty in STEM fields. Perhaps motivational factors can play out across STEM fields as well as faculty ranks. For more information to provide insight on this possible trend, overviews of gender breakdowns by STEM fields are presented in recent NSF annual reports (National Science Foundation Division of Science Resource Statistics, 2011).

Overall, interaction of the proportion of females in faculty roles with faculty pay can provide insight into the manner in which females may choose to enter STEM disciplines and institutions that emphasize STEM fields. Prior research has shown higher levels of female salaries as a proportion of male salaries reveal's a higher proportion of females at select Research Carnegie I institutions for assistant and associate faculty levels, yet not for full professors (May et al., 2010). Additional faculty variables on an institutional level related to gender equity may provide new evidence regarding the gender divide in STEM fields.

Prior research has found that, even when indicators of gender differences for entering science fields are held constant, females were still 10% less likely to choose a science track at the undergraduate level (Dunteman, 1979). Additional research seeks to find a more accurate, refined method for predicting success in undergraduate STEM fields (Toker & Ackerman, 2011). More research into institutional factors affecting STEM degree production are needed in addition to that which focuses only on aside from only motivational considerations.

A reminder that the approach taken in this study is that of an organizational systems view and thus presents the literature with this broad-based approach. Due diligence must be given to the fact that the socioeconomic context is much more complex, especially during an economic crisis such as the Great Recession. Student choices made prior to enrolling at institutions may impact student body composition. These same differences in student characteristics might be the factors that reveal themselves in choosing different types of STEM degrees (community college vs. bachelors). Differences by institutional type may be more a result of factors in student choice prior to enrolling than the influence of the institution (Berryman & Rockefeller Foundation, 1983).

There can be a range of factors that influence how and why a person chooses a select major and career track. A few factors are interest, ability, social life, or even simply finding a wellness of fit within STEM fields. There is also noted a significant difference regarding gender and Holland "types" relating to STEM fields. Specifically, males seem to end up with more realistic occupations, while females seem to be more prominent in settings where social roles play a larger part (Farmer, Rotella, Anderson, & Wardrop, 1998). This is relevant to the motivation to enter STEM fields to fulfill a helping role as touched upon previously (Deemer et al., 2012).

Additional studies seek to link gender to major and find that personality and political outlook are the main factors that can be used to predict a student's choice of major. However, the data used in the prior study were for a liberal arts school only and may not apply to students beyond liberal arts institutions (Porter & Umbach, 2006). There is the possibility that personality and political outlook can be screening factors for students who choose to attend land-grant universities, or universities that heavily emphasize STEM fields.

Critical Mass

For this study, critical mass means a certain amount of females in a select STEM field must be met in order to retain females in the given STEM field. In order to attract and retain females in STEM disciplines, there must be a certain level of professional faculty and staff who are female. Critical mass can be a factor that affects females in STEM fields at all education levels (Lott, Gardner, & Powers, 2009).

Physics can provide a discipline example. Critical mass, in this case the number of female physics teachers, is an element which can interact with student enrollments at the high school level with physics courses (White & Tesfaye, November 2010). Female physics teachers act as positive role models. Having an increased number of STEM faculty who are female could provide visibility for younger girls interested in going into STEM fields as well as provide supporting environment for females in STEM fields at the university level (Xu, 2008).

Evidence for critical mass has been shown on an undergraduate level through a female reluctance to enter male-dominated fields (Burke et al., 2011). Since self-concept is also an issue related to retention (Burke et al., 2011), combining self-concept with the critical mass factor can give a scenario which negatively effects females in STEM fields. A lack of supportive environments has been shown to be lacking and to be a rationale for why females leave the STEM disciplines (Xu, 2008).

In recent decades the gender divide in STEM fields has closed on the undergraduate level (Huang et al., 2000), however, gender disparities in STEM fields are still noted (Dave et al., 2010). Also, gender disparities in universities nationally represent stark gender disparities in jobs, with males in more prominent roles. In general, there is an inverse relationship between job status and female representation. The higher the job status, the lower the amount of females (Kulis, 1997).

There is also support for critical mass at the graduate level. Findings support where there are higher levels of females enrolled in STEM degree programs, greater retention rates for females in doctoral programs were found. Once a critical threshold is met, there is enough critical mass to sustain the levels of females in the field. The number of female doctoral students can also affect the graduation rates of females in STEM fields (Lott et al., 2009). At institutions where the majority of females were enrolled in bachelor's degree levels, there seemed to be a positive indication of overall females in faculty roles and for females obtaining doctorates (Kulis, 1997).

There is the potential for a reciprocal relationship between female students and female faculty. However, the exact nature of which entity allows for the retention of the second is unclear. There is room for exploration of which has greater influence; female faculty and staff attracting female students, or female students resulting in the hiring of female faculty (Kulis, 1997).

Critical mass can occur on both student and faculty/staff levels. Past evidence reveals select institutions in a national study revealed greater amounts of females in administrative ranks as compared to faculty ranks (Kulis, 1997). Overall levels of female administrators are still low. Research calls for female and minorities to move up into higher administrative roles to address this critical mass issue within administrative ranks (Oh & Lewis, 2011).

This is related to institutional level approaches that are being used to review the interplay between faculty and administrators. The purpose of this ongoing research on the interplay between faculty and administrators is to uncover an ideal ratio (three faculty per one administrator) between faculty and administrators relative to costs (Martin & Hill, October 2012). The effect of female in faculty or administrative ranks relative to indicators of female degree production is a variable worth exploring. Data from Martin and Hill (October 2012) focusing on faculty and administrators can provide a guiding framework. Similar approaches can be extended to females in administration when reviewing graduate STEM degrees for females.

Females in administrative roles might provide a more valid indicator than females in STEM fields regarding critical mass. Lower numbers of female faculty may have greater influence on students attaining degrees, especially STEM fields, than administrators due to the greater interaction and mentoring which could potentially take place between a faculty and student as opposed to an administrator and a student. There is evidence more females in tenured and tenure-track roles results in higher graduate degree productions rates for females in engineering (National Center for Education Statistics, 2012a; Ostreko, 2012). There is evidence which supports conversations outside of class may benefit female STEM students more than males (Gayles & Ampaw, 2011).

Prior findings indicate the significance of critical mass relate to mentoring and degree attainment because faculty of both genders have shown a bias towards students of their own gender (Tidball, 1976). An explanatory factor behind critical mass is simply the decreased quality of mentoring relationships where male faculty constitute the majority of options for mentoring roles (May et al., 2010). Given the lower rates of female faculty in graduate school, female students are at a disadvantage when finding these quality mentoring roles (Girves & Wemmerus, 1988).

Another unique aspect about critical mass is that there is not a set universal standard for what level/percentage of females must be attained to be considered effective. Case study of doctoral STEM disciplines at a university (not Research One) in the southern United States revealed in doctoral STEM programs with 33% or more of students were female exhibited a 39% lower rate of female attrition (Lott et al., 2009). This same principle regarding critical mass level/percentage could apply to faculty and staff as well.

There is potential interaction between levels of critical mass between the students and professional ranks. The ratio of faculty in a program may not be as critical, or a lower number compared to female administrators, and vice versa. Discussion of faculty turnover among females in STEM fields has been reviewed with results suggesting that the culture of STEM fields inherently results in higher turnover rate of female faculty (Xu, 2008). For example, the lower number of females in a classroom might lead to the contribution of a STEM class as an environment less open to females (Porter & Umbach, 2006).

A greater number of females displaying feminine qualities may adversely affect professional development (Tidball, 1976). Favoring teaching in STEM fields, a traditionally research-intensive sector, may be associated with lower levels of success and thus result in female academics out of STEM fields. The past research (Tidball, 1976) seems to indicate a disproportionate alignment of gender roles and research proclivity.

Perhaps there are means by which focusing on select types of research or teaching endeavors, and corresponding funding, can be used as indicators of graduate degree attainment in

STEM fields that reveal a gender divide. Funding from federal agencies that heavily invest in STEM fields could be key indicators. This is related to critical mass in the types of (research) roles which female faculty seek within STEM fields.

In recent times there has been a growth in the amount of control and influence that funding agencies have had on research and university STEM related projects from a federal level (Earle, 2011). Perhaps there are correlates between types of funding provided by such national agencies as the National Science Foundation (NSF) and gender divide in graduate degree attainment. NSF would be the main federal agency, since they are the premier funding agency for STEM fields (National Science Foundation, 2012).

If select types of research assistantships are held more by males, and assistantships can be a funding means to increase degree attainment (Ampaw & Jaeger, 2011), then the types of projects funded can be an indicator of gender equity in graduate STEM programs. Prior research reveals a slightly different effect on persistence when assistantships are considered (2.3 percent higher for males in a national sample) (Liseo, 2005). One of the studies reviewed by Liseo (2005) included a meta-analysis, which focused on data from 2000 that revealed an increased likelihood that females would persist with greater rates of assistantships and loans. In conclusion, assistantships are a type of critical mass, which can be considered as an indicator for graduate degree attainment by gender.

Gender Equity Framework

A gender equity framework will provide background context for this dissertation. The outlook that equity policies must continually be revisited in order to bring about gender equity is the rationale behind revisiting equity (Duflo, 2011). This constant revisiting of gender equity can be seen as a means to provide a measuring point for modern education “accountability” movements, including females in STEM fields.

Given the focus on gender equity in STEM as put forth by Lynch (2011), there is a kaleidoscope of perspectives that can be used when considering gender equity. With the current study, there is a not a single definition of gender equity which will be used. The overall outline of gender equity with numerous perspectives is considered as a whole. A full outline of the multitude of gender equity components used to create the gender equity framework is contained in the 2011 chapter by Lynch. Using this comprehensive approach of gender equity is recommended since this comprehensive approach is the most practical, relevant approach to the current study. This holistic approach allows for a full range of frameworks to be considered when reviewing factors related to degree production.

This gender equity framework will focus on outcomes and resource allocation to achieve these outcomes (Lynch, 2011). The outcomes in this study will be graduate degrees. Resource allocation will be considered the practices and policies, which can facilitate or impede the achievement of graduate degree attainment by gender.

Focusing on gender is part of a larger situation relating equity to diversity context. In addition to the need to maintain a sense of leadership regarding innovation within STEM fields, there is the manner in which policies provide context for degree production in STEM fields. This includes an impetus to produce not only more students in STEM fields, but also more STEM field graduates from diverse populations. This includes demographic background in addition to gender.

For example, additional gains in STEM undergraduate degree achievement have been shown using national databases (Integrated Postsecondary Education Data System) and Latino students. Overall, demographic variables in addition to gender provide context for growth in STEM fields. An example is a national approach that reveals lower rates of Latino in STEM (Dowd, Malcom, & Bensimon, December 2009). Additional approaches focus on traditionally underrepresented demographic minorities in STEM (Ostreko, 2012).

Conceptual Framework

The pipeline paradigm will be the main paradigm presented for the conceptual framework for this study. A secondary paradigm, the deficit model, will provide contextual support for the pipeline paradigm. The pipeline paradigm remains the overarching, guiding framework.

Pipeline paradigm. Historically, there have been lower rates of females in STEM disciplines (Huang et al., 2000). One perspective on why there are lower numbers of females in STEM fields is the pipeline model (Cabrera, 2009; Kulis, Sicotte, & Collins, 2002). Less reinforcement throughout STEM education is key for the pipeline paradigm.

The pipeline paradigm articulates the gender divide in a linear format. As the name would suggest, there is a linear “pipeline” by which females are introduced to subjects or fields of study which act as precursors to STEM fields. Over time the combination of lower initial numbers and lack of reinforcement while traveling along the STEM pipeline results in dissipating numbers of females in STEM fields. The problems and solutions to resolving the conflict over the gender divide in STEM fields revolve around finding ways to place more females into the pipeline along the STEM education developmental continuum (Cabrera, 2009).

The pipeline starts during early educational years when girls are observed to fall out of educational processes that would lead to their future choice of a career field in a STEM discipline. A review of related studies revealed elementary school as neutral regarding self-concept as related to STEM early education indicators (math and science) (Leslie et al., 1998).

However, reinforcement can be a result of social issues indicating females do not excel in precursors to STEM fields (Shapiro & Williams, 2012), such as math (Spencer, Steele, & Quinn, 1999).

Middle school reveals a change in this self-concept for females. High school shows the most difference with respect to gender role and self-concept for math and science, where females are polarized away from math and science (Leslie et al., 1998). Females see STEM fields as work that is not suitable to their gender (Dave et al., 2010). An example of the gender difference in pipeline model is a study that reviewed secondary school trends in the extent to which boys and girls enrolled in science and math courses. Findings revealed a predisposition for boys to enroll in science and math courses at higher rates than girls. Recommendations are to make such classes mandatory to address females actively partaking in the STEM pipeline (Berryman & Rockefeller Foundation, 1983).

Finding ways to keep STEM students within the pipeline can be critical to realizing the positive societal benefits that STEM graduates can provide (Dave et al., 2010). This can be especially true for traditionally underserved, underrepresented STEM students demographically. The "leaky pipeline"(Cabrera, 2009), maps out the manner in which females constantly leave STEM fields throughout the educational process.

Efforts to address the pipeline. States are taking steps to address the development for students going into STEM fields at early ages, long before the collegiate level (American Youth Policy Forum, 2009). An additional state-level example is an organization providing resources to aid in the attraction and retention of STEM students with a secondary education focused program for the state of Virginia (Career and Technical Education, 2012). Once in college, efforts are also placed on creating a quality STEM workforce, as evidenced by Minnesota's collaborative efforts to graduate STEM and related students to meet societal needs and promote the university through research and scholarly efforts to maximize the public good (Bloomfield & Kuhl, 2007).

Preparation for STEM fields parallels national education efforts. In the same manner in which there are statewide policies that seek to promote STEM fields at early ages (American Youth Policy Forum, 2009), there are also efforts to prepare youth for undergraduate education in general on a national level. Part of these general preparation approaches includes efforts to address methods of making postsecondary education a reality through financial awareness. Elements of select parts of these fields also include awareness of fields students may want to enter in college (College Foundation, 2011). These national efforts to promote finding an interest for subjects in college, and a readiness for college, can be a continuation of a step-wise approach for post-secondary education, higher education, and STEM fields.

Critics of federal initiatives to plug the leaky STEM pipeline or increase STEM graduates put focus on the poor history of federal intervention programs (Burke & McNeill, 2011). Current efforts focus on collaborative efforts, especially at the secondary school level, with an emphasis on the importance of the progression through the STEM pipeline (National Task Force on Teacher Education). One research resource on a national scale seeks to aid STEM departments at universities in addressing the leaky pipeline by offering software which seeks to aid faculty and administration in addressing the leaky pipeline (American Institutes for Research, 2012).

Using the pipeline paradigm (Cabrera, 2009) there is a corresponding decrease in the number of female students with each successive increase in education attainment level. This has proven to be the case in the faculty ranks as well. There are lower levels of females in faculty roles with increase in rank (May et al., 2010; Xie & Shauman, 2003).

A recent report, which emphasizes the pipeline paradigm in STEM context focuses on the K-12 education while also recognizing the professional level, demand that must be met (Rising Above the Gathering Storm Committee, National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2010). Without an increase in standards at the K-12 level, there cannot be a significant change in STEM female degree attainment. There cannot be a significant change in graduate degree production without a significant change in the pipeline feeding STEM disciplines.

Modern efforts to promote females in STEM fields include national efforts targeted at systemic, institutional level change. One such NSF sponsored grant was the ADVANCE program, which took place from 2001 - 2010. A case-study institution level approach of the ADVANCE program can be researched in depth while reviewing Virginia Tech University's ADVANCE report (Layne, 2011).

Current policies which seek to provide equality for females could end up having the same negative effects as past failed federal policies which have had unintended negative consequences. A specific example is the federal (NSF) funded project ADVANCE, which had an annual survey focusing on work-life balance. Faculty members revealed a full range of responses to the efforts to increase the climate of females in STEM fields at one STEM-dominant land-grant institution. Results may have been confined to departmental level factors. Project ADVANCE also revealed males taking an active role aid the attempts to address inequality (Layne, 2011).

The spirit of cooperation may be positive for all parties involved regarding gender equity in STEM fields. This includes all levels, such as department, institution, state and federal policies. Additional entities may include regional academic cooperatives, such as the Academic Common Market (Southern Regional Education Board, 2010).

In summary, the pipeline paradigm presents a structure explaining how females fall out of STEM fields at all education levels, hence the "leaky" aspect of the pipeline (Berryman & Rockefeller Foundation, 1983). Increasing the amount of females through the pipeline can be achieved via program, institution, state and federal interventions at all stages of the pipeline. Current efforts seek to address the number of females in STEM fields by succeeding where past initiatives have fallen short.

Deficit model. Cultural differences regarding gender can result in lessened efforts to persist in STEM fields due to a range of factors which contribute to the devaluation of the roles of female, especially related to female and work. This devaluation can be referred to as the cultural deficit model. The family unit can be seen as a critical means of providing support or revealing a continuation of these sociocultural norms. Also, simple expectations about gender inequalities can affect female's ability to choose STEM fields (B. Burke et al., 2011). For example, a study of undergraduate females revealed culturally different factors affected retention in STEM, specifically social views of females and carryover into STEM fields (B. Burke et al., 2011). As in non-STEM professions (legal), female's work is devalued compared to men's work (Dinovitzer, Reichman, & Sterling, 2009).

These sociocultural differences can interact with the pipeline paradigm. In this way the deficit model continues to create a broader rationale for the continued interplay between cultural devaluation and the dissipating number of females in the STEM pipeline from early education through graduate education. The pipeline paradigm takes a linear approach to providing an overview of the process for how females do not end up in STEM fields. The deficit model takes a cross-sectional cultural lens at each point within the pipeline timeline in order to attempt to explain why there are fewer females in STEM fields (Xu, 2008).

The deficit model focuses on the cultural differences, explicit and implied, which might explain the gender imbalance in STEM fields. The explicit differences focus on socialization processes which females may undergo as a result of inherent biological differences (Xu, 2008). One possible example is work-life practices for STEM professionals taking time out of the workforce for personal reasons, often family. The implicit differences reside more in the culture of STEM fields to perpetuate differences on organizational, structural levels. This includes inequity in pay, career advancement opportunity, as well as the daily culture, which STEM fields might perpetuate regarding gender inequalities (Xu, 2008).

Mapped conceptual framework. The pipeline paradigm provides a structure for the conceptual framework for with this study. An overview of the concepts in this study is presented in Table 1.

Table 1

Conceptual Framework

	Gender Equity	Great Recession	Degree Production
Accountability Movement	**Modern focus on prior education levels since 1980s**	**Disconnect with workforce training**	**Focus now on graduate level for US economic competitiveness**
STEM	**Traditional gender divide**	**Emphasized nationally**	**Innovation in basic research to meet workforce demands**
Graduate Focus	**Traditional gender divide**	**Increase in demand for graduate training**	**Gap in research at graduate level, prior focus on community college and undergraduate**
Graduate Assistantships	Gender divide in teaching and research assistantships	Recessions enrollment increases	Can be financial means to achieve degree
Critical Mass	Divide in number and ratio of female students on undergraduate and graduate level, faculty and administration	Economic hardship interacts with gender divide in university setting	Campus climate, Retention
Institutional Size	Department/Campus climate	Financial/Enrollment trends	Resources for STEM, Ratio
Research Expenditures	Resource allocation	Funding opportunities	Funding for students, graduate assistantships, institutional priorities, research emphasis related to STEM
Institutional Type	Campus climate	Ability to handle economic downturn	Land-grant, STEM focus, graduate focus

A brief phrase is used to represent the relationship between concepts. Concepts include guiding themes, as well as variables considered for review. This conceptual framework overview display format has been used previously (Smyth, 2004). In Table 1, the items in bold are concepts, while the items that are not in bold are variables.

Chapter II has presented a review of the literature related to gender equity and STEM fields on from three facets: economic, educational, and sociological. The economic context provided a time frame to guide the years to include for review for the methodology. The educational context sought to provide a means by which institutional characteristics could be explored by providing background to which characteristics should be included as independent variables for a predictive regression equation for female graduate STEM degree attainment. The sociological facet provided a context for gender equity and a conceptual framework, which brought together the significant elements of the economic and educational context.

CHAPTER III:

METHODOLOGY

The purpose of this study was to review graduate STEM degree production by gender in the context of the Great Recession. The Great Recession was defined according to the National Bureau of Economic Research, which placed the dates for the start and end of the Great Recession as December 2007 and June 2009, respectively (AAUP, 2011). This chapter will outline the methods used to investigate this purpose. This chapter starts with a rationale and brief context for taking this approach, followed by the research questions. The next sections address variables and data analysis methods.

Research Approach and Conceptual Perspective

Given the recent national push for STEM fields (Burke & McNeill, 2011; Obama, 2011), and the historical gender divide in STEM fields (Hanson, 2011; Huang et al., 2000), current student degree attainment by gender is of interest. A large-scale, broad-based approach was taken to review degree production. A large-scale approach is better suited to using a quantitative approach (Creswell, 2009).

There are similar approaches currently being used which focus on the department level and progression through STEM fields (American Institutes for Research, 2012). The broad approach taken in the current dissertation seeks to investigate an institutional level of analysis. Graduate degrees will be the focus of the current study.

Land-grant institutions were chosen to be emphasized as a comparison group due to their historic emphasis on the applied disciplines, which include STEM fields (Eddy, 1957; Ross, 1942; Thelin, 2004). Land-grant institutions that offer graduate degrees were included. This included Historically Black Colleges and Universities. Native American Tribal Colleges were not included for review.

The Academic Common Market was used as a comparison group due to interest in how regional factors might act as control variables for select socioeconomic conditions. A review of select states in the ACM relating to STEM fields and gender has been used before involving comparison of SREB states with merit-based aid and those without merit-based aid (Zhang, 2011). Additional research with emphasis on universities with high engineering degree production has found select findings related to underrepresented minorities in Engineering in the Southeastern US (Ostreko, 2012).

Given that the context for the Great Recession is the focus of the current study, the raw numbers of degree production can be misleading by themselves. Throughout this dissertation, context has been key. The methodology continued to emphasize context by providing context for graduate STEM degrees for females.

The context for the current study focused on the number of STEM graduate degrees. The dependent variable was the total number degrees granted to females for a STEM CIP field per year per institution out of the total number of degrees for the STEM CIP field per year by institution. Data was analyzed at the degree level by using CIP codes, or classification of instructional program codes. The CIP codes used were in line with prior data review (Hardy & Katsinas, 2010; Starobin & Laanan, 2008), with the addition of a single CIP code to include the technology part of STEM fields. The CIP codes match the current designation of STEM fields within the database system, IPEDS (National Center for Education Statistics, 2012b). The CIP codes used are as follows:

1. 11-Computer and Information Sciences and Support Services;

2. 14-Engineering;
3. 15-Engineering technologies and Related fields;
4. 26-Biology and Biomedical Sciences;
5. 27-Mathematics and Statistics;
6. 40-Physical Sciences, and
7. 41-Science Technologies/Technicians

(Hardy & Katsinas, 2010; National Center for Education Statistics, 2012b; Starobin & Laanan, 2008).

In recent years there has been a preset STEM degree designation in IPEDS (National Center for Education Statistics, 2012b). However, degrees awarded for the preset STEM fields in IPEDS are limited and do not include the years for this study. Consequently, CIP codes will be used outside of this recent preset STEM CIP area in order to capture the desired data from the years of interest.

Research Questions

The overarching purpose of the research was to come to a better understanding of the potential gender differences in graduate degree production for STEM fields in the context of the Great Recession. The null hypothesis in each analysis was there was no difference in degree production by gender during the context of the Great Recession. The alternative hypothesis was there was a difference in degree production by gender during the context of the Great Recession. The same ratio of STEM degrees attained for females compared to the number of STEM degrees attained by males during the time frame under review, 2005-2010, will be observed. The alternative hypothesis is that there is a difference in degree attainment by gender across STEM fields for the time frame under review, 2005-2010. The years 2005-2010 correspond to academic years 2005-2006 through 2010-2011.

In order to further refine the scope of the review and to provide a means to answer questions of interest, additional analysis was performed in order to answer select questions related to the main purpose of the study. Each question provided for further review regarding gender for each STEM field comparing degree attainment in the context of the Great Recession. Additional questions included a further look into gender differences within STEM fields according to CIP (Classification of Instructional Programs) codes in IPEDS, and institutional characteristics found in IPEDS (National Center for Education Statistics, 2012b). Below is a list of the research questions. The dependent variable for the research questions is the total number of females out of the total number of degrees in each CIP field for each institutions and each of the six years under review.

1. Is the gender divide greater among master's degrees compared to doctoral degrees for STEM;
2. Are there differences in graduate degree production for land-grant vs. non land-grant institutions;
3. What are the gender differences within each STEM field by two-digit CIP code for academic years 2005-2010;
4. Are there differences in graduate STEM degree production comparing the Academic Common Market vs. non-ACM institutions;
5. Are there trends in graduate degree attainment by gender across academic years 2005-2010; and
6. What institutional factors can be indicators of female graduate STEM degree attainment for academic years 2005-2010?

Research Design

Study Population and Sample

The study population was all not-for-profit universities that offer doctoral degrees in the United States. Universities must have been located in one of the 50 states or Washington, DC, not in US territories or protectorates. There has to be a doctoral degree offered. The institutional type is primarily baccalaureate or above. Institutions that offered only graduate degrees were not included for review. Given the institution type, focusing on institutions, which offer doctoral degrees and primarily bachelor's degrees or above are expected to offer master's degrees as well.

In order to provide a greater level of generalization of results, including a broader range of institutional type, a randomly selected group of institutions was included along with land-grant universities. Initial review of data found 63 land-grant institutions, which offered graduate degrees, 12 of which were HBCUs.

In order to determine the appropriate sample size, statistical software called GPower was used. GPower is free statistical software, which users can download from the internet. GPower was in the third edition, GPower 3, at the time of this study. GPower was designed by four German psychology professors, whose profiles were found on the GPower website section "Who We Are". GPower 3 allows for the calculation of power ranges for the following types of statistics: F test, t test, χ^2 test, z test, and exact tests. Additionally, power can be calculated from numerous approaches. These approaches include the following: a priori, compromise, context, criterion, and sensitivity. In summation, GPower is a useful, free statistical tool that can be used to calculate appropriate power ranges and sample sizes (Faul, Erdfelder, Lang, & Buchner, 2013).

For the purposes of this study, a desired power level can be put into GPower and a sample size needed to determine this power level can be obtained. The desired alpha level is .05.

The given power level is at least .80. Using GPower, an a priori analysis is conducted because the type of tests, alpha level, power level, and number of groups are all known before conducting the statistical analysis (Faul et al., 2013).

A separate analysis using GPower was conducted for each statistical test. The number of groups in this case is two. This two-group set remains true for the first four research questions. These first four research questions pertain to land-grant status, master's vs. doctoral, gender, and ACM status. Using two groups, alpha level .05, and power level .80, and the statistical approach of Repeated Measures ANOVA between factors with six measurements (for six years), the needed sample size is 76 (Faul et al., 2013). For the sixth research question, using an alpha level of .05 and a power level of .80, along with twelve predictor variables, then a sample size of 127 was needed. Combining the random sample with the land-grant institutions will provided a sample size of 139, enough to meet the needed size for the OLS Regression for research question six.

A random sample of 76 non-land-grant universities was drawn. This random sample of 76 institutions was drawn from all the possible non-land-grant universities in the US within the framework for this study. This framework did not include for-profit institutions. There was no removal of institutions prior to the selection of this random sample of 76 institutions. A list of all possible universities from the population was created using IPEDS (National Center for Education Statistics, 2012b). Afterwards, a research randomizer online tool (Urbaniak & Plous, 2012) will be used to select 76 institutions.

A comparison sample of 63 land-grant institutions, which offer graduate degrees, was included. Out of both the randomly selected population as well as the land-grant institutions, which are located in an Academic Common Market were compared to non-ACM institutions.

Also, gender was reviewed by field at the two-digit CIP level. Table 2 highlights the sample selection process.

Table 2

Institution Selection Overview

Sample	Number of Institutions
Non-land-grant institutions offering doctoral degrees in the US	660
Random Sample	76 (out of 660)
Land-grants which offer graduate degrees (including HBCU)	63 (12 of 63 are HBCU)
Academic Common Market participating institutions	TBD (28 land-grant) (12 of 28 are HBCU)
Total sample size	139 (12 HBCU)

Data Source and Data Acquisition

The Integrated Postsecondary Education Data System (IPEDS) was used as the database for obtaining the degree data for STEM fields. Seven Classification of Instructional Program (CIP) codes were used for each of the four STEM acronym fields. IPEDS takes measures to ensure confidentiality of data (National Center for Education Statistics, 2012b). Degree attainment at the graduate level within each corresponding year was reviewed.

IPEDS, or Integrated Postsecondary Education Data System, is an online data source housing data from annual national surveys administered by the US Department's NCES, or National Center for Educational Statistics. Every college or postsecondary institution that participates in the federal student financial aid program must report data to IPEDS. This reporting structure was set up as part of the Higher Education Act of 1965 (National Center for

Education Statistics, 2012b).

IPEDS is a public database made available to the public in two formats. The first is through a College Navigator interface intended to meet the needs of parents and students who seek to research information on colleges and postsecondary institutions of interest. The second manner in which data IPEDS collects is made available is through the IPEDS Data Center. The IPEDS Data Center provides relevant information for researchers, for purposes such as this study. Additional intended users include institutional researchers and policy analysts (National Center for Education Statistics, 2012b).

IPEDS provides a way to bring together separate surveys that are conducted annually. IPEDS has nine separate surveys that are used to present data. The nine main surveys are as follows: Institutional Characteristics, Completions, 12-month Enrollment, Student Financial Aid, Fall Enrollment, Finance, Graduation Rates, 200% Graduation Rates, and Human Resources. Select parts of each of these nine surveys are collected annually or bi-annually, depending on the survey and variables of interest. This data was acquired from IPEDS Resource Center, which can be accessed from the homepage of IPEDS. This IPEDS Resource Center also has exact screen shots of IPEDS surveys (National Center for Education Statistics, 2012b).

These nine surveys are organized into a "variable tree" format. The variable tree consists of each survey with accompanying data beneath each survey heading. The topics for these variable trees are as follows: *Frequently Used/Derived Variables, Institutional Characteristics, Admissions and Test Scores, Student Charges, Fall Enrollment, 12-Month Enrollment, Completions, Graduation Rates, Student Financial Aid and Net Price, Finance, and Human Resources* (National Center for Education Statistics, 2012b).

Only select variable trees are of interest for this study. The variable tree topics of interest are as follows: *Frequently Used/Derived Variables, Institutional Characteristics, Completions, 12-Month Enrollment, Finance and Human Resources*. Below is a brief overview of each of the six variable trees of interest for this study.

Frequently used/derived variables is a set of data fields that contains commonly used variables of interest from the primary surveys. Data presented in this section includes a range of data regarding costs, attendance, completions, and institutional characteristics.

Institutional characteristics are at the foundation of IPEDS. This section included data regarding private or public status, institutional control or affiliation (public/private, for-profit), types of degrees awarded, and even mission statement. Geographic location was included as well.

Completions included data on degrees awarded. This included a drill-down level to the Classification of Instructional Program level as well as by gender and race, and degree level. There is also a separate section for Postsecondary Awards in STEM fields for select years.

Twelve-month enrollment included information regarding unduplicated headcount, credit hours and instructional activity. Enrollment information can further be broken down into gender, level of student, and race. Level of student includes undergraduate and graduate.

The *finance* variable tree included a range of financial data including research expenditures, scholarships, fellowships, expenses, operational costs, and endowments and related assets. There was often a dual reporting structure for public and private institutions. There are also data that define revenue sources on the state and federal level.

The *human resources* variable tree included data related to salaries, benefits, number of employees, job duties and tenure status of faculty. The number of graduate assistantships and type of assistantship is also included. Occupational type was broken down by gender and race/ethnicity for select data.

Each of the previously touched upon six variable trees contains variables of interest to the current study. The variables of interest are explained after Table 3, which summarizes them. Below is a list of each variable of interest and the IPEDS source from which it comes. The variables of interest were variables as defined in this study. Closer description in the variables of interest section explains how each variable was obtained from the IPEDS database.

Table 3

IPEDS Variable Trees Matched with Variables of Interest

IPEDS Survey	Variables
Frequently Used/Derived Variables	1. Land-grant status
Institutional Characteristics	1. Institutional control or affiliation 2. Academic Common Market Status (derived from state location)
Completions	1. CIP code 2. Degree level (Master's or Doctoral) 3. Ratio of graduate STEM degrees 4. Gender 5. Year
12-Month Enrollment	1. Ratio of females enrolled in undergraduate studies 2. Ratio of females enrolled in graduate studies 3. Institutional size
Finance	1. Annual research expenditures per institution
Human Resources	1. Ratio of female faculty 2. Ratio of female graduate assistantships 3. Ratio of female administrators

Variables of Interest

All variables were obtained from IPEDS. For a full list of variables and their concise definitions, please see the Data Dictionary in Appendix A. Each variable will be presented followed by a brief explanation of the variable. Additionally, there are two separate tables that focus on variables. Table 4 matches each question with variables used to answer the question. Table 5 repeats this information, with the addition of a column for a matched statistical analysis used to answer each question. The researcher calculated all ratios. Ratios were not automatically available in IPEDS. Operational definitions follow.

1. *Ratio of graduate STEM degrees.* Ratio of graduate degrees for females was reviewed in a single format. The DV compared graduate female degrees for each STEM CIP as a ratio of total STEM degree for that CIP code, per year, per institution. The researcher calculated this ratio by raw values from IPEDS. These raw values were graduate degrees for females out of graduate degrees total for the aforementioned format by CIP, year, and institution. The ratio was used to address the context of females in STEM.
2. *Ratio of female faculty.* The ratio of females in faculty roles was included in order to address the ratio of females among faculty. The ratio was the number of female faculty out of the total number of faculty. This ratio was used as an IV throughout the study. IPEDS did not allow for the review of number of female faculty by CIP code to coincide with degree level.
3. *Ratio of females enrolled in undergraduate studies.* The ratio of females enrolled in undergraduate studies as a proportion of the total number of students enrolled

in undergraduate studies. IPEDS did not allow for review of enrollment by STEM field. This variable was treated as an IV throughout the study.

4. *Ratio of females enrolled in graduate studies.* The ratio of females enrolled in graduate studies as a proportion of the total number of students enrolled in graduate studies. This variable was treated as an IV throughout the study.

5. *Ratio of female administrators.* Ratio of female administrators out of all of the administrators was used. This variable was treated as an IV throughout the study.

6. *Annual research expenditures per institution.* Annual research expenditures is an IPEDS variable. This variable was treated as an IV throughout the study.

7. *Land-grant status.* Land-grant status was designated within IPEDS. The two types of land-grant institutions, which were considered for review, are land-grants and HBCU land-grants. Both types of land-grant institutions were included for review as long as they met the framework criteria for this study. This variable was treated as an IV throughout the study.

8. *Institutional size.* Institutional size was a continuous variable based on total student enrollment. This was in place of the default five level classifications in IPEDS. This variable was treated as an IV throughout the study.

9. *Ratio of female graduate assistantships.* The number of graduate assistantships for females out of the total number of graduate assistantships comprised this variable. IPEDS does not allow for review by gender within teaching and research assistantships, or even service assistantships that are part of land-grant institutions. This variable was an IV throughout the study.

10. *CIP code.* CIP code was used to review the DV for seven different STEM fields. The CIP codes used were as follows: 11-Computer and Information Sciences and Support Services, 14-Engineering, 15-Engineering technologies and Related fields, 26-Biology and Biomedical Sciences, 27-Mathematics and Statistics, 40-Physical Sciences, and 41-ScienceTechnologies / Technicians (National Center for Education Statistics, 2012b). CIP code was treated as a control or categorical sorting variable in order to present a drill-down discipline level of review.

11. *Gender.* Gender was indicated as male or female. In IPEDS, graduate degrees can be separated by gender (female and male) for each CIP code. Gender was used to derive the ratios for the dependent variables.

12. *Degree level*. Master's and doctoral degree levels were used. STEM degrees were reviewed by CIP code as well as by degree level. Degree level was treated as an IV. Results from question one determined how master's and doctoral degrees were treated for further questions in the study.

13. *Year*. The years considered for review are 2005-2010. Since the year focuses on degree production (May), the actual academic years in IPEDS are 2005-2006 through 2010-2011. Year was being treated as an IV. Year was also used in post-hoc analysis when necessary.

14. *Academic Common Market status.* Institutions, which were in Academic Common Market (ACM) participating states, were coded along with those institutions that were not located in ACM-Participating states. In general, ACM participating states are in the southeastern United States. ACM status was used as an IV.

15. *Institutional control or affiliation.* This is a control variable. Only not-for-profit institutions were included for review. For-profit institutions were not part of this study.

Table 4

Variables Matched to Research Questions

Question	Variables
1. Is the gender divide greater among master's degrees compared to doctoral degrees for STEM?	Gender, CIP, Degree level, Year
2. Are there differences in graduate degree production for land-grant vs. non land-grant institutions?	Gender, CIP code, Degree level, Land-grant status
3. Are there gender differences in each STEM field by two-digit CIP code for academic years 2005-2010?	Gender, Year, Degree Level, CIP
4. Are there differences in graduate STEM degree production comparing the Academic Common Market vs. non-ACM institutions?	Gender, CIP code, ACM status, Degree level
5. Are there trends in graduate degree attainment by gender across academic years 2005-2010?	Gender, CIP, Degree Level, Year
6. What institutional factors can be indicators of female graduate STEM degree attainment for academic years 2005-2010?	CIP code, Gender, Ratio of undergraduate females, Ratio of graduate females, Ratio of female administrators, Ratio of female faculty, Institutional size, Research expenditures, Land-grant status, Academic Common Market Status, Ratio of females in teaching and research assistantships

Data Analysis

All analyses were performed using data from IPEDS. Data was obtained from IPEDS in comma separated value (CSV) format and reformatted into Excel files. After the data was cleaned into the desired format, the Excel file was uploaded into data analysis software for review. SPSS (Statistical Package for Social Science) (IBM, 2012) was used to analyze data.

Initial descriptive statistics were used to introduce the dataset. For each follow-up question, descriptive statistic highlights were presented as needed. The level of review was at the two-digit CIP code level.

The overall statistical approach used was the General Linear Model (Kutner, Nachtsheim, Neter, & Li, 2005). The General Linear Model includes ANOVA and Ordinary Least Squares Regression. There were three main statistical techniques employed. Each of the three main statistical techniques is discussed in detail below. For each statistical approach, the dependent variables of ratio of female graduate STEM degrees was used. Depending on the research question, select independent variables were used.

ANOVA. An ANOVA was used to review differences along select sub-questions involving differences by institutional type and degree level for each CIP degree code. Statistical significance was determined as difference from the null. For example, an ANOVA was intended to review difference by gender by degree level-either master's or doctoral. The basic formula for a one-way ANOVA follows: $Yij = \mu + \ aj + \varepsilon$ij (Lomax, 2007).

While parametric statistics, which are based on meeting select assumptions, such as a normal distribution, homogeneity of variance, and select population sizes were intended to be used; often these assumptions were not met. Consequently, nonparametric statistics were used instead. Non-parametric tests do not need the assumptions of parametric tests in order for analysis to be run on the dataset under review. Nonparametric tests used included a Kruskal-Wallis in place of ANOVA and a Friedman's Test in place of a Repeated Measures ANOVA. Additionally, one independent variable (Research Expenditures) was transformed in order to meet the assumptions needed for an ordinary least squares regression test (Lomax, 2007).

Piecewise regression is appropriate for trends with two time periods. The basic formula for piecewise regression follows (Ryan & Porth, 2007): $\hat{Y} = a1 + \beta 1x$, for x < breakpoint, $\hat{Y} = a2 + \beta 2x$, for x > breakpoint. Piecewise regression was to be used only based on preliminary findings. Preliminary findings include statistical analysis focusing on trends, such as linear, cubic, and quadratic, as can be found through a repeated measures review (Lomax, 2007).

Regression was used to review predictive variables of female graduate degree attainment in STEM fields from 2005-2010. Number of degrees awarded is a continuous variable, while a range of independent variables will be used, both continuous and dummy-coded to be continuous. Ordinary Least Squares regression was used because this approach has a continuous Y variable (number of degrees) predicted by categorical dummy coded or continuous X (Lomax, 2007).

All possible subsets approach to regression were used. The final formula depended on the model of best fit. Variables were transformed to meet the assumptions for OLS Regression using log or square root transformations. The basic formula for multiple OLS regression follows: $\hat{Y} = a + b1x1 + b2x2 + \varepsilon$ (Lomax, 2007).

Quality Assurance

Steps are taken within controllers of the IPEDS database to conceal identities of select persons under review. The level of data reviewed was at a two-digit CIP STEM discipline level by institution. There was no individual or program level review of degree attainment. Also, this data is presented in aggregate. Individual universities were not reviewed or discussed in this study.

Given the nature of the database being used, IPEDS, this study did not fall under the purview of human subjects research. This is secondary data review. Consequently, this study was exempt from being submitted to the Institutional Review Board (IRB). Personal communication with the IRB office at the University of Alabama confirmed IPEDS is an approved database with exempt status due to its designation as a database that is part of the National Center for Education Statistics (NCES). This approval is listed under document titled "AAHRPP Document #190," (University of Alabama Institutional Review Board, 2012). Additionally, the IRB approved exempt status determination letter for this study is contained in Appendix C.

The researcher was a full-time graduate student attending a university that is not a land-grant institution. The researcher held no degrees from land-grant universities, nor had they ever been a full-time employee of land-grant universities. The researcher had never participated in the Academic Common Market.

Intended Outputs

A summary table is presented below matching each question with each variable and statistical approach. After the table, each question is presented, along with a narrative summation of how results will determine an answer to each question. Statistical significance is included in the narrative section for each question.

For purposes of this research study the statistical tests to be used are ANOVA, Ordinary Least Squares Regression, and Piecewise Regression. Statistical significance was determined by the resulting p value for the F statistics for each of these analyses. The p value indicates the cutoff value at which a statistical result will differ from a value expected to occur by chance. A significant *p* value, equal to or less than .05, indicated the differences between the means (for ANOVA) and differences from zero (for regression) was greater than the expected probability which would occur by chance. This difference was referred to as a statistically significant difference.

Chi-Square statistic was used to determine statistical significance for non-parametric tests. For example, mean ranks from Kruskal-Wallis were compared in place of one-way ANOVA. The chi-square statistic for Friedman's test was used for the repeated measures ANOVA. The alpha level remained the same for non-parametric tests, $p = .05$.

Table 5 aligns the research questions with variables and the statistical analysis. For the table below, two CIP fields were removed. These included Engineering Technologies and Science Technologies. This resulted in five CIP fields as dependent variables, and is reflected in Table 5 and the intended narrative outputs.

Table 5

Questions and Variables Matched with Statistical Methods

Question	Dependent Variables	Independent Variables	Analysis
1. Is the gender divide greater among master's degrees compared to doctoral degrees for STEM?	Ratio of graduate degrees for females	Gender, CIP, Degree level, Year	One-Way ANOVA or Kruskal-Wallis
2. Are there differences in graduate degree production for land-grant vs. non land-grant institutions?	Ratio of graduate degrees for females	Gender, CIP code, Degree level, Land-grant status	One-Way ANOVA or Kruskal-Wallis
3. Are there gender differences in each STEM field by two-digit CIP code for academic years 2005-2010?	Ratio of graduate degrees for females	Gender, Year, Degree Level, CIP	Repeated Measures ANOVA, 5 (CIP) x 6(Year), or Friedman's Test
4. Are there differences in graduate STEM degree production comparing the Academic Common Market vs. non-ACM institutions?	Ratio of graduate degrees for females	Gender, CIP code, ACM status, Degree level	One-Way ANOVA or Kruskal-Wallis
5. Are there trends in graduate degree attainment by gender across academic years 2005-2010?	Ratio of graduate degrees for females	Gender, CIP, Degree level, Year	Piecewise regression
6. What institutional factors can be indicators of female graduate STEM degree attainment for academic years 2005-2010?	Ratio of graduate degrees for females	CIP code, Gender, Ratio of undergraduate females, Ratio of graduate females, Ratio of female administrators, Ratio of female faculty, Institutional size, Research expenditures, Land-grant status, Academic Common Market status, Ratio of females in teaching and research assistantships	OLS Regression, All possible subset

The following are intended outputs for each research question.

1. Is the gender divide greater among master's degrees compared to doctoral degrees for STEM?

   A statistically significant *F* ratio comparing institutions at the doctoral and master's level for each of the six CIP codes provided an answer to this question, for a parametric ANOVA. A Kruskal-Wallis χ^2 was used as a non-parametric alternative. The χ^2 statistic provided useful data for further analysis regarding the difference in degree level (master's vs. doctoral) in treating these degree levels as separate variables.

2. Are there differences in graduate degree production for land-grant vs. non land-grant institution?

   A significant difference in degree production by land-grant status can be determined using alpha level .05 and a significant change in *F* value using an ANOVA, or non-parametric Kruskal-Wallis χ^2 comparing land-grant vs. non land-grant.

3. Are there gender differences in each STEM field by two-digit CIP code for academic years 2005-2010?

   Significant differences in *F* ratios for the five two-digit CIP codes for each of the six years under review. A repeated measures 5 (CIP) x 6 (Year) ANOVA or a Friedman's non-parametric alternative can answer this question. Statistically significant differences between genders as indicated for the ANOVA *F* statistic or Friedman's χ^2 using alpha level .05 would indicate statistically significant results to answer this question.

4. Are there differences in graduate STEM degree production comparing the Academic Common Market vs. non-ACM institutions?

   A significant F *or* χ^2 statistic will determine the answer to this question. A significant difference in the F or χ^2 statistic will determine statistical significance, alpha level .05.

5. Are there trends in graduate degree attainment by gender across academic years 2005-2010?

   This question was answered according to the statistical findings for preliminary data review for piecewise regression. Piecewise regression was used if there were significant trends in the distribution of the data. For example, an upward trend followed by a downward or plateau trend provided scenarios that called for piecewise regression. Additional statistical trends were for cubic and quadratic trends as backup to scatter plots were used to provide preliminary review of data. The F statistic regarding R^2 difference from zero with alpha level .05 was the alpha level for review. Piecewise regression was expected to be performed only if warranted based on preliminary data review.

6. What institutional factors can be indicators of female graduate STEM degree attainment for academic years 2005-2010?

   Significant predictor variables were determined by using an alpha level of .05. Change in the F value regarding the ratio for predictor variables on the dependent variable using differences from zero were used in the regression equations. Statistical significance using $p < .05$ for IV beta weights will determine which IVs contributed to the model.

Chapter III has outlined the proposed methodology. This includes the institutional selection process as well as the statistical analysis to be employed. This statistical analysis includes both parametric and non-parametric alternatives. Additionally, this methodology outlines the manner in which preliminary data will be reviewed, as well as exclusion of missing data. Chapter IV will report the results of the study.

CHAPTER IV:

RESULTS

This chapter presents the results of the study, starting with an introduction to the dataset used. Afterwards, the format of the chapter follows a question-by-question analysis and summary for questions one through six of the research study. The primary purpose of the study was to review graduate STEM degree production by gender during the recent economic context, which included academic years 2005-2006 through 2010-2011. IPEDS was used to collect all data. There was select statistical analysis used for each of the six separate questions.

As previously noted, parametric statistics, which are based on meeting select assumptions, such as a normal distribution and homogeneity of variance were intended to be used, often these assumptions were not met. Consequently, nonparametric statistics were used instead. Non-parametric tests do not have the assumptions of parametric tests in order for analysis to be run on the dataset under review. Nonparametric tests used included a Kruskal-Wallis in place of ANOVA and a Friedman's Test in place of a repeated measures ANOVA (Lomax, 2007).

Before analysis could be calculated on the dataset, missing data was addressed. Given the focus of the study is STEM degree production by gender during the recent Great Recession, a value was needed in order to be able to provide a means by which degree production could be reviewed. The dependent variable value used was the ratio of female graduate STEM degree by CIP level out of the total number of degrees for the CIP field under review. If the ratio was initially zero (0.00), or the ratio was so low the value was equal to zero (0.00), then the data were removed from the dataset. Data were removed at the CIP, degree, and institution level for each year if a zero or zero equivalent value, 0.00, was observed. An entire institution was not removed if a single year value was removed due a zero or zero equivalent value of 0.00 having been observed. A zero value could also indicate no graduates for the years under review as reported by the institution(s).

For two CIP fields, Engineering technologies and Related Fields and Science Technologies/Technicians (National Center for Education Statistics, 2012b), there were insufficient data reported to continue analysis. For select years in these disciplines, there were often no data at all. There were not zero ratios; there simply was no data. This can be a result of the fact that Engineering Technologies and Related Fields and Science Technologies/Technicians might better lend themselves to a community college STEM definition, while the focus of the current study is on the graduate level. These two CIP fields may simply exist at such small levels at the graduate level there are not enough data to review them on a broad scale, as is the nature of this study.

Additionally, the ratio value of zero (0.00), was too numerous with the format of the dependent variable that sought to address the ratio of female graduate degrees by CIP field out of total number of graduate female at an institution. Consequently, this dependent variable was discarded. There was no analysis performed with this dependent variable after review of initial data.

The practical value (clinical significance) of a zero value (0.00) can be noteworthy. Degree programs which result in no female graduates, or female graduates with such a low ratio a to equal zero (0.00), as a percent of the total number of graduates by the CIP level can still reveal information regarding the status of the graduate gender divide in STEM fields from 2005-

2010. A summary, Table 6, of how the zero values were removed from the dataset is presented in order to provide an overview of how the zero values were dispersed across years, CIP fields and degree levels. All zero removals were conducted after institutions were selected.

The summary table below presents a ranked order of zero values removed. The table starts with the CIP code level with the least number of zero values removed, and progresses to the CIP code level with the highest number of zero values removed. The summary table presents data by CIP discipline, followed by CIP discipline at the master's level, and finally CIP discipline at the doctoral degree level. Please note abbreviated CIP titles. Data in bold are ranked according to the criteria of the column in bold.

Table 6

Zero Removal Ranked by CIP Field for All Degrees, Master's, and Doctoral

CIP Field Ranked by All Degrees	**All Degrees**	Master's	Doctoral
26 Biomedical	**25**	9	16
40 Physical Science	**52**	24	28
14 Engineering	**61**	12	49
27 Math	**90**	32	58
11 Computer Science	**133**	41	92

CIP Field Ranked by Master's Level	All degrees	**Master's**	Doctoral
26 Biomedical	25	**9**	16
14 Engineering	61	**12**	49
40 Physical Science	52	**24**	28
27 Math	90	**32**	58
11 Computer Science	133	**41**	92

CIP Field Ranked by Doctoral Level	All degrees	Master's	**Doctoral**
26 Biomedical	25	9	**16**
40 Physical Science	52	24	**28**
14 Engineering	61	12	**49**
27 Math	90	32	**58**
11 Computer Science	133	41	**92**

Note. CIP titles have been abbreviated after the two-digit CIP field indicator.

Table 7 indicates the number of zeroes removed by CIP field for both master's and doctoral levels across years. Please note the original CIP two-digit code is kept in the CIP field, but an abbreviated description of each CIP code is used for both Table 6 and Table 7. Table 7 is not ranked in any way.

Table 7

Zero Removal by CIP, Master's or Doctoral Level and Year

	Master's Degree Count of Zero Ratios Removed					
CIP Field	2006	2007	2008	2009	2010	2011
11 Computer Science	6	8	7	5	8	7
14 Engineering	0	1	5	2	0	4
26 Biomedical	1	1	2	1	2	3
27 Math	5	2	6	4	8	7
40 Physical Science	5	7	4	3	3	2
Total	17	19	24	15	21	23

	Doctoral Degree Count of Zero Ratios Removed					
CIP Field	2006	2007	2008	2009	2010	2011
11 Computer Science	17	10	13	14	22	16
14 Engineering	11	10	5	5	6	12
26 Biomedical	5	4	3	2	2	0
27 Math	14	12	6	7	7	12
40 Physical Science	9	3	7	4	2	3
Total	56	39	34	32	39	43

The ranked results for both master's and doctoral degree levels by CIP fields in Table 6 indicate biology is consistently the CIP field with the lowest number of zero ratios removed. Physical sciences and engineering are the second and third fields, respectively. There were more engineering zero ratios removed at the doctoral level than the master's level. Math and computer science were the fields with the most zero ratios removed.

Table 8 indicates the data remaining after zero removal. There was no effort to rank data for Table 8. Data is displayed according to the lowest CIP value until the highest CIP value.

Table 8

Data Available for Review After Zeros and Outliers Removed by CIP Field and Degree Level

CIP Field	All Degrees	Master's	Doctoral
11 Computer Science	732	528	204
14 Engineering	794	466	328
26 Biomedical	1,026	605	421
27 Math	718	465	253
40 Physical Science	850	490	360

Overall, there were 361 zero ratios removed. There were 118 zero ratios removed at the master's level and 243 zero ratios removed at the doctoral level. There were 51% more zero ratios removed at the doctoral level compared to the master's level.

Reviewing the zero ratios removed by CIP field across years 2006-2011 revealed a split pattern at the master's level. The years are indicative of academic years 2005-2006 through 2010-2011. The first three years indicate increase in the removal of zero ratios by each successive year. This same pattern is repeated in the final three years under review. For the doctoral level the initial 2005-2006 academic year revealed the highest number of zero ratios removed, with a decrease in the ratio of zeroes removed through 2009. After 2009, there was an increase in zero removal for the final two years.

After the zeroes were removed from the dataset, outliers were removed. Outliers were removed by CIP field for all years under review combined. An outlier was determined to be three standard deviations beyond the mean. There were no outliers removed across all five CIP fields that were less than three standard deviations below the mean. For biology there were no outliers removed which were more than three standard deviations above the mean. For biology this resulted in 1.00 ratios being included in the final dataset for analysis. The remaining four

CIP fields had outliers removed, which were more than three standard deviations above the mean. Often these outliers consisted of only values that equaled 1.00 ratios, indicating female were the only gender to graduate with the respective CIP field degree for the specific data point per institution.

After the removal of outliers, a second data set was constructed, allowing for the review of CIP field by degree level. While the first data set placed all degree fields into one group for review by CIP field, the second data set separated master's degrees from doctoral degrees by CIP field. The purpose of the second dataset was to allow for review of data by degree level. After the creation of the second data set, a third data set further separated the data by year. The third data set included fields specific to each CIP field (five total), degree level (master's and doctoral), as well as year (2005-2006 through 2010-2011). The purpose of the third dataset was to allow for repeated measures ANOVA or Friedman's Test by degree level across all years under review.

Descriptive statistics of the first research question concerning master's and doctoral degree levels are presented in Table 8 as well as in Appendix D. Descriptive statistics of the second and third datasets will be presented as needed for the research questions, which made use of the datasets. Research question one made use of the first data set. Research questions two, four, five, and six made use of the second dataset. Only question three which included a repeated measures ANOVA approach included the third dataset.

A final note concerning HBCUs. There were only 14 HBCUs in the entire dataset out of 139 institutions. Depending on the exact CIP field under review, there was also potential for no HBCUs to be present in the dataset given the numbers were so low. From a statistical standpoint there was no rationale for using statistical significance to provide a rationale for removing

HBCUs given the low numbers of HBCU institutions. Given HBCUs provide a level of institutional diversity then including them in the dataset is in line with including institutions that provide institutional diversity. Since select HBCUs are a type of land-grant universities, 1890 land-grant institutions, and land-grant institutions are emphasized, HBCUs were kept in the dataset.

Research Question One

Is the gender divide greater among master's degrees compared to doctoral degrees for STEM? Dataset one was used in order to answer research question one. Means by degree level for each of the five CIP fields were compared using a Kruskal-Wallis procedure comparing master's versus doctoral. For the analysis, there is a complete set of reference data in Table 9, Table 10 and Appendix D for the question. These reference data include summary statistics including number of cases, descriptive statistics such as mean, median, mode, range, and normality graphs by CIP code alone as well as by degree level along with statistical tests for normality. Please reference Table 8 for an available summary of data points available for review for research question one.

Table 9

Summary Statistics by CIP Field for Research Question One Comparing Master's and Doctoral Degrees

		11 Comp Sc. 2006-2011	14 Eng. 2006-2011	26 Biomed 2006-2011	27 Math 2006-2011	40 Phys. Sc. 2006-2011
N	Valid	732	794	1026	718	850
	Missing	936	874	642	950	818
M		.2722	.2309	.5645	.4153	.3689
Mdn		.2500	.2191	.5516	.4189	.3508
Mode		.33	.20	.50	.50	.33
SD		.12850	.08803	.16507	.15256	.13870
Variance		.017	.008	.027	.023	.019
Range		.73	.57	.89	.83	.79
Minimum		.02	.04	.11	.06	.07
Maximum		.75	.61	1.00	.89	.86

Table 9 presents summary descriptive statistics by CIP field for research question one. Table 10 displays summary descriptive statistics by CIP field and degree level. Statistics include the sample size, mean, standard deviation, standard error, minimum, and maximum values, as shown in Table 10. Table 9 has select data not in Table 10, including the following: median, mode, variance, and range.

Table 10

Research Question One Descriptive Statistics by Degree Level (Master's and Doctoral), 2006-2011

CIP Field by Degree Level		*n*	*M*	*SD*	*SE*	Min.	Max.
11 Comp Sc.	Master	528	.2775	.12590	.00548	.02	.75
	Doc	204	.2584	.13434	.00941	.05	.67
	Total	732	.2722	.12850	.00475	.02	.75
14 Eng.	Master	466	.2318	.07766	.00360	.06	.55
	Doc	328	.2295	.10106	.00558	.04	.61
	Total	794	.2309	.08803	.00312	.04	.61
26 Biomed	Master	605	.5981	.15993	.00650	.18	1.00
	Doc	421	.5162	.16045	.00782	.11	1.00
	Total	1026	.5645	.16507	.00515	.11	1.00
27 Math	Master	465	.4456	.14289	.00663	.10	.89
	Doc	253	.3596	.15435	.00970	.06	.80
	Total	718	.4153	.15256	.00569	.06	.89
40 Phys. Sc.	Master	490	.4068	.13617	.00615	.13	.86
	Doc	360	.3173	.12493	.00658	.07	.75
	Total	850	.3689	.13870	.00476	.07	.86

Assumptions (see Table 9 and Table 10 and Appendix D) were met for the minimum number of data points (values for DV) had at least 50 institutions in each degree level. The lowest number of DV data points for a CIP field was 204 doctoral degrees for *computer and information sciences and support services* as well as 465 for master's degrees for *mathematics* and *statistics*. Statistically tests for normality were only met for *mathematics* and *statistics*. Additionally, the assumption for homogeneity of variance was not met for the CIP codes of *engineering* and *mathematics* and *statistics*. Given there was not a single field, which met the criteria for both normality and homogeneity of variance, a Kruskal-Wallis procedure was as a non-parametric test in place of the parametric ANOVA (Lomax, 2007).

Statistical significance is measured at the alpha .05 level. For a Kruskal-Wallis, there are only two groups being compared, master's vs. doctoral, so there is only one overall comparison being made. Statistically significant differences between the mean ranks for master's and doctoral degrees were found with CIP codes *computer sciences*, *biomedical sciences*, *mathematics* and *statistics*, and *physical sciences*. Statistically significant results were not found for CIP codes engineering. Given that the focus of the study is on the graduate degree level, the remaining questions in this dissertation were reviewed at the degree level. This remains true for all CIP fields, even though one CIP field was not found to have statistically significant differences in the means between the master's and doctoral degrees.

Table 11

Research Question One Kruskal-Wallis Differences in Gender by Degree Level (Master's and Doctoral), 2006-2011

CIP Field	χ^2	*df*	Significance
11 Computer Sciences	5.410	1	.020*
14 Engineering	2.837	1	.092
26 Biomedical Sciences	83.432	1	.000*
27 Math	51.886	1	.000*
40 Physical Sciences	92.074	1	.000*

*$p < .05$.

The Kruskal-Wallis procedure ranks means from lowest to highest. For the five CIP fields under review, the ranked means for master's degrees were all higher than the ranked means for the doctoral degrees. Reviewing the statistical summary data in Appendix D also reveals the means for master's degrees were higher for all five CIP fields compared to doctoral degrees. In other words, master's degrees have a higher ratio of female obtaining graduate degrees for each respective CIP field under review for the academic years 2005-2010.

Research Question Two

Are there differences in graduate degree production for land-grant vs. non land-grant institutions? Research question two sought to review the manner in which there was a potential difference in female degree attainment by land-grant status. Revisiting the mission of land-grant institutions as the people's institutions, there was the possibility that there could be more female obtaining graduate degrees at land-grant institutions. This is partially why land-grant institutions were included in the dataset. There was no attempt made to differentiate between types of land-grant institutions. Institutions were automatically coded as land-grant institutions or non-land institutions according to identifiers present in IPEDS.

Table 12 summarizes the data points available for review for research question two. The data is organized according to smallest to largest two-digit CIP field. A more detailed descriptive table of data for research question two is contained in Appendix E.

There was no directional hypothesis made for the current review of data. A two-way hypothesis with a standard alpha level of .05 was used when determining statistical significance. In order to compare means of land-grant institutions vs. non-land-grant institutions, an ANOVA was chosen to compare institutions by CIP and degree level. In order to meet the assumptions of an ANOVA, there had to be at least 50 cases per CIP and degree level (Lomax, 2007). An initial review of the data revealed there was insufficient data to perform an ANOVA because there were not at least 50 cases in each category. Appendix E summarizes statistics for cases by CIP and degree level regarding land-grant status. Also, for an introduction to the dataset used for research questions two there is a summary table of descriptive statistics in Appendix E, followed by a case summary table of land-grant institution status with percent by CIP level.

Table 12

Data Available by CIP Field, Degree Level and Land-Grant Status

CIP Field	Master's		Doctoral	
	LG	Non-LG	LG	Non-LG
11 Computer Science	299	229	145	59
14 Engineering	335	131	257	71
26 Biomedical	354	251	285	136
27 Math	315	150	193	60
40 Physical Science	326	164	264	96

Note. LG = Land-Grant

While Table 12 presents data available for review, Table 13 presents additional descriptive statistics, including mean, standard deviation, standard error, as well as minimum and maximum. Additionally, Table 13 presents the previously mentioned descriptive statistics available for review for both land-grant and non-land-grant institutions.

Table 13

Research Question Two Descriptive Statistics by Land-Grant Status, 2006-2011

CIP Field		*n*	*M*	*SD*	*SE*	Minimum	Maximum
11 Comp Sc. master	1	299	.2625	.12382	.00716	.05	.75
	2	229	.2972	.12614	.00834	.02	.75
	Total	528	.2775	.12590	.00548	.02	.75
11 Comp Sc. doc	1	145	.2424	.13414	.01114	.05	.67
	2	59	.2979	.12750	.01660	.11	.58
	Total	204	.2584	.13434	.00941	.05	.67
14 Eng. Master	1	335	.2308	.07423	.00406	.06	.55
	2	131	.2344	.08605	.00752	.06	.54
	Total	466	.2318	.07766	.00360	.06	.55
14 Eng. Doc	1	257	.2156	.08658	.00540	.04	.50
	2	71	.2801	.13034	.01547	.05	.61
	Total	328	.2295	.10106	.00558	.04	.61
26 Biomed master	1	354	.5998	.14993	.00797	.22	1.00
	2	251	.5958	.17332	.01094	.18	1.00
	Total	605	.5981	.15993	.00650	.18	1.00
26 Biomed doc	1	285	.4934	.13901	.00823	.11	1.00
	2	136	.5638	.18989	.01628	.20	1.00
	Total	421	.5162	.16045	.00782	.11	1.00
27 Math master	1	315	.4491	.13765	.00776	.10	.89
	2	150	.4383	.15352	.01253	.14	.89
	Total	465	.4456	.14289	.00663	.10	.89
27 Math doc	1	193	.3554	.15229	.01096	.06	.80
	2	60	.3734	.16134	.02083	.11	.67
	Total	253	.3596	.15435	.00970	.06	.80
40 Phys. Sc. Master	1	326	.3970	.12581	.00697	.13	.83
	2	164	.4262	.15328	.01197	.17	.86
	Total	490	.4068	.13617	.00615	.13	.86
40 Phys. Sc. doc	1	264	.3026	.10601	.00652	.08	.67
	2	96	.3576	.16009	.01634	.07	.75
	Total	360	.3173	.12493	.00658	.07	.75

Note. Land-grant status is indicated by a 1, while non-land-grant status is indicated by a 2.

Normality was consistently violated, and the homogeneity of variance was violated as well for select CIP fields (see Appendix E for tables summarizing assumptions). Since the assumptions for an ANOVA were not met a non-parametric equivalent was chosen. Kruskal-Wallis ranks means from lowest to highest. Additionally, unequal sample sizes for non-parametric comparison make post-hoc inappropriate due to the post-hoc format of pairwise comparisons by year.

For the ten dependent variables being measured, there were higher case numbers of land-grant institutions reporting a value for ratio of female obtaining graduate degrees in the CIP field. The following Kruskal-Wallis summary Table 14 reveals statistical significance for the following fields: *computer and information sciences and support services* master's, *computer and information sciences and support services* doctoral, *engineering* doctoral, *biomedical sciences* doctoral, and *physical sciences* doctoral. Statistical significance was determined used alpha level .05. In Table 15, mean ranks from the Kruskal-Wallis are also included in order to present an introduction to mean ranks being compared for land-grant vs. non-land-grant institutions.

Table 14

Kruskal-Wallis Differences by Land-Grant Status by CIP Field and Degree Level, 2006-2011

CIP Field	χ^2	*df*	Significance
11 Computer Sciences master	13.585	1	.000*
11 Computer Sciences doctoral	9.157	1	.002*
14 Engineering master	.052	1	.820
14 Engineering doctoral	.000	1	.000*
26 Biomedical Sciences master	.059	1	.808
26 Biomedical Sciences doctoral	14.208	1	.000*
27 Math master	1.161	1	.281
27 Math doctoral	.901	1	.343
40 Physical Sciences master	2.695	1	.101
40 Physical Sciences doctoral	7.154	1	.007*

*p < .05.

Four of the five CIP codes for which there were differences in female degree production by land-grant status were for the doctoral degree level. For all five of the statistically significant results, the means and mean ranks were higher for the non-land-grant institutions (see Table 15). Math was the only CIP, which did not have a significantly different female's degree production ratio by land-grant status for the doctoral degree level.

Table 15

Research Question Two Kruskal-Wallis Mean Ranks by CIP Field, Degree Level and Land-Grant Status, 2006-2011

CIP Field	Land Grant Institution Status (1=land-grant, 2=non-land-grant)	N	Mean Rank
11 Comp Sc. master	1	299	243.09
	2	229	292.46
	Total	528	
11 Comp Sc. doc	1	145	94.53
	2	59	122.08
	Total	204	
14 Eng. Master	1	335	232.61
	2	131	235.77
	Total	466	
14 Eng. Doc	1	257	153.76
	2	71	203.39
	Total	328	
26 Biomed master	1	354	304.45
	2	251	300.95
	Total	605	
26 Biomed doc	1	285	195.57
	2	136	243.34
	Total	421	
27 Math master	1	315	237.63
	2	150	223.28
	Total	465	
27 Math doc	1	193	124.57
	2	60	134.82
	Total	253	
40 Phys. Sc. Master	1	326	238.06
	2	164	260.30
	Total	490	
40 Phys. Sc. doc	1	264	171.66
	2	96	204.82
	Total	360	

Given that the purpose of research question two is to focus on the differences in degree production ratios by land-grant vs. non-land-grant status, follow-up post-hoc pairwise comparisons between years were not performed to determine the exact years for which there were differences by land-grant status during the time frame under review. The unequal group sizes and non-parametric test used makes employing non-parametric pairwise comparisons such as would be the case with a Mann-Whitney U or Wilcoxon unsatisfactory. While the previous trends for statistically significant difference for doctoral degree level and higher mean and mean ranks for non-land-grant institutions remain true, a year-by-year comparison was not performed. The focus remained on the context of the years under review, 2006-2011.

Research Question Three

What are the gender differences within each STEM field by two-digit CIP code for academic years 2005-2010? The purpose of research question three was to determine if there were differences in the ratios of female degree production by year for the time period under review. In order to address this question, a repeated measures ANOVA and Friedman's Test were conducted by CIP field and degree level. This approach presented 10 analyses for 10 dependent variables corresponding to each of the CIP fields, five master's and five doctoral.

The purpose of question three is to determine if there are mean differences within institutions. In order to allow for analysis used a repeated measures design, assumptions must first be addressed. In order to perform a repeated measures ANOVA, assumptions include samples size (at least 50), sphericity, normality, independence, and homogeneity of variance (Lomax, 2007). Given there are no between-subjects factors for this repeated measures ANOVA, there are no homogeneity of variance assumption between subjects.

The first assumption to be addressed is sample size. For each of the six years under review, there needs to be at least 50 data points, in this case, at least 50 institutions which report a non-zero ratio of female's graduate degree production for academic years 2005-2010. Table 16 presents a summary of data available by year.

Table 16

Research Question Three Case Processing Summary by CIP Field, Degree Level and Year, 2006-2011

		Cases					
		Valid		Missing		Total	
	Year	N	Percent	N	Percent	N	Percent
11 Comp Sc. master	2006	89	64.0%	50	36.0%	139	100.0%
	2007	87	62.6%	52	37.4%	139	100.0%
	2008	88	63.3%	51	36.7%	139	100.0%
	2009	91	65.5%	48	34.5%	139	100.0%
	2010	85	61.2%	54	38.8%	139	100.0%
	2011	88	63.3%	51	36.7%	139	100.0%
Comp Sc. doc	2006	35	25.2%	104	74.8%	139	100.0%
	2007	43	30.9%	96	69.1%	139	100.0%
	2008	30	21.6%	109	78.4%	139	100.0%
	2009	21	15.1%	118	84.9%	139	100.0%
	2010	35	25.2%	104	74.8%	139	100.0%
	2011	40	28.8%	99	71.2%	139	100.0%
14 Eng. Master	2006	78	56.1%	61	43.9%	139	100.0%
	2007	78	56.1%	61	43.9%	139	100.0%
	2008	75	54.0%	64	46.0%	139	100.0%
	2009	77	55.4%	62	44.6%	139	100.0%
	2010	80	57.6%	59	42.4%	139	100.0%
	2011	78	56.1%	61	43.9%	139	100.0%
14 Eng. Doc	2006	54	38.8%	85	61.2%	139	100.0%
	2007	61	43.9%	78	56.1%	139	100.0%
	2008	48	34.5%	91	65.5%	139	100.0%
	2009	41	29.5%	98	70.5%	139	100.0%
	2010	64	46.0%	75	54.0%	139	100.0%
	2011	60	43.2%	79	56.8%	139	100.0%

		Cases					
		Valid		Missing		Total	
	Year	N	Percent	N	Percent	N	Percent
26 Biomed master	2006	101	72.7%	38	27.3%	139	100.0%
	2007	100	71.9%	39	28.1%	139	100.0%
	2008	100	71.9%	39	28.1%	139	100.0%
	2009	104	74.8%	35	25.2%	139	100.0%
	2010	100	71.9%	39	28.1%	139	100.0%
	2011	100	71.9%	39	28.1%	139	100.0%
26 Biomed doc	2006	75	54.0%	64	46.0%	139	100.0%
	2007	73	52.5%	66	47.5%	139	100.0%
	2008	62	44.6%	77	55.4%	139	100.0%
	2009	47	33.8%	92	66.2%	139	100.0%
	2010	80	57.6%	59	42.4%	139	100.0%
	2011	84	60.4%	55	39.6%	139	100.0%
27 Math master	2006	75	54.0%	64	46.0%	139	100.0%
	2007	81	58.3%	58	41.7%	139	100.0%
	2008	77	55.4%	62	44.6%	139	100.0%
	2009	80	57.6%	59	42.4%	139	100.0%
	2010	74	53.2%	65	46.8%	139	100.0%
	2011	78	56.1%	61	43.9%	139	100.0%
27 Math doc	2006	41	29.5%	98	70.5%	139	100.0%
	2007	46	33.1%	93	66.9%	139	100.0%
	2008	35	25.2%	104	74.8%	139	100.0%
	2009	29	20.9%	110	79.1%	139	100.0%
	2010	56	40.3%	83	59.7%	139	100.0%
	2011	46	33.1%	93	66.9%	139	100.0%
40 Physical Sc. master	2006	80	57.6%	59	42.4%	139	100.0%
	2007	78	56.1%	61	43.9%	139	100.0%
	2008	80	57.6%	59	42.4%	139	100.0%
	2009	83	59.7%	56	40.3%	139	100.0%
	2010	83	59.7%	56	40.3%	139	100.0%
	2011	86	61.9%	53	38.1%	139	100.0%
40 Physical Sc. Doc	2006	61	43.9%	78	56.1%	139	100.0%
	2007	69	49.6%	70	50.4%	139	100.0%
	2008	50	36.0%	89	64.0%	139	100.0%
	2009	42	30.2%	97	69.8%	139	100.0%
	2010	69	49.6%	70	50.4%	139	100.0%
	2011	69	49.6%	70	50.4%	139	100.0%

Below is Table 17 summarizing the violations of assumptions for the repeated measures ANOVA. For each of the master's degree levels, there were enough cases, however, for each doctoral degree level, there was insufficient data to run a repeated measures ANOVA. There was only one CIP field, *mathematics* and *statistics*, which met the assumption for normality. Additionally tables presenting information regarding and normality tests are presented in Appendix F.

Table 17

Research Question Three ANOVA Assumptions Violations by CIP Field and Degree Level, 2006-2011

CIP Field	Minimum Cases	Normality	Sphericity
11 Computer Sciences master	Pass	Violates	N/A
11 Computer Sciences doctoral	Violates	Violates	N/A
14 Engineering master	Pass	Violates	N/A
14 Engineering doctoral	Violates	Violates	N/A
26 Biomedical Sciences master	Pass	Violates	N/A
26 Biomedical Sciences doctoral	Violates	Violates	N/A
27 Math master	Pass	Pass	Pass
27 Math doctoral	Violates	Violates	N/A
40 Physical Sciences master	Pass	Violates	N/A
40 Physical Sciences doctoral	Violates	Violates	N/A

$*p < .05$.

Given *mathematics* and *statistics* was the only dependent variable to pass both the minimum number of cases as well as normality, this DV was the only test used for a repeated measures ANOVA. Homogeneity of variance in the repeated measures ANOVA is tested using a sphericity assumption that tests whether or not the variances in each year are approximately equal. For *mathematics* and *statistics*, Mauchly's Test of Sphericity was met, ($\chi^2 = 14.662$, $df = 14$, $p = .402$). The repeated measures ANOVA was not significant, ($F = .325$, $df = 5$, $p = .898$).

Since the repeated measures ANOVA was not significant, there was no follow-up post-hoc analysis performed.

Table 18

Research Question Three Friedman's Test Chi-Square Statistic and p value Comparing Years by CIP Field and Degree Level, 2006-2011

CIP Field	χ^2	*df*	Significance
11 Computer Sciences master	8.012	5	.156
11 Computer Sciences doctoral	3.799	5	.579
14 Engineering master	3.470	5	.628
14 Engineering doctoral	9.871	5	.079
26 Biomedical Sciences master	11.089	5	.050*
26 Biomedical Sciences doctoral	6.233	5	.284
27 Math doctoral	1.358	5	.929
40 Physical Sciences master	8.185	5	.146
40 Physical Sciences doctoral	3.736	5	.588

*$p \leq .05$.

For the remaining nine dependent variables, a non-parametric alternative to the repeated measures ANOVA was used. The specific test was a Friedman's Test. Unlike the repeated measures ANOVA, a Friedman's Test does not make the underlying assumptions regarding normality. A Friedman's Test ranks means and compares ranked means to determine if they are similar. A chi-square statistic is used to determine statistical significance with a Friedman's Test (Lomax, 2007). A summary table of the Friedman's Test for the nine dependent variables is in Table 18.

Additionally, a summary of the mean ranks from the Friedman's Test is presented in Table 19. Table 19 presented the mean ranks for each year by CIP field and degree level. Please note mean ranks for Math master are shown in place of means, even though the repeated measures ANOVA was calculated for this dependent variable with no statistically significant findings.

Table 19

Research Question Three Friedman Test Mean Ranks by CIP Field, Degree Level and Year, 2006-2011

Year	11 Comp Sc. master	11 Comp Sc. doc	14 Engineering master	14 Engineering doctoral	26 Biomedical Sciences master
2006	3.67	2.95	3.63	4.18	3.16
2007	3.45	3.55	3.25	3.63	3.27
2008	3.44	3.27	3.61	3.17	3.29
2009	3.95	3.64	3.69	3.90	3.83
2010	3.36	3.23	3.30	3.07	3.71
2011	3.13	4.36	3.51	3.05	3.74

	26 Biomedical Sciences doctoral	27 Math master	27 Math doctoral	40 Physical Sciences master	40 Physical Sciences doctoral
2006	4.00	3.52	3.44	3.25	3.47
2007	3.63	3.3	3.29	3.69	3.91
2008	3.45	3.48	3.71	3.65	3.77
2009	3.62	3.52	3.62	3.53	3.21
2010	3.03	3.46	3.76	3.08	3.33
2011	3.28	3.71	3.18	3.81	3.3

Note. The degrees of freedom for each of the statistics above was five.

Using an alpha level of .05, there was only one statistically significant response, *biomedical sciences* master. All eight remaining values did not reveal statistically significant differences. For the single significant value, *biological* and *biomedical sciences* master, a follow-up post-hoc analysis was performed to determine differences by year. In Table 20 is a summary of descriptive statistics for *biological* and *biomedical sciences* master by year.

Table 20

Research Question Three Biomedical Sciences Master's Mean Ranks by Quartiles and Year

CIP Field	N	Percentiles			Mean Rank
		25th	50th (Median)	75th	
26 Biomed master 2011	90	.4780	.5736	.6533	3.16
26 Biomed master 2010	90	.5000	.6000	.6967	3.27
26 Biomed master 2009	90	.4843	.5714	.6847	3.29
26 Biomed master 2008	90	.5034	.6124	.6947	3.83
26 Biomed master 2007	90	.5240	.5963	.7029	3.71
26 Biomed master 2006	90	.5087	.6000	.7143	3.74

Using a Bonferroni adjusted post-hoc multiple comparison procedure, each year for Biomedical sciences master was compared to every other year using a Wilcoxon Ranked Sum Test (Lomax, 2007). A Bonferroni adjustment was made so that all pairwise comparisons are reported at the .003 significance level. Using alpha level .003, there were no statistically significant results. There were no statistically significant differences between pairs of years for *biomedical sciences* master for 2006-2011. Below is a summary table of *z* scores and significance level for the Wilcoxon follow-up procedure. The *z* score is presented in Table 21, followed by the significance level in parentheses.

Table 21

Research Question Three Wilcoxon Summary for Biomedical Sciences Master's z scores by Year, 2006-2011

Year	2010	2009	2008	2007	2006
2011	-7.15 (.475)	-.424 (.672)	-2.012 (.044)	-2.866 (.004)	-1.772 (.076)
2010		-1.035 (.301)	-.2690 (.204)	-1.091 (.275)	-.993 (.321)
2009			-2.191 (.028)	-2.074 (.038)	-1.814 (.070)
2008				-.0720 (.943)	-.8040 (.422)
2007					-3.880 (.698)

Note. A *z* score is presented followed by statistical significance level in parenthesis.

A review of descriptive statistics in Table 22 for *biomedical sciences* master for 2006-2011 indicates the highest mean was for 2007 and the highest median was for 2010. While there were no statistically significant results using alpha level .003, one score came close to statistical significance, the pairwise comparison between 2011 and 2007 with a score of $p = .004$.

Table 22

Research Question Three Descriptive Statistics for Biomedical Sciences Master's by Year, 2006-2011

Descriptive Statistic	2011	2010	2009	2008	2007	2006
M	.5856	.5981	.5631	.6174	.6181	.6076
Mdn	.5763	.6000	.5630	.6124	.5963	.6000
Mode	.5000	.5000	.7500	.5000	.5000	.5000
SD	.16414	.16107	.16043	.15802	.15786	.15470

Overall, there were no statistically significant differences within years when reviewing data by degree level and CIP code. For the one DV, *biomedical sciences* master, with a statistical significance Friedman's Test, follow-up analysis that accounted for the adjusted alpha level did not reveal statistical significance. Data for this single DV only approached statistical significance.

Research Question Four

Are there differences in graduate STEM degree production comparing the Academic Common Market vs. non-ACM institutions? The purpose of this question was to determine whether or not there were statistically significant differences between institutions that were located in states, which were part of the Academic Common Market compact, compared to those, which were not. The rationale behind this question was to address geographic location. The ACM included states in the southeastern United States. Based on the state indicated via IPEDS, a manual coding of 1 (ACM) or 2 (non-ACM) was performed on 139 institutions.

Below is a summary of data available for review for ACM versus non-ACM status. Table 23 presents data by CIP level as well as degree level, master's or doctoral for the time frame under review, 2006-2011. Data are presented in order of the smaller CIP code in the first row, with the largest CIP code number in the last row.

Table 23

Data Available by CIP Field and Degree Level by Academic Common Market Status

CIP Field	Master's		Doctoral	
	ACM	Non-ACM	ACM	Non-ACM
11 Computer Science	200	328	75	129
14 Engineering	162	304	120	208
26 Biomedical	252	353	158	263
27 Math	163	302	91	162
40 Physical Science	172	318	117	243

Descriptive statistics for research question four are presented in Table 24. Descriptive statistics are presented by ACM status as well as a total for ACM and non-ACM institutions.

Table 24

Research Question Four Descriptive Statistics by ACM Status, 2006-2011

CIP Field		N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
11 Comp Sc. master	1	200	.2954	.13189	.00933	.07	.75
	2	328	.2667	.12101	.00668	.02	.71
	Total	528	.2775	.12590	.00548	.02	.75
11 Comp Sc. doc	1	75	.2700	.14273	.01648	.06	.67
	2	129	.2517	.12931	.01138	.05	.58
	Total	204	.2584	.13434	.00941	.05	.67
14 Eng. Master	1	162	.2410	.08248	.00648	.07	.55
	2	304	.2269	.07463	.00428	.06	.50
	Total	466	.2318	.07766	.00360	.06	.55
14 Eng. Doc	1	120	.2321	.11580	.01057	.04	.61
	2	208	.2281	.09175	.00636	.05	.50
	Total	328	.2295	.10106	.00558	.04	.61
26 Biomed master	1	252	.6224	.17647	.01112	.18	1.00
	2	353	.5808	.14476	.00770	.20	1.00
	Total	605	.5981	.15993	.00650	.18	1.00
26 Biomed doc	1	158	.5220	.16231	.01291	.18	1.00
	2	263	.5126	.15953	.00984	.11	1.00
	Total	421	.5162	.16045	.00782	.11	1.00
27 Math master	1	163	.4782	.14677	.01150	.13	.89
	2	302	.4280	.13781	.00793	.10	.89
	Total	465	.4456	.14289	.00663	.10	.89
27 Math doc	1	91	.3780	.15499	.01625	.11	.75
	2	162	.3493	.15350	.01206	.06	.80
	Total	253	.3596	.15435	.00970	.06	.80
40 Phys. Sc. Master	1	172	.4148	.15105	.01152	.13	.86
	2	318	.4024	.12744	.00715	.14	.83
	Total	490	.4068	.13617	.00615	.13	.86
40 Phys. Sc. doc	1	117	.3321	.11803	.01091	.08	.67
	2	243	.3102	.12775	.00820	.07	.75
	Total	360	.3173	.12493	.00658	.07	.75

Note. (1=ACM, 2=Non-ACM).

The minimum number of cases was met. Aside from two CIP fields, the assumption for homogeneity of variance was met using alpha level .05. The assumption for normality was not met for any of the samples using alpha level .05. Since the assumption for normality was not met, a non-parametric equivalent to the one-way ANOVA was chosen, the Kruskal-Wallis test. While the assumption for normality is not always a problem with ANOVA, a non-parametric equivalent was still chosen given this assumption for normality was not met.

A Kruskal-Wallis test was conducted on all 10 dependent variables. The summary table below reveals the results of the Kruskal-Wallis test. A Kruskal-Wallis uses a chi-square statistic with an alpha level of .05 for this analysis. A Kruskal-Wallis was chosen over a Mann-Whitney Test due to the unequal sizes of the ACM and non-ACM groups for each dependent variable.

Results indicated a statistically significant difference in ACM vs. non-ACM institutions for 2006-2011 for the following CIP fields: *computer sciences* master, *biomedical sciences* master, and *math* master. For all three CIP fields, the mean ranks were higher for the ACM institutions compared to the non-ACM institutions. A complete list of all mean ranks for all 10 CIP fields is contained in the Appendix G. Mann-Whitney U post-hoc or Wilcoxon comparisons were not performed given the significant difference in sample sizes. The unequal pairs combined with the Bonferroni adjustment would make conclusions based on post-hoc analysis of this nature unlikely and potentially invalid given the amount of pairwise comparisons which will be left out due to the unequal sample sizes.

Significant results were found for three of the dependent variables under review: *computer and information sciences* and *support services*, *biological* and *biomedical sciences*, and *mathematics* and *statistics*. All three statistically significant findings were at the master's level, as shown in Table 25.

Table 25

Research Question Four Academic Common Market Comparison Kruskal-Wallis Chi-Square Statistic and Significance Level, 2006-2011

CIP Field	χ^2	*df*	Significance
DV1 11 Computer Sciences master	6.509	1	.011*
DV1 11 Computer Sciences doctoral	.471	1	.493
DV1 14 Engineering master	1.308	1	.253
DV1 14 Engineering doctoral	.009	1	.926
DV1 26 Biomedical Sciences master	9.883	1	.002*
DV1 26 Biomedical Sciences doctoral	.186	1	.667
DV1 27 Math master	9.957	1	.002*
DV1 27 Math doctoral	1.712	1	.191
DV1 40 Physical Sciences master	.287	1	.592
DV1 40 Physical Sciences doctoral	2.982	1	.084

*$p < .05$.

For all three of the statistically significant results, the mean ranks for the non-ACM institutions was larger than the mean rank for the ACM institutions. Mean ranks are contained in Table 26. Academic Common Market status is indicated alongside the sample size and mean rank in Table 26.

Table 26

Research Question Four Academic Common Market Kruskal-Wallis Mean Ranks by CIP Field and Degree Level, 2006-2011

CIP Field	Academic Common Market (1=ACM, 2=non-ACM)	N	Mean Rank
11 Comp Sc. master	1	200	286.19
	2	328	251.27
	Total	528	
11 Comp Sc. doc	1	75	106.21
	2	129	100.34
	Total	204	
14 Eng. Master	1	162	243.27
	2	304	228.29
	Total	466	
14 Eng. Doc	1	120	163.86
	2	208	164.87
	Total	328	
26 Biomed master	1	252	329.43
	2	353	284.13
	Total	605	
26 Biomed doc	1	158	214.29
	2	263	209.02
	Total	421	
27 Math master	1	163	259.73
	2	302	218.57
	Total	465	
27 Math doc	1	91	135.02
	2	162	122.50
	Total	253	
40 Phys. Sc. Master	1	172	250.15
	2	318	242.98
	Total	490	
40 Phys. Sc. doc	1	117	194.15
	2	243	173.93
	Total	360	

Post-hoc analysis was not performed by year due to the large inequality of sample sizes for ACM vs. non-ACM institutions for the three statistically significant dependent variables.

Results for such an analysis would not be valid given the pairwise comparison of a potential non-parametric follow-up analysis.

Research Question Five

Are there trends in graduate degree attainment by gender across academic years 2005-2010? The purpose of this question was to determine if there were common trends among the dependent variables, which may have been unique in the context of the recent Great Recession. There were two main ways to approach this question. The first manner was through a visual review of the data via histograms of means by degree level and CIP code. An initial review of these scatter plots (contained in Appendix H) revealed potential trends based on the distribution of the data. In general, the scale of the x and y axis was small using the graphs in Appendix H, so ability to determine trends was not readily detected by preliminary visual review alone. An initial review of each histogram by degree level and CIP field revealed trends across CIP fields and degree levels may have been difficult to determine given the initial lack of similarity among the histograms.

The only regression analysis undertaken after review of the visual plots was for *engineering* doctoral degrees. The plot of the means for *engineering* doctoral degrees was reviewed using simple linear regression analysis for two time periods. The first time period was 2006-2008, and the second time period was 2009-2011.

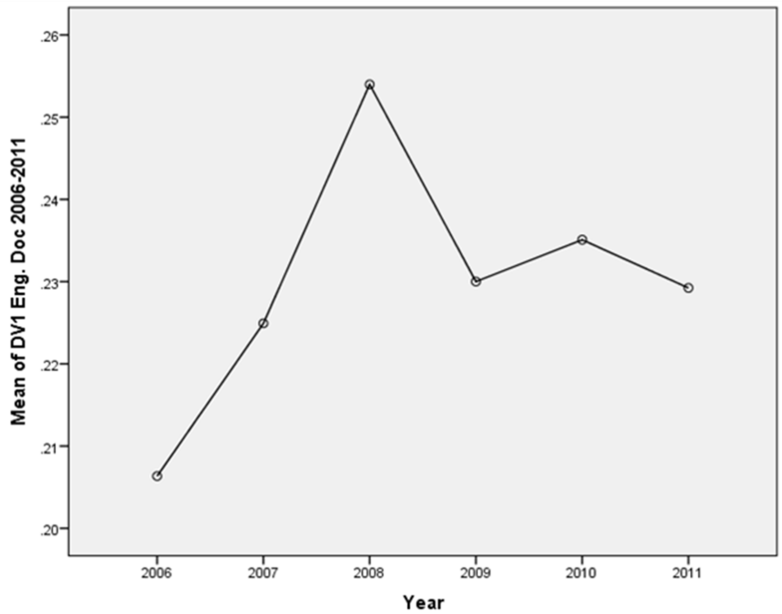

Figure 1. CIP 14 Engineering Doctoral Means Plot by Year

The first time period indicated an increase in the dependent variable of degree production for each of the three years. The second time period indicated no relationship between the dependent variable degree production and each of the three years. A copy of the histogram for these plotted means is displayed in Figure 1.

Simple linear regression, with IV by year, results indicated a significant relationship for the first three years, but no relationship for the last three years. The regression results for the dependent variable of graduate female's degree production in engineering doctoral programs was not significantly correlated to year, 2006-2011, with r^2 = .188, significant using alpha level .05. A Pearson correlation below .20 indicates no correlation (Lomax, 2007). The ANOVA for the regression analysis was significant, F = 5.891, df = 1, 161, p = .016, with adjusted R^2 = .029. While there may have been statistically significant data, practical significance was not found.

In order to test for trends in the data aside from preliminary review of plotting means, each dependent variable was tested for the contrasts of linear, cubic, and quadratic. Additional analysis for Order 4 and Order 5 trends were conducted with no significance. Given that there were only six means provided for each year under review, testing for these trends was sufficient, so only data for these trends is presented (see Table 27).

Table 27

Research Question Five Summary of Linear, Quadratic, and Cubic Trends Across Years, 2006-2011

CIP Field	Trend	*F*	*df*	Significance
11 Comp Sc. master	Linear	.332	1, 70	.566
	Quadratic	3.354	1, 70	.071
	Cubic	1.524	1, 70	.221
11 Comp Sc. doc	Linear	.727	1, 10	.414
	Quadratic	.385	1, 10	.549
	Cubic	.629	1, 10	.446
14 Eng. master	Linear	.006	1, 72	.938
	Quadratic	.097	1, 72	.756
	Cubic	.001	1, 72	.981
14 Eng. doc	Linear	6.060	1, 29	.020*
	Quadratic	.009	1, 29	.924
	Cubic	3.057	1, 29	.091
26 Biomed master	Linear	3.086	1, 89	.082
	Quadratic	1.977	1, 89	.163
	Cubic	.046	1, 89	.830
26 Biomed doc	Linear	3.076	1, 38	.088
	Quadratic	.146	1, 38	.704
	Cubic	1.141	1, 38	.292
27 Math master	Linear	.072	1, 63	.789
	Quadratic	.005	1, 63	.946
	Cubic	.485	1, 63	.489
27 Math doc	Linear	.144	1, 16	.710
	Quadratic	2.680	1, 16	.121
	Cubic	.109	1, 16	.745
40 Physical Sc. master	Linear	.007	1, 70	.935
	Quadratic	.827	1, 70	.366
	Cubic	2.690	1, 70	.105
	Linear	2.761	1, 32	.106
40 Physical Sc. doc	Quadratic	1.543	1, 32	.223
	Cubic	.873	1, 32	.357

*$p < .05$.

The only trend which was statistically significant using alpha level .05 was the *engineering* doctoral linear trend with $p = .02$. A graph of the marginal means for *engineering* doctoral is included in Figure 2. Also, there were select trends which approached statistical significance yet were not statistically significant using alpha level .05. These three linear trends tests were for the following: *computer sciences* master quadratic, *biomedical sciences* master linear, and *biomedical sciences* doctoral linear.

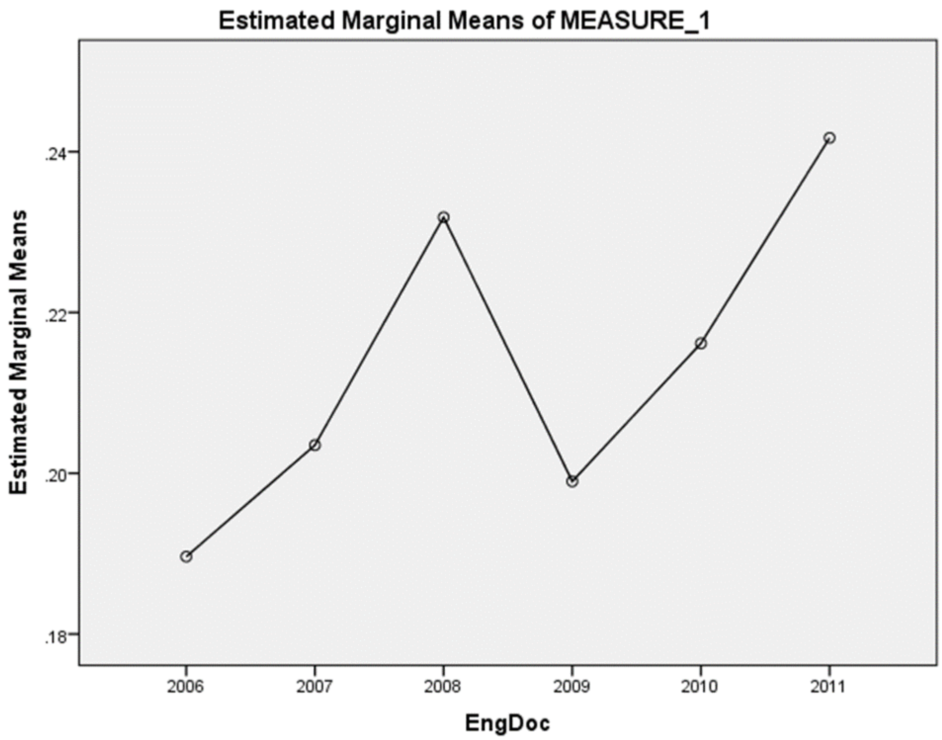

Figure 2. CIP 14 Engineering Doctoral Marginal Means Plot by Year

Figure 2 indicates there are two repeated similar slopes between the first three years of data (2006-2008) and the last three years of data (2009-2011). Given that the significance of the linear trend and the purpose of the piecewise regression trend review is to determine if there was a significant change in trend for the data, further analysis using piecewise regression was not pursued. The statistical significance of the linear trend remains a simple linear growth in female ratio of *engineering* doctoral degrees for 2006-2011. Additionally, this dependent variable had already been reviewed by the same pairs of years.

Overall, there were not distinct sets of years that were reviewed across the 10 DVs under review. There were no clear trends for when degree production changed in the context of the Great Recession. The only statistically significant result was for a linear trend only, not a piecewise trend. The scope of Figure 1 and Figure 2 is needed to provide context for the exact difference in means (see Figure 1) and marginal means (see Figure 2).

Research Question Six

What institutional factors can be indicators of female graduate STEM degree attainment for academic years 2005-2010? The purpose of question six was to determine what institutional level factors could be used to indicate female's graduate degree production by degree level and CIP field for the ten dependent variables under review for academic years 2005-2010. Based on findings from the literature review, there were seven independent variables chosen. These seven independent variables were as follows: ratio of female graduate students, ratio of female undergraduate students, ratio of female graduate assistants, ratio of female faculty, ratio of female administrators, enrollment, and research expenditures.

For a simple case processing summary of the data used for research question six, please see Table 8. The first step in attempting to answer this question was to choose an appropriate regression approach. Ordinary Least Squares (OLS) regression was chosen because all variables were being measured on a ratio scale of measurement. The assumptions for OLS regression include the following: interval/ratio scale of measurement, linear relationship between dependent and independent variables, homoscedasticity, normal distribution of dependent variable, and low multicollinearity (Tabachnick & Fidell, 2007).

The assumption for linear relationships between dependent and independent variables was checked via a scatterplot of the ten dependent variables with each independent variable. Initial review of data revealed either a linear relationship or no relationship between each independent variable and the dependent variable. Scatterplot relationships slightly differed based upon the dependent variable under review. The scatterplot for the relationship of research expenditures to each of the ten dependent variables was consistently positively skewed, perhaps due to the larger amount of low research expenditures. A log transformation of research expenditures was performed and the scatterplot of the log transformed research expenditures independent variable with each dependent variable was reviewed to ensure the assumption for linearity was met. Scatter plots of all independent variables with dependent variables are contained in Appendix I.

The second assumption was for homoscedasticity. Homoscedasticity attempts to address the consistency of the range of variance for the dependent variables. In order to address the assumption for homoscedasticity, the dependent variable standardized predicted values and standardized residual values were presented using a scatterplot. Each scatterplot had a line of best fit. This line of best fit was meant to indicate whether or not the variance changed over time. For all ten of the dependent variables, there was a line of best fit that was a simple horizontal line through the data, indicating there was not a change in variance. The assumption for homoscedasticity was met. A scatterplot for each of the ten dependent variables in contained in Appendix I.

The third assumption was the assumption for normality of the dependent variable. Simple histograms with normal distribution lines of best fit were used to review the dependent variables for normality. Nine of the ten dependent variables were normally distributed. One of the dependent variables did not display a normal distribution, Computer Sciences doctoral, and was transformed using a log transformation. Histograms for each of the dependent variables are displayed with normal distribution lines of best fit in Appendix I.

The fourth assumption was for absence of multicollinearity. Checking the assumptions is an attempt to ensure the independent variables are not too highly correlated. There are numerous acceptable cutoff points for multicollinearity using a variance inflation factor (VIF). While the most desirable cutoff point is 1.0, slight deviations to this cutoff point were deemed acceptable . Given the focus of the study emphasizes predictive ability and not explanatory ability, multicollinearity is not as integral an issue for predictive models (Tabachnick & Fidell, 2007).

Reviewing the data revealed slightly increased VIF among select independent variables. The independent variable which consistently displayed the highest levels of VIF was ratio of graduate female students. The VIF between enrollment and ratio of graduate female students was 3.148, and the VIF for the log transformed *research expenditures* was 3.142. While the VIF for both of these factors was above 1.0, the independent variable ratio of female graduate students was left in the analysis. The VIF was not high enough to be removed, the levels were deemed tolerable. Multicollinearity was met by a review of the variance inflation factors. A complete list of VIF values is contained in Appendix I, Table I1.

Given that the dataset met the assumptions for OLS regression, the analysis proceeded. The best possible subsets feature was used in SPSS to determine which independent variables were significant predictors for each of the ten dependent variables. Ten separate OLS regression analyses were run in the SPSS best possible subset feature through the Regression and Automatic Linear Modeling. Results for each of the significant independent variables are contained in Table 28 through Table 32. The independent variables that were used the most were enrollment, ratio of graduate female students, and ratio of undergraduate female students. Ratio of female faculty was not used at all, and ratio of female graduate assistants was only used for the CIP field 26 *biomedical sciences* at both the master's and doctoral degree levels.

Once the significant predictor variables for each of the 10 best possible subset analysis was completed in SPSS, the predictor variables were placed into a linear regression equation in SPSS. Given that the independent variables had already been chosen via SPSS all possible subset analysis, the independent variables were directly entered into the OLS regression equation at once. In order to review the data for statistical significance, an alpha level of .05 was used. Also, the ratio was compared to an absolute value change from zero was used.

Table 28 through Table 32 summarize the *F* statistic from the ANOVA used to analyze the regression equation along with the significance level for the ANOVA. An initial review of the data revealed statistically significant findings according to the difference from zero as found through a significant ANOVA. Since the purpose of this approach is to find institutional predictors of graduate female's degree attainment, the emphasis of the results is placed on the predictive quality, *R*. The CIP field with the highest R value was *computer science* doctoral, and the CIP field with the lowest *R* value was Physical Sciences doctoral.

The ability to explain variation in the dependent variable (R^2 and adjusted R^2) is not emphasized as much as the predictive quality of *R*. The only adjusted R^2 value with practical value is CIP field *computer science* doctoral (adjusted R^2 = .235) or even master's (adjusted R^2 = .155). The lowest variance explained by the independent variables used included Biological and Biomedical Sciences at both degree levels, as well as *physical science* for both degree levels.

Statistical significance was only found for select independent variables contributing to the model. The standardized beta weight values are included in the Table 28 through Table 32 with master's degrees in the left sector and doctoral degrees in the right sector for each CIP code. Statistically significant values are denoted with an asterisk.

Enrollment consistently resulted in a negative beta weight. Ratio of female undergraduate students was a negative beta weight for two out of the three occasions this beta weight was statistically significant. There were also several occasions when enrollment as well as ratio of female undergraduate students were significant predictor variables in the all possible subsets analysis, yet did not achieve statistically significant beta weight values in the final regression analysis. Ratio of female faculty did not contribute any significant beta weights at either degree level. Ratio of female graduate assistants was only significant for *biological* and *biomedical sciences,* doctoral. Overall these beta weights are low, which is consistent with the overall low predictive and explanatory approach of the independent variables used in this study, as shown through the *R* values in Table 28 through Table 32.

In addition to the beta weight values presented in Table 28 through 32, the degrees of freedom and *t* values are shown as well. All beta weights, statistically significant and non-significant are presented in Table 28 through Table 32. The significance level was $p < .05$.

Table 28

Research Question Six OLS Regression Summary Table for 11 Computer Sciences, 2006-2011

Master's				Doctoral			
R	.402			R	.517		
R^2	.162			R^2	.267		
Adjusted R^2	.155			Adjusted R^2	.235		
F (*df*)	23.522*	4, 487		F (*df*)	8.420*	5, 174	
Independent Variables	*b**,	*t*	*df*	Independent Variables	*b**,	*t*	*df*
Ratio F Grad St.	.455*	6.869	487	Ratio F Grad St.	.407*	4.318	174
Ratio F Ugrad St.	-.129	-1.954	487	Ratio F Ugrad St.	-.160	-1.542	174
Enrollment	-.105*	-2.380	487	Ratio F Adm.	-.162*	-2.078	174
Research Expenditures	-.074	-1.687	487	Enrollment	-.316*	-4.499	174
				Research Expenditures	-.102	-1.470	174

*$p < .05$.

Table 29

Research Question Six OLS Regression Summary Table for 14 Engineering, 2006-2011

Master's				Doctoral			
R	.348			R	.332		
R^2	.121			R^2	.110		
Adjusted R^2	.112			Adjusted R^2	.102		
F (*df*)	13.630*	4, 395		F (*df*)	13.346*	3, 324	
Independent Variables	*b**,	*t*	*df*	Independent Variables	*b**,	*t*	*df*
Ratio F Adm.	.202*	4.186	395	Enrollment	-.235*	-4.305	324
Research Expenditures	-.113*	-2.376	395	Research Expenditures	-.188*	-3.474	324
Ratio F Grad St.	.190*	2.702	395	Ratio F Ugrad St.	.118*	2.204	324
Ratio F Ugrad St.	.046	.650	395				

*$p < .05$.

Table 30

Research Question Six OLS Regression Summary Table for 26 Biomedical Sciences, 2006-2011

Master's				Doctoral			
R	.204			R	.214		
R^2	.041			R^2	.046		
Adjusted R^2	.035			Adjusted R^2	.032		
F (*df*)	6.649*	3, 461		F (*df*)	3.318*	5, 346	
Independent Variables	*b**,	*t*	*df*	Independent Variables	*b**,	*t*	*df*
Ratio F Grad St.	.201*	3.612	461	Ratio F Ugrad St.	-.235*	-3.232	346
Ratio F Adm	.077	1.598	461	Ratio F GA	.151*	2.485	346
Ratio F GA	-.090	-1.655	461	Enrollment	-.111	-1.885	346
				Ratio F Adm.	.114	1.830	346
				Research Expenditures	-.062	-1.121	346

*$p < .05$

Table 31

Research Question Six OLS Regression Summary Table for 27 Math, 2006-2011

Master's				Doctoral			
R	.337			R	.307		
R^2	.114			R^2	.094		
Adjusted R^2	.108			Adjusted R^2	.082		
F (*df*)	19.686*	3, 461		F (*df*)	7.660*	3, 221	
Independent Variables	*b**,	*t*	*df*	Independent Variables	*b**,	*t*	*df*
Ratio F Grad St.	.462*	6.631	461	Ratio F Grad St.	.162*	2.492	221
Ratio F Ugrad St.	-.254*	-3.706	461	Ratio F Adm	-.183*	-2.791	221
Enrollment	-.068	-1.506	461	Enrollment	-.198*	-3.051	221

*$p < .05$.

Table 32

Research Question Six OLS Regression Summary Table for 40 Physical Sciences 2006-2011

Master's				Doctoral			
R	.235			R	.143		
R^2	.055			R^2	.020		
Adjusted R^2	.050			Adjusted R^2	.015		
F (*df*)	9.511*	3, 486		F (*df*)	3.372*	2, 357	
Independent Variables	*b**,	*t*	*df*	Independent Variables	*b**,	*t*	*df*
Enrollment	-.091*	-2.047	486	Enrollment	-.118*	-2.246	357
Ratio F Ugrad St.	.109	1.471	486	Ratio F Grad St.	.077	1.461	357
Ratio F Grad St.	.110	1.476	486				

* $p < .05$.

Overall, results do not indicate good predictive ability using the variables under review. Chapter V will continue to discuss the statistical significance versus practical significance of findings. Additionally, explanations and insights will be addressed in Chapter V regarding the results in Chapter IV. Implications for future research and policy relevance will be addressed as well.

CHAPTER V:

CONCLUSION

The purpose of this study was to review the graduate gender divide in STEM fields in the context of the recent Great Recession. Part of this review included analyzing degree production to see if there were significant changes over the years. A secondary goal was to determine if select institutional characteristics could serve as indicators of degree production for female graduate degree attainment in select STEM fields at the two-digit CIP level. Additional interest was placed in select aspects of institutional type, such as land-grant status or Academic Common Market participation in order to determine the relationships of degree attainment by gender according to these select factors.

This chapter will summarize and interpret the findings from Chapter IV. The chapter starts by a question-by-question interpretation of the findings for each of the six research questions. Afterwards, a discussion of future research efforts as well as policy-related initiatives will be presented.

Research Question One

Is the gender divide greater among master's degrees compared to doctoral degrees for STEM? The framework for this study uses a pipeline model in which the level of female participation in the STEM pipeline dissipates as the education level increases. While graduate studies have not been examined in the same extent as undergraduate or community colleges, seeking differentiation between the two graduate degree levels in this study provided insight into the pipeline framework at the graduate level. The two graduate degree levels were master's and doctoral. Two of the original CIP fields (CIP 15 Engineering Technologies, and CIP 41 Science Technologies) did not provide enough data to review. This is perhaps because these fields are emphasized more at the community college level. Additionally, while there are select fields emphasized at the graduate level such as Engineering Technologies, programs in these fields are so few that there was insufficient data for a study such as this one, which took a broad perspective.

Four of the five CIP fields reviewed revealed statistically significant differences by graduate degree level. The only CIP field which did not display a significantly different result by graduate degree level was *engineering*. Additionally, while statistical significance was found for *computer sciences*, the practical difference was not. This is shown by using the mean values of the master's (M= .2775) compared to the doctoral (M=.2584), a difference of .019%. For the remaining three CIP fields of Biomed, Math and Physical Sciences, statistical significance was found, and there was a difference in female graduate degree production for master's versus doctoral degrees.

Combined with the summary of zero removals in Table 6, there is a ranked order of the five CIP fields reviewed. However, the trend in Table 6 by degree level reveals similar rankings of the number of zero values removed by CIP field for both masters and doctoral degrees. This similar zero removal by degree level may be a related indicator that while there are statistically significant difference by degree level, the overall strength of this difference is not large. There is also the possibility that fields follow the same trend despite degree level.

While there is a statistically significant difference in female degree production by degree level, there is still agreement by CIP field as to the extent to which this degree level difference is distributed. Differences by degree level may not display strong practical significance. This is especially true for the previously mentioned *computer and information sciences and support services*. For the three CIP fields which displayed a significance level of $p < .001$, (Table 11), there was approximately 8% to 9% difference in means between master's and doctoral degrees.

Additionally, the pipeline paradigm regarding difference in degree level in the context of the recession was reviewed by degree level was warranted. There may have been select differences in pursuit of master's and doctoral degrees. For master's degrees, there was potentially shorter time to degree and a potential terminal nature of select master's STEM degrees, such as *engineering*. The lack of statistically significant difference by degree level for *engineering* is the most difficult to interpret. *Engineering* is the one CIP field which can be virtually no debate as to the status as a STEM field. Surprisingly, the means in Table 10 of master's versus doctoral degrees for *engineering* are the lowest among the five CIP fields reviewed. This provides insight into a demand for females through the STEM graduate pipeline by CIP field, specifically Engineering.

The highest means came from *biological* and *biomedical sciences*. The graduate level degree production for *biological* and *biomedical sciences* revealed the single CIP field where the ratio of graduate degree production for females was higher than that for males. *Biological* and *biomedical sciences* also displayed the lowest amount of zero removals from the five CIP fields. Overall, these findings for *biological* and *biomedical sciences* are consistent with the movement of females through the STEM pipeline in which *biology* fields are emphasized. Perhaps additional biology-related fields in medical and health professions may provide more insight into this greater STEM review.

The difference in the number of values available for review was also larger for all master's degrees compared to doctoral degrees (see Table 8 and Table 10). This difference in availability of data to review provides insight into the pipeline framework, providing more support for a difference in review of degree production by degree level. Given that there was a six year time frame under review, the time to degree left room for a single doctoral degree, and given a traditional time to degree of two years, there was room for at most three master's degrees within the time frame under review. For a full time student, there were potentially three full two year periods within the time frame under review. Difference in degree production could have been revealed within years. Given the statistical significance of the difference by degree level and the difference in time to degree, review by degree level for the remaining questions in the study was warranted.

Acknowledgement must also be given to the individual choice to pursue graduate studies in light of the Great Recession and the economic context characteristic of the Great Recession. There is the possibility that select STEM fields may be promoted more at the master's level compared to the doctoral level. This may especially be true with Engineering and Computer Sciences, as both of these CIP fields may present select economic value at the master's level which may be provide more of a reward than a doctoral degree in these CIP fields. This presents another facet of the pipeline paradigm at the graduate level regarding the gender divide and higher education. If more females choose to enter a master's degree, or are not promoted to enter doctoral degrees for STEM fields, then this can provide further insight into the gender divide in STEM fields at the graduate level.

There is also the possibility with the new collaborative efforts between government, business, and education (Burke & McNeill, 2011) for select partners within this three-part system to effect the gender divide. For example, if there is a framework where education exists to provide workers for business and government, specifically with advanced graduate training, there is room for debate on what constitutes advanced study. One of the differences may include the master's versus the doctoral degrees, and the potential practitioner versus scholarly attributes of the master's and doctoral degrees, respectively. Government, business, and education may dispute the merits of advanced graduate degrees, as well as the qualifications each degree may provide. If business considers master's degrees to be sufficient, then business may promote females in STEM fields at the master's level. This promotion of females for master's degrees may influence the dynamics of females in STEM fields at the graduate level, specifically the progression through the pipeline at the master's and doctoral degree levels.

The Great Recession also provided unique economic context for individuals choosing to pursue degrees as well as the financial standing of businesses. A business may seek a master's candidate given financial standing or pay compared to a doctoral candidate. Also promotion of the master's degree for business may present a more attainable financial investment. Business may not seek to lose workers, females specifically, to the pursuit of a degree which takes longer to obtain, such as the doctoral, or which may cost more. There is the potential for tuition reimbursement to be less for masters. Overall, the three entities of government, education and business can end up promoting self-interest over a collaborative approach to increasing STEM degree production.

This can be especially true for females and STEM given the historical paucity of degrees observed for females in STEM fields (Huang et al., 2000). There is also a hint of an indictment of higher education regarding the ratios of females in STEM fields, specifically at the doctoral level. Given the results of this study reveal lower rates of degree attainment at the doctoral level compared to master's for select CIP fields, there is the room for debate as to the manner in which higher education as an industry will seek to promote STEM field degree production, specifically for females. With the historically low rates of females in STEM (Huang et al., 2000), issues of cultural capital, access, and choice to pursue advanced degrees, specifically doctoral, in higher education come to the forefront. Using the previously mentioned scenario of business promoting practitioner master's degrees over doctoral, there is a potential balancing of the promotion of female doctoral students in STEM. If business continued to promote master's level without an equal balance of doctoral degrees from higher education, the master's degree can be promoted at the cost of the doctoral degree for females in STEM fields.

This also presents a commentary on choice. Given the historically low rates of females in STEM (Huang et al., 2000) the degree to which a doctoral degree may seem like a realistic "choice" compared to a master's may come into play. The pipeline paradigm presented throughout this study also provides insight into the manner in which females in STEM fields may seek to pursue graduate STEM fields. Prior research has indicated female students who leave STEM fields in the first year of undergraduate studies tend to change degrees to more helping oriented professions, including the following: psychology, speech therapy, physical therapy, kinesiology, and nursing, among others (Cole & Dong, 2013). There is the possibility that a similar pattern may exist when expanding this pattern to the transition from undergraduate to graduate studies. Female students who obtain a STEM bachelors degree may transfer to one of the previously mentioned related helping professions at the graduate level in place of a traditional STEM field. Research into institutions which offer and promote these helping graduate degrees may provide more insight into this trend. Reviewing such institutions on an institutional level by review of institutional characteristics is consistent with the approach of the current study, and may provide insight for future research. The Great Recession provided rich historical context to review student choice to pursue STEM degrees and related institutional characteristics to STEM degree pursuit for females in light of the unique economic circumstances.

Research Question Two

Are there differences in graduate degree production for land-grant vs. non land-grant institutions? The purpose of this question was to review female graduate degree production by a select institutional characteristic, land-grant status. The rationale behind this question was the manner in which land-grant institutions have been historically promoted as emphasizing equality (Eddy, 1957; Ross, 1942) as well as applied (STEM) fields (Thelin, 2004). These elements were addressed at length in the literature review.

Unfortunately, the amount of missing data from non-land-grant institutions was extremely high. This may have been due to the small sample size, only 76 institutions, and parameters for institutional type, or even simply which institutions were selected in the random sample of 76 institutions. The parameters for institutional type included doctoral-granting institutions, and institutions which were primarily baccalaureate or above in IPEDS (National Center for Education Statistics, 2012b). This left room for institutions to be selected which may have offered select types of doctoral degrees which did not include STEM fields.

An alternative approach would have been to review all 723 institutions which offered doctoral degrees and were primarily doctorate or above in IPEDS and only reviewed institutions which reported data, or at least data which was more than a zero value at a two decimal points (0.00). Having institutions in the population which provide greater diversity of institutional type can provide insight into institutional types or characteristics which may not be as relevant or influential in promoting female graduate degree attainment in STEM fields. This might be especially relevant for policy initiatives. Having a broader set of institutional types in the selection process can provide insight into STEM degree attainment, even if degree production is not noted for select institutional types.

Comparing the random sample of 76 institutions to the sample of 63 land-grant institutions indicated there was more data available for every dependent variable for land-grant institutions compared to non-land-grant institutions. The extent of this divide in reported data values is shown in Table E1. Aside from master's degrees in *computer and information sciences and support services*, there is often two or three times the amount of data reported for land-grant institutions compared to non-land-grant institutions. A more thorough review of institutional factors between these two institutional types is needed in order to learn about institutional differences or potential factors not considered as part of this study. For instance, are land-grant institutions with values being reviewed synonymous with high enrollment universities compared to non-land-grant institutions which may be low-enrollment universities?

There were five statistically significant differences comparing land-grant status vs. non-land-grant status. The results of the comparison revealed statistically significant differences for only one master's level CIP, *computer and information sciences and support services*. The remaining four statistically significant differences were all at the doctoral level. The statistically significant differences did not occur for *mathematics* and *statistics*. For all five dependent variables which displayed statistically significant differences, the means (see Table 13) (and corresponding mean ranks in Table 15) were all higher for non-land-grant universities. The simple interpretation is that non-land-grant institutions have higher graduate degree production ratios for female graduate students in the CIP fields under review for the allotted time frame. However, given the stark difference in reported values and remaining institutional characteristics which may influence this ratio, caution is advised in making this interpretation.

Research Question Three

What are the gender differences within each STEM field by two-digit CIP code for academic years 2005-2010? The purpose of this question was to determine if there was a significant difference by year for all six years under review. The goal was to determine if there were significant differences in the context of the Great Recession for the five CIP fields under review at both the master's and doctoral level. A repeated measures ANOVA approach was taken for this approach, given that the intent was to find differences by year within each dependent variable.

The repeated measures ANOVA resulted in no statistically significant findings. For the non-parametric Friedman's Test, only *biological and biomedical sciences* for master's degrees resulted in a statistically significant finding. The follow-up post-hoc comparison by year for the significant Friedman's Test for *biological and biomedical sciences* master's degrees using Wilcoxon Rank Sum procedure also resulted in no statistically significant findings. The lack of statistically significant findings in the post-hoc analysis is a result of the Bonferroni adjustment which greatly increased the needed significance value. The original p value from the Friedman's Test was also p = .05, so the statistically significance was the highest value possible, as shown in Table 18.

There were several post-hoc analyses which came close to statistically significant findings. Using Table 21 which indicates values from post-hoc comparisons, as well as Table 22 which highlights descriptive statistics for dependent variable *biological and biomedical sciences* master's degrees, there is insight which can be gained from the results which approached statistical significance. There were six values which approached statistical significance as shown in the post-hoc analysis Table 21. They were comparing 2006 vs. 2011, 2006 vs. 2009, 2007 vs.

2011, 2007 vs. 2009, 2008 vs. 2011, and 2008 vs. 2009. Combined with Table 22 which shows means and medians for this dependent variable, consistently 2009 and 2011 values are lower than the prior years in the comparisons. There is a small decrease in the ratio of degree production for female graduate students in *biological and biomedical sciences* when making these pairwise comparisons. Every earlier year has a higher value than every later year.

There are three insights which can be drawn from this data. The first insight is the manner in which the pairwise comparisons occur across years. The formal dates of the recession are from December 2007 through June 2009 (AAUP, 2011). Using a traditional two-year model or even three for obtaining a master's degree in *biological and biomedical sciences*, there is the possibility that, after the Great Recession hit, there may have been a corresponding enrollment change within two to four years. Perhaps this is the reason why there is a corresponding decrease in the ratios for 2009 and 2011, as well as slightly lower means for the last three years compared to the first three years.

The second insight is the significance of the CIP field being reviewed. Given female degrees in the dependent variable *biological and biomedical sciences* were higher than half, .50, there is the possibility that more males started to get degrees in *biological and biomedical sciences* master for 2009 and 2011. This insight fits with the idea that the recession hit males more than females (Kochhar, 2011). Within the academic setting, one of the reactions would be for males to seek degrees where there is traditionally a greater rate of females in the field. Some of these fields during the post-recession could be fields within *biological and biomedical sciences*.

The third insight is that males potentially began to seek degrees which were in demand during the recession, and which traditionally revealed greater degree production for females in the earlier years under review. This fits with data showing that health and education were not as negatively impacted economic sectors compared to construction (Kochhar, 2011). Nursing is one possibility. Nursing is contained in Health Professions and Related Programs (National Center for Education Statistics, 2012a). There is room for future research which seeks to promote expansion of the STEM concept to STEMM, or Science, Technology, Engineering, Math, and Medical. Overall this context is part of the larger revisiting of the idea of how STEM fields are defined. In summation, this is shown through the lower means and medians for the later years in the pairwise comparisons in Table 21 and Table 22.

Research Question Four

Are there differences in graduate STEM degree production comparing the Academic Common Market vs. non-ACM institutions? The purpose behind this question was to address geography and a corresponding regional entity. Geography has been highlighted in prior research which focused on engineering degree production, specifically the southeastern United States. Also, the Academic Common Market was developed in the 1970s during the context of a recession.

Preliminary data review, as shown in Table 23, revealed there were more non-ACM institutions than ACM institutions. Additionally, aside from *engineering* doctorates, all mean ranks for non-ACM institutions were higher for each of the remaining nine dependent variables compared to ACM institutions (see Table 26). There were three statistically significant results (see Table 25) for the following master's CIP codes: *computer sciences*, *biological* and *biomedical sciences*, and *mathematics* and *statistics*. For the three statistically significant differences, pairwise post-hoc comparisons were not made due to the large inequality between sample sizes.

For the three statistically significant findings, results indicate that non-ACM institutions display higher degree production ratios for three out of the 10 dependent variables. For these three CIP codes, there were statistically significant differences. Again, given the difference in sample size between the two groups being compared, caution is promoted when interpreting statistically significant differences. Overall, a greater depth of review for geography by CIP code is warranted to greater refine these statistically significant findings in order to provide insight into why these differences were found. Being able to come to a greater understanding of different institutional characteristics (i.e., level of urbanization) related to degree production may provide further insight with these statistically significant findings. Perhaps a more in-depth review of the CIP level code and corresponding jobs which may be in demand which align with select four or six-digit CIP codes by geography also could provide more insight.

For the remaining seven dependent variables, there was no statistical difference. Aside from the previously touched upon higher mean ranks for non-ACM institutions, there were no discernible trends for the data under review when considering all 10 dependent variables. Geography did not seem to have an influence on degree production for female graduate students in the curricular areas under review for this time frame. In general, geography does not appear to be of critical importance moving forward when reviewing STEM degrees by CIP code. At a minimum, future efforts need to take a more dynamic approach to reviewing geography in place of a simple comparison between two regions.

Research Question Five

Are there trends in graduate degree attainment by gender across academic years 2005-2010? The purpose of this question was to discern trends within groups of years within or across CIP codes. Research question five is a continuation of research question three which sought to determine differences within CIP codes by comparing years. Given statistically significant results were not found from research question three, post-hoc pairwise comparisons to provide a way to analyze trends was not conducted. This also served as an indicator for the difficulty in reviewing the data of piecewise trends regarding finding of statistically significant results. There was a commonality of lack of statistically significant findings relative to year. Without statistically significant differences between years, there may not be statistically significant differences in groups of years. Histograms of marginal means for each dependent variable by year can be found in Appendix H.

The impetus to review the data for piecewise regression revolved around the significant context of the Great Recession. Two years prior to the Great Recession and two years after the Great Recession were included for data review. This allowed for a comparable two-year context immediately before and after the recession. Also, the latest time period for data in IPEDS at the time of this dissertation was academic year 2010-2011. Using the 2010-2011 year allowed for the most recent year of data available in IPEDS which was final, and avoided any complications with preliminary data. However, there is the limitation that additional post-recovery data may be available to provide insight into the continuing manner in which trends during or immediately after the recession continue to influence ratio of graduate STEM degree attainment for females.

This is especially true in light of the fact that higher education as an industry may lag behind the economy at large. Simply because the accepted period of the Great Recession, December 2007-June 2009, came to a close does not mean the financial impact on higher education has stopped. This includes an immediate financial impact, as well as the interaction between higher education and the economy, changes in ways students seek degrees, and which degrees are in demand. Policies which serve as indicators of degrees in demand are especially relevant post-recession.

Given this impetus, data was reviewed for select trends which may have revolved around context of the Great Recession. These included any combinations of trends where there was a significant shift in the dependent variable. Examples included growth followed by plateau, or plateau followed by growth or decline, etc.

The visual plotting of means was done to review the data for such trends. The only plot (see Figure 1) displaying a potential trend revealed no correlation between the dependent variable and years for the period which appeared to reveal growth. Given the scope of the histograms used to display data was so precise (see Appendix H), a statistical analysis of trends in the data proceeded. Review of linear, cubic, and quadratic trends revealed only one statistically significant finding for linear growth. However, given that this was the dependent variable already reviewed in the prior analysis for a potential growth trend; the analysis was redundant. The same two sets of linear growth trends (see Figure 1 and Figure 2) in the statistical review of the estimated marginal means were the same means of the initial scatterplot of data which lead to the analysis of the dependent variable by groups of years.

The analyses were more a commentary on means versus marginal means when determining linear growth. The weighted growth of the marginal means relative to sample size within years indicated a linear trend for *engineering* doctoral. This was only a linear trend with statistical significance. There was no significance in sets of years.

The significance levels of these statistical trends which approached significance at the .05 alpha level are contained in Table 27. *Biological* and *biomedical sciences* master's level approached a linear trend with p = .082, *biological* and *biomedical sciences* doctoral level approached a quadratic trend with p = .088, and *computer and information sciences* and *support* *services* approached a quadratic trend with $p = .071$. The data for the *biological* and *biomedical sciences* master's level seem to replicate the data which approached statistically significant findings by year for research question three. In both of these questions there was similarity in how the dependent variable approached statistically significant trends, yet significance was not observed at the .05 alpha level. Data for *computer and information sciences* and *support services* master's indicated growth followed by decline, although significance was not found. Additional monitoring of degree production trends post-recession may provide insight given the lag which may be observed between higher education and the economy as a whole.

Research Question Six

What institutional factors can be indicators of female graduate STEM degree attainment for academic years 2005-2010? The purpose of this question was to learn if there were institutional characteristics which could serve as indicators for female graduate STEM degree attainment for the chosen CIP fields for the time frame under review. Given that STEM fields are being emphasized, combined with an interest in facilitating female progression through the pipeline in STEM fields, there is a renewed interest on a broad scale in articulating factors which facilitate degree production. Reviewing institutional characteristics which may serve as these factors provides one way of approaching STEM degree production in such a broad-based manner.

There was variation in which factors were significant for select CIP fields, as well as the degree level of select CIP fields. Overall, the beta weights and significance values were low for the statistically significant predictions. Give that emphasis was on predictive quality of the OLS regression employed, there were still models which came up with a small amount of predictive ability. The only model which had a noteworthy degree of predictive ability was for the *computer and information sciences* and *support services* doctorates, as shown in Table 28 through Table 32.

The ranked order of predictive values by CIP code (see Table 28 through Table 32) for the *R* value was the opposite of the ranked order when CIP fields were ranked by CIP field according to the amount of zeroes removed. While there was the lowest number of zeroes removed for *biological* and *biomedical sciences* and *physical sciences*, these two CIP fields, at both degree levels, were the dependent variables with the four lowest *R* predictive values. *biological* and *biomedical sciences* was the only dependent variable with a higher number of females than males. *Computer and information sciences* and *support services* for both degree levels revealed the highest predictive ability based on *R* values, for master's $R = .402$, and for doctoral, $R = .517$.

The amount of available data for the *computer and information sciences* and *support services* is in contrast to *biological* and *biomedical sciences* and *physical sciences,* which had a greater amount of data (beyond minimal values) available for review. Perhaps this predictive ability is due to a more sensitive critical mass ratio. For *computer and information sciences* and *support services*, higher predictive and explanatory ability of the regression equation factors could be linked to the low rates of females in *computer and information sciences* and *support services* in general. Once a critical mass threshold is met, then the gender composition of a field may not be as important. However, when the ratios of females within a field are lower, then the ratios of female in the field may provide a greater influence. Perhaps this is why the institutional characteristics are more sensitive for *computer and information sciences* and *support services* compared to *biological* and *biomedical sciences*.

The higher numbers of female in *biological* and *biomedical sciences* also results in outside factors becoming more salient when predicting female graduate degree attainment simply due to the fact that females already obtain the majority of degrees. Greater variation within the female population obtaining degrees in *biological* and *biomedical sciences* is likely. Additional factors which can seek to provide insight into the degree production ratio for *biological* and *biomedical sciences* within the female population may provide insight. Aspects of the degree which are focused more on the field of *biological* and *biomedical sciences* in place of the gender divide may be more beneficial to review as well in light of the greater ratio of females in *biological* and *biomedical sciences*. Factors influence graduation for *biological* and *biomedical sciences* aside from gender.

This explanation also fits within the greater field of predictive analytics. Predictive analytics is a process of using historical data to forecast future behavior. This includes retention and enrollment management (Barber, 2013). Levels of review for predictive analytics include discipline, college, university, or even university system(s).

Given the trends in the emphasis on STEM studies and the focus of the studies on the graduate level, there is a new emphasis for predictive analytics to be used in order to come to a better understanding of institutional level predictors which can be used to try and forecast future trends in graduate STEM degree production. This is especially relevant for graduate enrollment offices at institutions which emphasize STEM fields.

There was not a clear cut trend in the regression analysis by degree level. CIP field, not degree level, influenced regression equation predictive ability. The similar trends in CIP rankings using the zero removal Table 6 and data from Table 28 through Table 32 reveal consistent trends in which CIP fields are emphasized. There was the most data for *biological* and *biomedical sciences* and *physical sciences*, while *engineering* was in the middle (ranked three out of five), and *mathematics* and *statistics* and *computer and information sciences and support services* had the least amount of data reported. The predictive *R* values were essentially reversed.

Perhaps there is prevalence for type of field by concrete approach within the field. *biological* and *biomedical sciences* and *physical sciences* were the most concrete fields, Engineering balanced concrete and abstract, and *mathematics* and *statistics* and *computer and information sciences and support services* were the most abstract. This trend may exist in prior education levels. Perhaps prior education levels interact with STEM fields longitudinally regarding this concrete to abstract dichotomy across gender in education. Additional research could provide insight into trends from prior education levels to the graduate level. Reinforcement from educators to students on abstract thinking skills versus concrete throughout the STEM pipeline provides a means to begin exploring this idea. This simply was not part the focus of this dissertation.

Focusing on the beta weights of the statistically significant values reveals commonalities regarding which institutional characteristics can be indicators of female's graduate STEM degree production in the context of the recent Great Recession. Overall, the beta weights for all of these statistically significant findings were low. Beta weights will briefly be discussed along with each independent variable. The tables consistently used for this discussion are Table 28 through Table 32.

Ratio of female graduate students was intuitively the most related to the degree production dependent variables, and there were seven occasions where this IV was statistically significant. All seven beta weights were positive. This was the most salient finding, as the context of obtaining a STEM degree may be linked to the greater context of the university setting. The most direct manner would be the student body makeup at the graduate level. Institutions with higher ratios of females in graduate studies had higher STEM female degree production ratios for the time frame under review.

Ratio of female undergraduate students also revealed significant beta weights for three DVs. However, only one of these beta weights was positive and the remaining two were negative. This presents a difference in context between undergraduate and graduate student body makeup. While the strength of the beta weights does not differ significantly, the direction of their predictive quality of their respective IVs does. Ratio of graduate female students had positive beta weights, while two of the three ratio of undergraduate female students had negative beta weights.

Enrollment continues this trend of a negative beta weight for all six of the statistically significant beta weights. Both the undergraduate and enrollment beta weights indicate a similar trend. For the university type under review, primarily baccalaureate or above, as indicated in IPEDS (National Center for Education Statistics, 2012b), undergraduate studies are more likely to be the majority of students for the universities under review. With negative beta weights, the university context as reflected in the two IVs related to enrollment and ratio of female undergraduates may not be as significantly related to the student body makeup of graduate students for the CIP fields under review. This may present a discrepancy between student body makeup at the undergraduate and graduate levels relating to ratio of females in the student body. Ratio of STEM female degree production could be more influenced by graduate student body dynamics in place of undergraduate student body dynamics or even the total university enrollment.

Perhaps there is an alternative explanation instead. Given that the DV was in ratio format, this finding is couched within the ratio context. The raw numbers of female graduates would also need to be reviewed in order to come to a better understanding of how these IVs and DVs are related. Are institutions with higher ratios of female graduates for the DVs under review overall simply smaller institutions? If a smaller institution has a lower number of overall graduates of interest, then this can certainly be the case. However, if an institutional type with higher overall enrollment has a lower ratio of female graduates with the DVs of interest, does this necessarily mean the institution with the larger enrollment does not do a better job of graduating female in the STEM pipeline? For the immediate ratio format of the DV the answer is yes.

However, if the institution with the larger enrollment graduates a significantly larger number of females, yet still a smaller ratio of females, which institution does a better job of moving females through the graduate student STEM pipeline? Which institutional type does a better job of meeting the demands of the workforce related to STEM graduates? This is a limitation of treating the dependent variable in the ratio format. While the ratio format does a better job of addressing the DV in context, there is a scope which is lost in the ratio format.

An additional aspect is student life and student culture for the undergraduate and graduate levels. Graduate culture may be very closely tied to one's degree, or at least one's discipline, and perhaps the undergraduate level disciplinary culture is not as emphasized as much. A more precise approach would have been to simply use enrollment by gender and CIP field, however, IPEDS does not offer consistent information for every year under review by enrollment, as well as all of the CIP fields of interest. Perhaps additional databases could be used to further refine the scope of the gender makeup of students at the graduate level in order to provide a more precise reflection of the dynamics between student body makeup and female degree production for the DVs of interest.

The only statistically significant beta weight for ratio of female graduate assistantships was Biological and Biomedical Sciences doctoral. This was a positive beta weight. Perhaps this DV was one of the few where there was sufficient data to allow for the IV and DV relationships to be clear. Given the additional time required for a doctorate, assistantships became more prevalent at the doctoral level rather than master's for this CIP field.

Perhaps the majority of females in *biological and biomedical sciences* at the doctoral level allowed for the assistantship value not to be "masked" when graduate assistantships are reviewed en masse. An additional limitation of IPEDS is the lack of an ability to review gender by type of graduate assistantship. Being able to review gender by type of assistantship may provide insight into gender roles by assistantship and how this divide can affect degree production. Since all assistantships were reviewed by gender combined, there was the possibility that different gender ratios by type of assistantship were masked when reviewed in aggregate. The ratio of graduate research assistantships by gender could have counterbalanced the ratio of teaching assistantships by gender.

Future research is recommended using databases which allow for this gender divide at the level of type of assistantship (research, teaching, etc.). This may be especially true with "service" assistantships (National Center for Education Statistics, 2012b). This is based on the rationale that service is akin to "helping" and there is the biased that a female graduate student may be more inclined to take a helping role than a male graduate student.

There were no statistically significant predictor variables for ratio of female faculty. This is likely due to the way in which this ratio included the full range of those with instructor duties.

Tenure and tenure-track faculty were not singled out compared to teaching professionals not involved in tenure. However, tenure status by gender may still remain a better indicator, or at least a statistically significant one, than including professionals with teaching abilities who are not involved in the tenure track in any fashion. Also, a closer level of this tenured faculty divide on the discipline level is warranted compared to simply a characteristic across an institution. This is a limitation of the chosen database, IPEDS.

Critical mass among faculty related to mentoring is still relevant. Who is actually doing the mentoring or providing the outlet for support for female students in their respective STEM graduate degree pursuits? Do faculty with tenure or faculty off the tenure track have more influence? If not faculty, then who? A greater review of the literature and future research with the changing dynamics of STEM, gender, and faculty ranks may provide more information.

Going by the data presented in this study, overall, there was no relationship between ratio of female administrators and female graduate degree production for seven of the ten DVs. Ratio of female administrators was statistically significant on three occasions. Two occasions were negative beta weights at the doctoral level with CIP fields where there seemed to be the lowest amount of data available for female obtaining degrees, *computer and information sciences and support services* and *mathematics* and *statistics*. One positive beta weight was *engineering* at the master's level. Again, ratios based on administration tied to one's discipline may provide a more precise way to detect relationship between female administrators and student makeup by gender. This may be especially true given the increasing emphasis on enrollment management, especially at the graduate level, and even parsing out enrollment trends which may occur between the master's and doctorate levels. Efforts which seek to address gender makeup for administration and faculty by field may still be warranted, simply not in the broad manner as in this study.

The final independent variable was research expenditures. The purpose of reviewing research expenditures was in order to get a basic sense of devotion to research. This is related to the assumption the STEM fields under review are research fields, specifically at the graduate level. For select institutions, even having research expenditures may have been significant within the economic context of the recession. Being able to continually invest in research could have been an indicator of dedication to and stability of research endeavors, however, this is only a tertiary commentary regarding the IV. The opposite also could be true; there was money being spent on research during the economic downturn which would normally have been lessened or nonexistent, as this would have been research money being brought into the institutions.

Research expenditures were statistically significant with *engineering* at both master's and doctoral degree levels. The beta weights were negative. With an increase in research expenditures, there was a decrease in the ratio of females receiving degrees in Engineering. For purposes of this study, research expenditures were not associated with ratio of female degree attainment by gender for 80% of the DVs, and negatively associated for 20% of the DVs.

Research and finances were purposely addressed in a broad, yet not in-depth manner due to the context and scope of this study. Future research should definitely take a more in-depth approach to reviewing research and finances, especially as related to funding for graduate assistants, and related funding mechanisms. These funding sources should be researched and reviewed with the gender divide in mind. These research expenditures and financial components are of great importance to the current study. The rationale for not taking an in-depth approach to research and finances with the current study is that taking such an in-depth approach constituted a separate study in itself.

Implications for Policy and Practice

Overall, this study is timely, given the status of education in the United States. Due to the Great Recession, education as an industry and a field has come under increased scrutiny (Obama, 2011). Given the economic context of the US during the Great Recession, it remains to be seen how the US will respond to the economic downturn via policy and practices related to education.

Part of this response is a broader question of the collaboration and interconnectedness of education with industry. This is more of a philosophical framework which must address the idea of the mission of education. Is the mission of education to provide jobs, and only to provide jobs for industry? This is a changing dynamic where industry expects education to train individuals to fill the ranks of industry slots.

Consequently, there is a point of view from which the framework where education is seen as the provider of individuals for jobs. In the context of the Great Recession, which jobs were to be emphasized was going to determine which education fields would be emphasized. STEM fields were emphasized during the Great Recession on a national scale. Perhaps this is due to the historical manner in which emphasizing STEM fields on a national level has helped spur industry in the past. Examples include the rise of the research institution after World War II, as well as the National Defense Education Act (NDEA) of 1958 (Thelin, 2004).

While this framework of learning from the past is logical, there is a new landscape among higher education institutions. Policies promoting STEM fields in the past may seek to take similar forms, differences will be due to the current climate of higher education and the economy. The role of higher education seems to be continuing a trend of private gain (Rhoades, 2006) in place of public benefits (Gildersleeve, Kuntz, Pasque, & Carducci, 2010).

While, in the past, NDEA of 1958 (Thelin, 2004) sought to find a way for federal influence to seek to promote education at all levels in the US through funding, such an effort seems unlikely in the current context. Also, the rise of the research university (Thelin, 2004) as influenced by federal funding seems to be changing as well. One prime example of this trend in lack of federal influence is the "Sequester" phenomenon (White House, 2013). While the Sequester is an ongoing phenomenon, the symbolism of the Sequester remains.

Monies for research on a national scale from federal funding are being reduced (White House, 2013). However, future budget forecasts indicate a trend towards a strategic approach to funding STEM fields. Emphasis is placed on fields of innovation in STEM and education, and there appears to be less forecasted funding for military efforts as related to STEM (Office of Science and Technology Policy, 2013). Both the Sequester (White House, 2013) and the budget release (Office of Science and Technology Policy, 2013) reveal a change in which STEM fields or how STEM fields may be emphasized via funding on a national scale. Only time will tell how this process unfolds. This is one of the drawbacks to conducting a study which is so current-policy is developing on a daily basis in response to STEM fields on a national level.

In reviewing the language of the 2014 budget for science and technology (Office of Science and Technology Policy, 2013), STEM fields still seem to be emphasized nationally. However, there is the possibility that there is a changing dynamic regarding the traditional manner in which university research was perhaps tied to the military (Thelin, 2004). The result is a new outlook on how STEM fields will be emphasized on a national level, and perhaps this will echo a change in how universities interact with traditional partnerships, such as the military and industry as well. The manner in which policy related to STEM fields at the graduate levels between government, industry and education may need to be articulated precisely in order to move forward with finding ways to build on collaboration between the respective industries. For now, there seems to be an evolving dynamic which is too malleable on a day-to-day basis to be communicated effectively. However, providing guidelines for collaboration among these industries is key, as communicating and articulating the desired manner in which STEM fields are to be emphasized on a national level may facilitate providing a stable context in which STEM field degree attainment can be achieved for all STEM students.

There is also the manner in which STEM students may be recruited and reinforced to proceed through the STEM pipeline. This study shows a stark contrast in the ratio of degree attainment between males and females for four of the five CIP fields reviewed, with the one exception in Biological and Biomedical Sciences. Perhaps study of Biological and Biomedical Sciences and the preceding educational level pipelines which feed into Biological and Biomedical Sciences can provide insight into ways in which reinforcing female in other STEM fields, specifically through the graduate levels. This can be a simple, yet very effective way to increase STEM degree production as is being articulated nationally, while emphasizing a gender which does not appear to have progressed into the graduate pipeline for the four remaining CIP fields under review. Differences by master's and doctoral levels can be integral, specifically as related to terminal degree status of select STEM fields.

The manner in which such policies seek to reinforce ways of promoting females in graduate studies needs to be on a broad scale using broad-based data. Such a broad-based approach fits the national level policy agenda being promoted to strategically emphasize STEM fields (Office of Science and Technology Policy, 2013). One manner in which to achieve such broad-based policies is to articulate policies across institutions. While there are strengths to be had in allowing institutions to develop their own policies regarding the reinforcement of females in the STEM pipeline, or a balance of national policy implemented on an institutional level, leaving institutions to decide the best manner in which to provide such reinforcement seems to be the status quo. Unfortunately, the status quo underrepresents females in STEM fields as reviewed in this study. A broader, more articulate approach is warranted for policy makers.

Implications for Research and Practice

Initially, part of the practice component of research endeavors in this economic context concerns the relationship between education and industry. The dynamic, or disconnect, between degree production and job demands in the continual "recovery" phase from the formal Great Recession will be key. Practitioners who seek to facilitate degree production in STEM fields, specifically degree production for females, may continue to face similar challenges faced in the past. The exact dynamic of the strategic emphasis of STEM fields on a national level which unfolds daily will provide more light on the manner in which practitioners will be important when seeking to increase degree production in STEM fields, specifically for females.

Research at the institutional level needs to continue. This allows for broad-based approaches which can provide data to support and direct policy. Also, there seems to be a lack of research which focuses on institutional type. A broader review of institutional type can be reviewed at the graduate level in order to arrive at a place where there is better data regarding female in STEM fields. One manner in which more STEM field specific data can be reviewed is by using databases which seek to go beyond information IPEDS provides. One such database is the NSF-NIH Survey of Graduate Students and Postdoctorates in Science and Engineering (NSF & NIH, 2013).

Additionally, seeking to refine differences by master's and doctoral degree levels is key in the current economic context. This is especially true for the master's degrees which can be considered terminal degrees for students seeking to practice upon graduation; CIP 14 Engineering is an example. However, within the five CIP fields reviewed, the exact majors provide a more refined way of reviewing STEM fields in place of the all-encompassing two-digit CIP field. A more exact approach is needed, as simply going beyond the two-digit CIP can provide greater precision between field of study and job outlook. This dynamic is especially pivotal for the current economic context.

Additionally, this study has taken a quantitative, broad review. There is room for qualitative researchers to design studies which can provide more in-depth knowledge of STEM fields in relation to female in STEM. Qualitative researchers can review ways in which funding, such as graduate assistantships, may differ by graduate assistantship type. Also, qualitative approaches can provide more in-depth knowledge of the rationale for individual choice to pursue STEM fields for females. These differences in individual choice may be true between master's versus doctoral level students as well.

Definitions of STEM may need to be revisited on an institutional level. Given that there is no universal agreement on what constitutes a STEM field, how an institution seeks to define STEM is directly related to reported data on degree production, especially for females. The exact inclusion of STEM fields, perhaps by more than simply two-digit CIP codes, can influence how an institution seeks funding, develops partnerships with industries related to STEM fields, and overall develops these respective STEM or non-STEM fields as a whole. The climate of the Sequester and cutting of research funds further compounds this process of seeking funding or emphasizing select STEM fields (White House, 2013). Perhaps continued clarification and articulation, even consistency, for funding and reinforcement of STEM fields may facilitate conceptualizing and defining STEM.

A recent conference presentation highlighted the extent to which various definitions of STEM fields were more inclusive or exclusive of select fields by six-digit CIP code. Institutional researchers compared three definitions at the six-digit CIP level, or classification of instructional program level. The three definitions came from the Department of Homeland Security (DH), the National Science Foundation (NSF), and IPEDS (Integrated Postsecondary Education Data System). A comparison was made of how inclusive each definition was of the six-digit CIP codes regarding which fields would be defined as STEM fields and which would not. All CIP codes were programs at a large land-grant institution in the southeastern US. Results revealed the definition with the most inclusive number of fields was from DH, followed by NSF, and the definition which included the least number of six-digit CIP codes was the IPEDS definition (Moore & Sapp, 2013). Again, consistency of STEM definition from a federal level may be key.

However, the significance of the Moore & Sapp (2013) presentation to the current study was two-fold because the institution reviewed was a land-grant institution. Since land-grant institutions were emphasized in this study, and STEM fields are at least historically tied to land-grants in as much as STEM fields tend to be applied fields of study (Thelin, 2004), there is the question of whether or not land-grant institutions should embody and embrace the STEM fields which are being emphasized nationally. Alternatively, should practitioners at land-grants, and other university types, seek to self-define STEM fields? This is an intriguing question in the current climate which sees a potential disconnect between public education and the public forum. There can be a divide when seeking to emphasize STEM fields which are strategically emphasized nationally at the cost of emphasizing STEM fields which may be more prominent locally, such as in an institution's home state.

Perhaps this is a unique time in which land-grants find themselves. At the inception of programs which we now know as STEM fields, there was a degree of self-determination (Ross, 1942) regarding the fields which would be emphasized. During the Great Depression, graduate studies seemed to cement themselves at land-grant institutions, and funding changed from a partnership with states to a partnership with federal funding (Eddy, 1957). Given that prior solutions to funding of land-grants were not solved in the Great Depression (Eddy, 1957), perhaps the Great Recession has indicated a shift in funding partnership which has not changed since the Great Depression.

There is another opportunity for land-grant institutions to emphasize STEM fields of interest on a local level. The shift is on-going, but there seem to be two main trends. The first trend is for institutions to self-define STEM fields in partnership with the institution and industry. This allows for collaboration between STEM fields and the respective geographic areas in which STEM fields may be located regarding research and industry collaboration externally. This is essentially a service or public partnership.

The second trend is for the universities to seek to maximize their profit. With the cuts in funding through the Sequester, there is a shift in how institutions obtain funding. In place of federal influence, there remains institutional-level private gain through maximizing profits from an institution's own research endeavors. This shift removes public ties to an institution which was founded to serve the states in which they were created (Thelin, 2004). This is the context in which researchers and practitioners are placed in order to seek to maximize STEM degree production, specifically for females. Overall, trends in STEM fields may influence females in STEM more than mere localized efforts at female retention in STEM.

Given that land-grant institutions historically emphasized the applied disciplines, there is future research which could review types of practical degrees related to STEM. These include the recent Professional Science Master's degrees (Professional Science Master's, 2012), which seek to impart practical business knowledge not gained while studying in a STEM undergraduate degree. Research could compare how efforts from these PSM's may influence current curriculum in STEM fields. There is also the reconceptualization of "practical" in a modern sense, however, this has been touched upon previously when discussing how to define STEM fields. This is a novel research approach given that similar trends were observed during the Great Depression (Eddy, 1957).

Finally, while there have been trends observed in the past regarding payment for tuition by gender (Liseo, 2005), STEM-specific research efforts which review differences by gender regarding finding ways to pay for education in the STEM fields in the recent economic context are of interest. While there are qualitative lenses, a broad-based review of financial databases is the recommended starting point. Such research could ideally provide resources for practitioners who seek to increase female STEM graduate student degree production by addressing financial obstacles to obtaining graduate STEM degrees by gender in the recent economic context.

Closing Thoughts

There is room in future studies of this topic using other advanced statistical methods and increased data precision. Recommended statistical methods include using a broader range of independent variables, perhaps from different databases, in order to create a multi-level regression model, or even longitudinal data analysis. Both would allow for a more complex review of data. Longitudinal data analysis (Singer & Willet, 2003) would also allow for a more precise review of data over time. A larger review across time may be beneficial as well in order to allow for the review of data across the recent recession(s) prior to the Great Recession, such as those of the 1970s and 1980s.

Overall, the context of the study provides a means by which there can be renewed research emphasis on the gender divide in STEM fields, specifically at the graduate level on a broad scale. An investigation of additional institutional characteristics can be a means to further review this research. Further exploration of the traditional gender divide in STEM can provide a transition from individual differences to institutional differences. Select institutional characteristics may be more prevalent in allowing for the progression of females through the STEM pipeline. Finding such characteristics may provide insight into content related to the current study, and allow for a means to discuss institutional diversity as well. This is based in the bias that strength of the higher education system in the United States has historically been the diversity of institutional type.

The amount of missing data and the consistently low ratios for female in STEM fields was a disappointing, yet not surprising, finding throughout the data review. Overall, there was significant room for increased rates of females in the graduate STEM pipeline. If STEM fields are going to be emphasized nationally, then there needs to be corresponding national efforts to allow for the entire population to partake and to be reinforced for participating in the STEM pipeline.

STEM education being emphasized nationally (Obama, 2011) foreshadows changes in education as a whole. Elements in the current debate include which gender will be at an advantage educationally moving forward. Also, which types of universities will be at a more (dis)advantaged point with recessions and decreased funding to meet the national strategic initiatives set out for STEM fields? Lastly, how individual institutions deal with the gender divide in STEM fields at the graduate level can serve as an indicator of reactions to the gender divide in graduate education as a whole. The current condition of females in STEM fields at the graduate level is lacking and needs to improve.

Finally, there is recognition of the framework that the emphasis is on degree production in STEM as a whole regardless of demographic background of the student. While this study primarily promotes a specific demographic, females, there is an alternative framework where any student graduating with a STEM degree in the US can be seen as beneficial. This may involve lower ratios of female. This alternative viewpoint is short-sighted, and a more process-oriented approach is promoted which develops students regardless of background along the STEM pipeline.

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APPENDICES

Appendix A

Data Dictionary

Ratio of graduate degrees for females	The ratio of female graduate STEM degrees compared to all STEM degrees, as well as a second ratio of female graduate STEM degrees compared to all female graduate degrees.
Ratio of females in faculty roles	Ratio is the number of female faculty out of the total number of faculty.
Ratio of females enrolled in undergraduate studies	Ratio of females enrolled in undergraduate studies as a proportion of the total number of students enrolled in undergraduate studies. This is also the number of females in STEM fields for each CIP code as a proportion of the total number of females in undergraduate studies.
Ratio of females enrolled in graduate studies	Ratio of females enrolled in graduate studies as a proportion of the total number of students enrolled in graduate studies. The ratio can also be approached as the number of females in STEM fields for each CIP code as a proportion of the total number of females in graduate studies.
Ratio of female administrators	Ratio of female administrators out of all of the administrators will be used.
Annual research expenditures per institution	Annual research expenditures per institution.
Land-grant status	Land-grant status is designated within IPEDS. The two types of land-grant institutions which will be considered for review are land-grants and HBCU land-grants.
Institutional size	Institutional size is based on total student enrollment.

Ratio of female graduate assistantships	Ratio of female teaching assistantships out of the total number of assistantships as well as ratio of female research assistantships out of the total number of assistantships.
CIP code	CIP code, classification of instructional program, will be used to review the DV for six different STEM fields. The CIP codes to be used are as follows: 11-Computer and Information Sciences and Support Services, 14-Engineering, 15-Engineering technologies and Related fields, 26-Biology and Biomedical Sciences, 27-Mathematics and Statistics, 40-Physical Sciences, and 41-ScienceTechnologies/Technicians
Gender	Gender will be indicated as female or male. This is consistent with IPEDS.
Degree level	Master's and Doctoral programs will be included for review.
Year	Years included for review are 2005-2010. These correspond to academic years 2005-2006 through 2010-2011.
Academic Common Market status	Institutions which are located in Academic Common Market participating states will be used. States which participate in the ACM are as follows: Oklahoma, Texas, Arkansas, Louisiana, Mississippi, Alabama, Georgia, Florida, Tennessee, Kentucky, South Carolina, North Carolina, West Virginia, Virginia, Maryland, and Delaware.
Sector aka Institutional Control or Affiliation	This variable describes whether or not the institution is public or private, and specifies the type of private institution. Only not-for-profit institutions will be considered for review. Within the compare institutions group creator in IPEDS, Sector is section used to choose not-for-profit institutions. Within the IPEDS variable tree, this can also be achieved via Institutional Control or Affiliation.

Appendix B

List of Institutions Included in the Study

Abilene Christian University
Alabama A & M University
Armstrong Atlantic State University
Auburn University
Baker College Center for Graduate Studies
Bard College
Bellarmine University
Benedictine University
California Institute of the Arts
California State University-Fresno
Cambridge College
Clemson University
College of Saint Elizabeth
Colorado State University-Fort Collins
Cornell University
CUNY Hunter College
Delaware State University
Drew University
Duquesne University
Elon University
Emory University
Florida Agricultural and Mechanical University
Fordham University
George Washington University
Humphreys College-Stockton and Modesto Campuses
Illinois State University
Immaculata University
Indiana University-Purdue University-Indianapolis
Iowa State University
Jackson State University
Kansas State University
Kent State University at Kent
King's University
Lamar University
Langston University
Lawrence Technological University
Lewis University
Lincoln University
Long Island University-Brooklyn Campus

Long Island University-C W Post Campus
Louisiana State University and Agricultural
& Mechanical College
Loyola University-Chicago
Maharishi University of Management
Mercy College
Michigan State University
Mirrer Yeshiva Cent Institute
Misericordia University
Mississippi College
Mississippi State University
Montana State University
Morehead State University
Ner Israel Rabbinical College
New Jersey Institute of Technology
New Mexico State University-Main Campus
New York University
North Carolina A & T State University
North Carolina State University at Raleigh
North Dakota State University-Main Campus
Nova Southeastern University
Ohio State University-Main Campus
Oklahoma State University-Main Campus
Oregon State University
Otterbein University
Pennsylvania State University-Main Campus
Pepperdine University
Prairie View A & M University
Purdue University-Main Campus
Robert Morris University
Rochester Institute of Technology
Rutgers University-New Brunswick
South Carolina State University
South Dakota School of Mines and Technology
South Dakota State University
Southern University and A & M College
Stevens Institute of Technology
Tennessee State University
Texas A & M University-College Station
Texas A & M University-Commerce
Texas A&M Health Science Center
Texas Tech University Health Sciences Center
The University of Tennessee
The University of Texas at San Antonio
Tuskegee University

United States Sports Academy
University of Alaska Fairbanks
University of Arkansas
University of Arkansas for Medical Sciences
University of California-Berkeley
University of California-Davis
University of California-Merced
University of California-Riverside
University of Central Arkansas
University of Connecticut
University of Delaware
University of Denver
University of Florida
University of Georgia
University of Hawaii at Manoa
University of Idaho
University of Illinois at Urbana-Champaign
University of Kentucky
University of Louisiana at Lafayette
University of Maine
University of Maryland Eastern Shore
University of Maryland-Baltimore
University of Maryland-College Park
University of Massachusetts Amherst
University of Minnesota-Twin Cities
University of Mississippi Medical Center
University of Missouri-Columbia
University of Missouri-St Louis
University of Nebraska-Lincoln
University of Nevada-Las Vegas
University of Nevada-Reno
University of New Hampshire-Main Campus
University of New Haven
University of Oklahoma Health Sciences Center
University of Rhode Island
University of Rochester
University of Southern California
University of Southern Indiana
University of Vermont
University of Virginia-Main Campus
University of Wisconsin-Madison
University of Wisconsin-Milwaukee
University of Wisconsin-Oshkosh
University of Wyoming
Utah State University

Virginia Polytechnic Institute and State University
Virginia State University
Washington State University
Waynesburg University
West Virginia University
Wheaton College
Wilkes University
Wilmington University
Winston-Salem State University
Yale University
Yeshivath Viznitz

Appendix C
IRB Approval Letter

Office for Research

Institutional Review Board for the
Protection of Human Subjects

THE UNIVERSITY OF
ALABAMA
RESEARCH

April 25, 2013

Austin Ryland
711 11th St. MM
Tuscaloosa, AL 35401

Re: "A Review of Graduate STEM Degrees by Gender in the Context of the Great Recession"

Dear Mr. Ryland,

This letter comes as a response to your request for IRB review to your communication received 4/19/2013. Following initial review by the Office for Research Compliance, it has been determined that the activities outlined within the project description do not meet the criteria for human subjects research as set forth within UA IRB Form # 31 titled "Human Research Determination Checklist".

Because the activity is not considered research involving the use of human subjects, the activity does not require IRB approval and is therefore excluded from review by the IRB. If you have any questions or if I can be of further assistance, please do not hesitate to contact me.

Sincerely,

Carpantato T. Myles, MSM, CIM
Director & Research Compliance Officer
Office for Research Compliance
The University of Alabama

Appendix D

Research Question One Statistics

Table D1

Research Question One ANOVA Tests of Normality by CIP

	Shapiro-Wilkes		
	Statistic	*df*	Significance
11 Comp Sc. 2006-2011	.949	732	.000*
14 Eng. 2006-2011	.973	794	.000*
26 Biomed 2006-2011	.969	1026	.000*
27 Math 2006-2011	.994	718	.067
40 Phys. Sc. 2006- 2011	.970	850	.000*

*$p < .05$.

Table D2

Research Question One ANOVA Test of Homogeneity of Variance

CIP Field	Levene Statistic	*df*1	*df*2	Significance
11 Comp Sc. 2006-2011	1.524	1	730	.217
14 Eng. 2006-2011	16.139	1	792	.000*
26 Biomed 2006-2011	2.251	1	1024	.134
27 Math 2006-2011	4.926	1	716	.027*
40 Phys. Sc. 2006- 2011	2.503	1	848	.114

*$p < .05$.

Table D3

Research Question One Tests of Normality by Degree Level

CIP Field	Degree Level	*df*	Shapiro-Wilkes Sig.
11 Comp Sc 2006-2011	Master	528	.000*
	Doc	204	.000*
14 Eng. 2006-2011	Master	466	.000*
	Doc	328	.000*
26 Biomed 2006-2011	Master	605	.000*
	Doc	421	.000*
27 Math 2006-2011	Master	465	.074
	Doc	253	.010*
40 Phys. Sc. 2006- 2011	Master	490	.000*
	Doc	360	.669

* $p < .05$.

Figure D1. CIP 11 Distribution

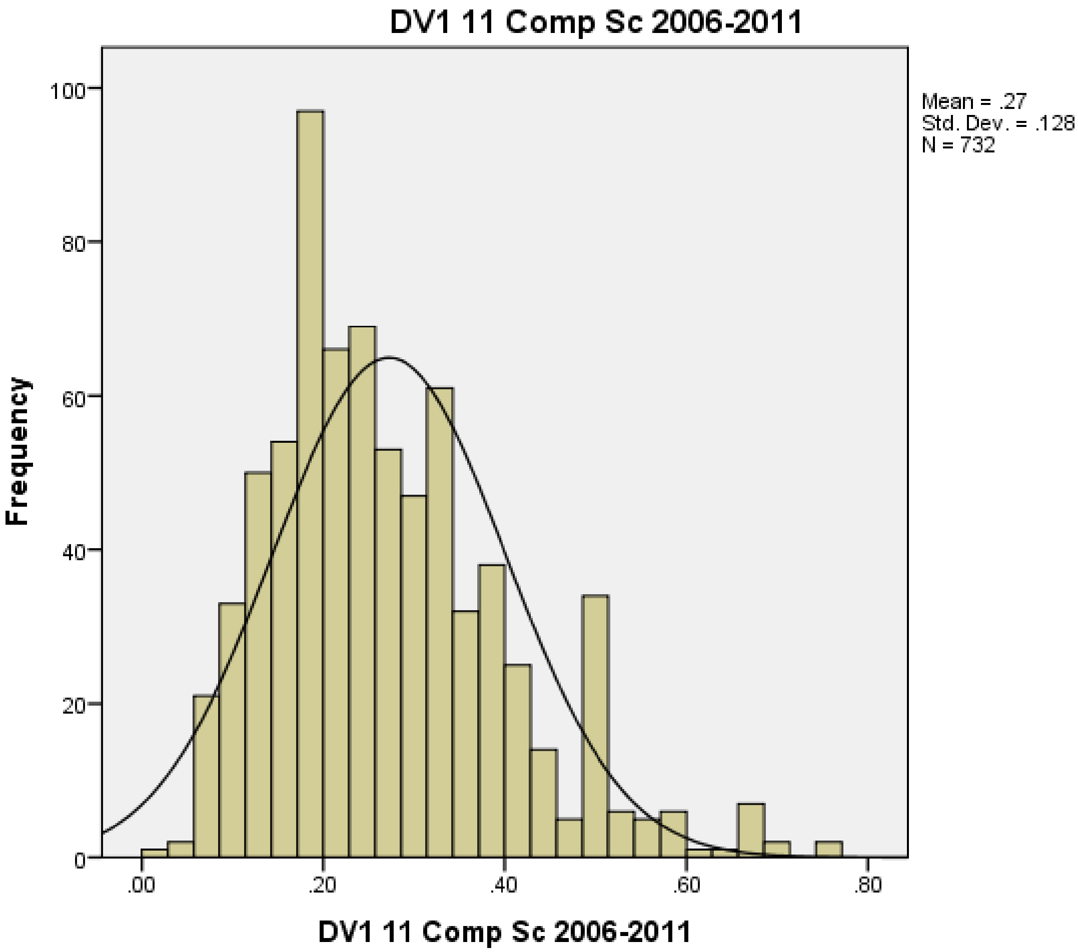


Figure D2. CIP 11 Master Distribution

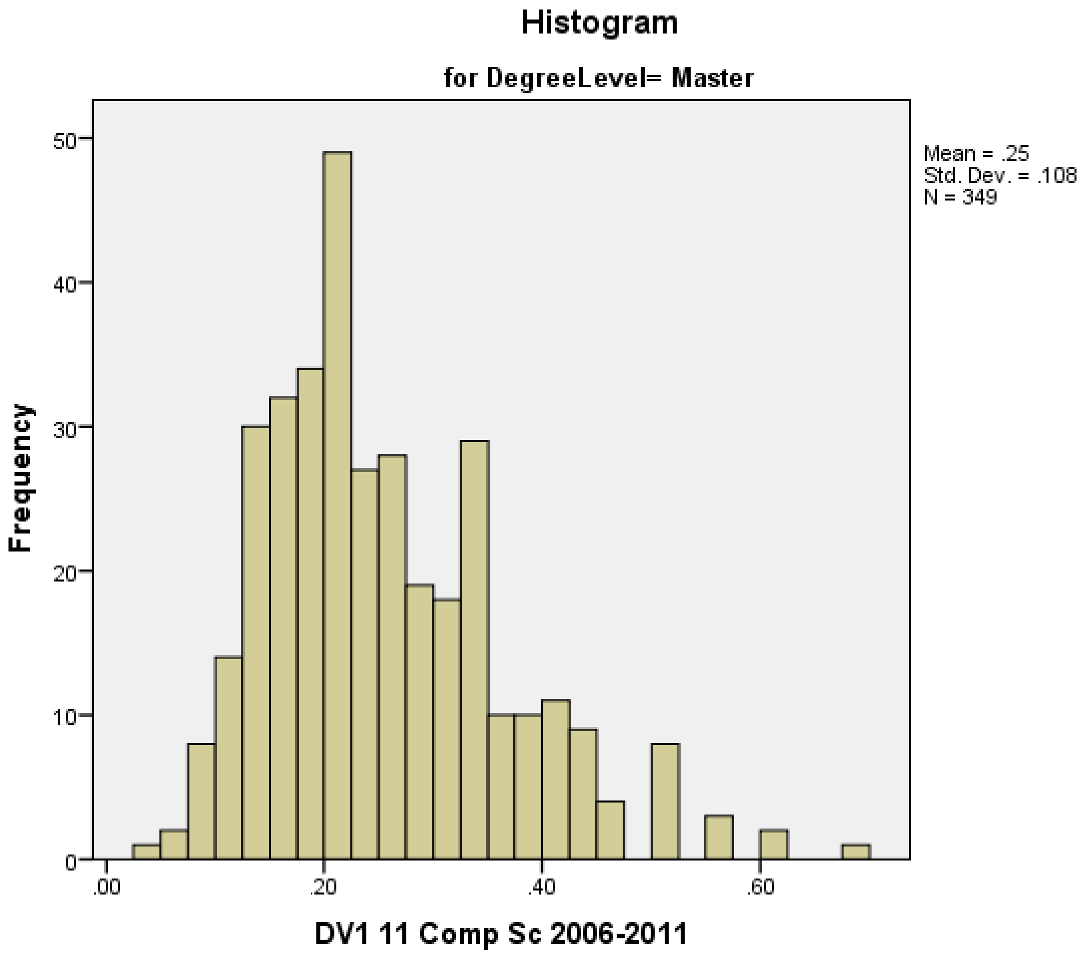


Figure D3. CIP 11 Doctoral Distribution

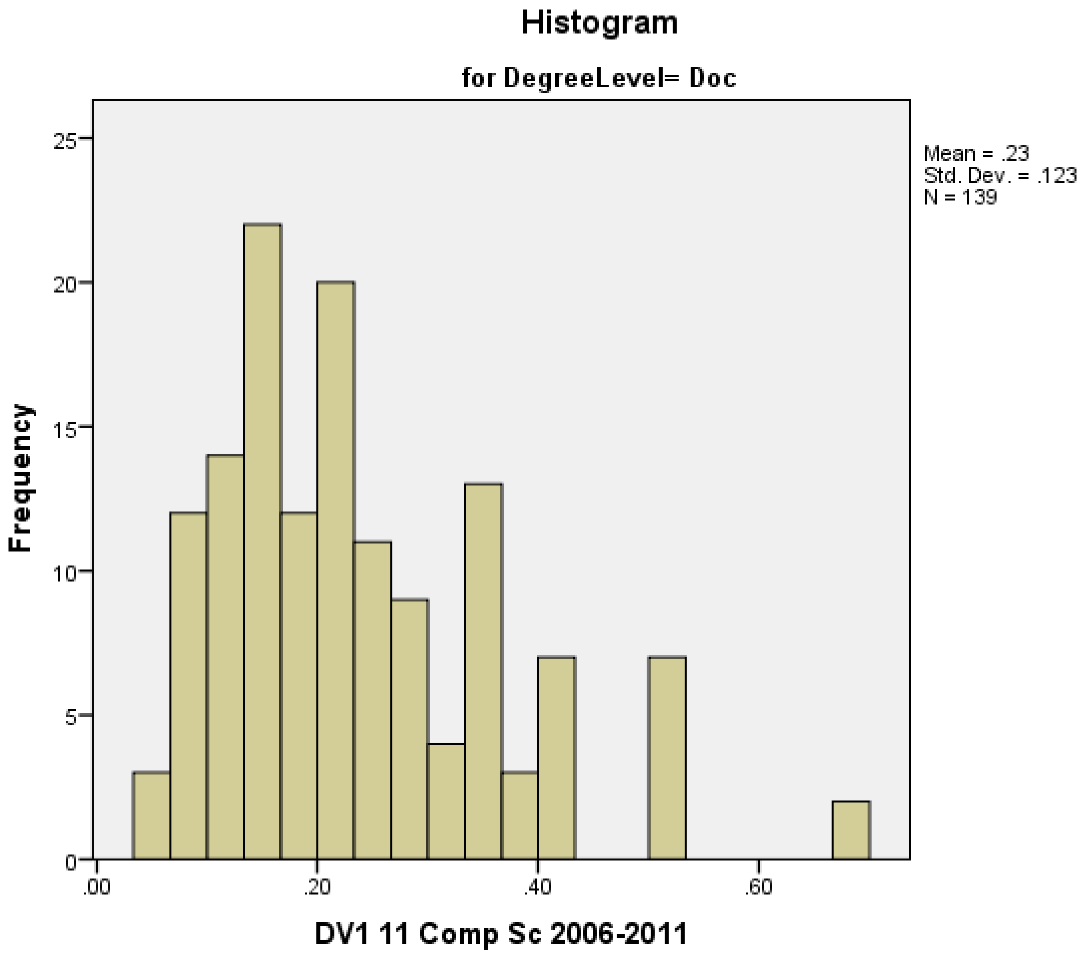


Figure D4. CIP 14 Distribution

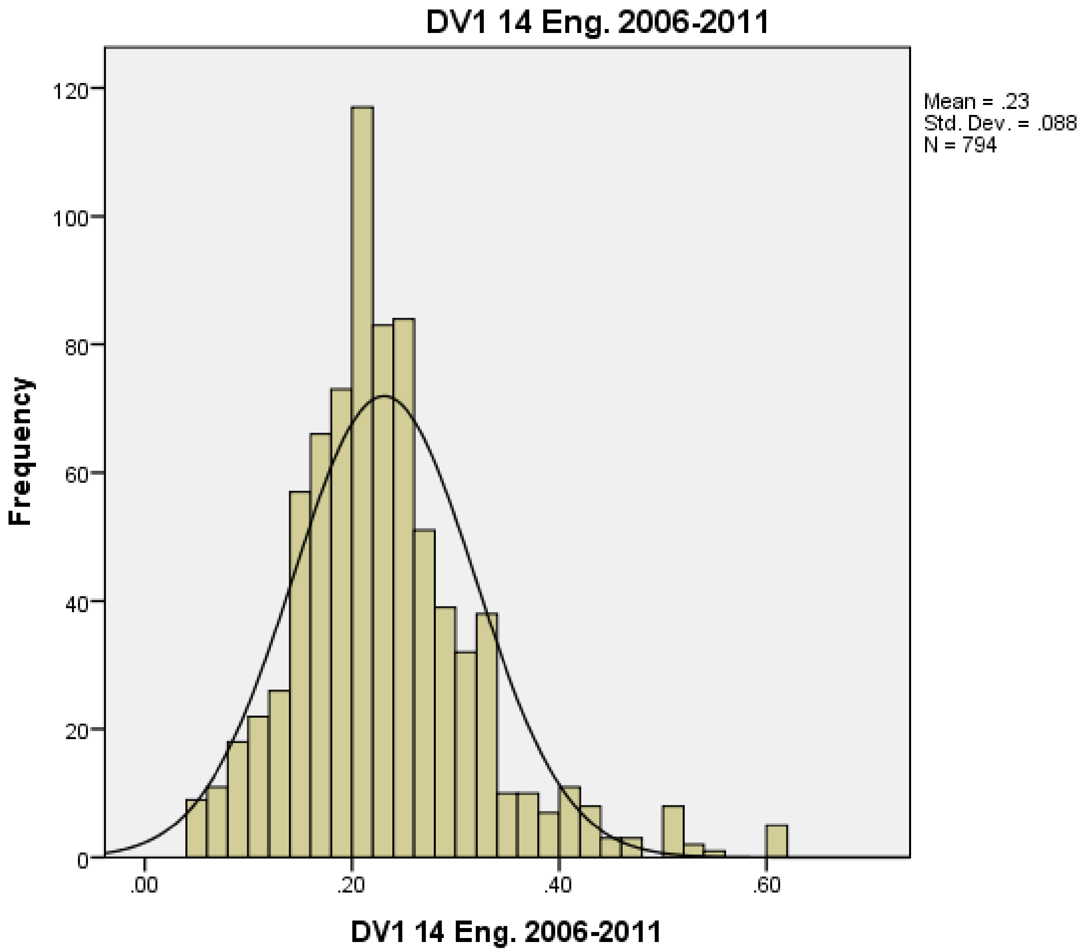


Figure D5. CIP 14 Master Distribution

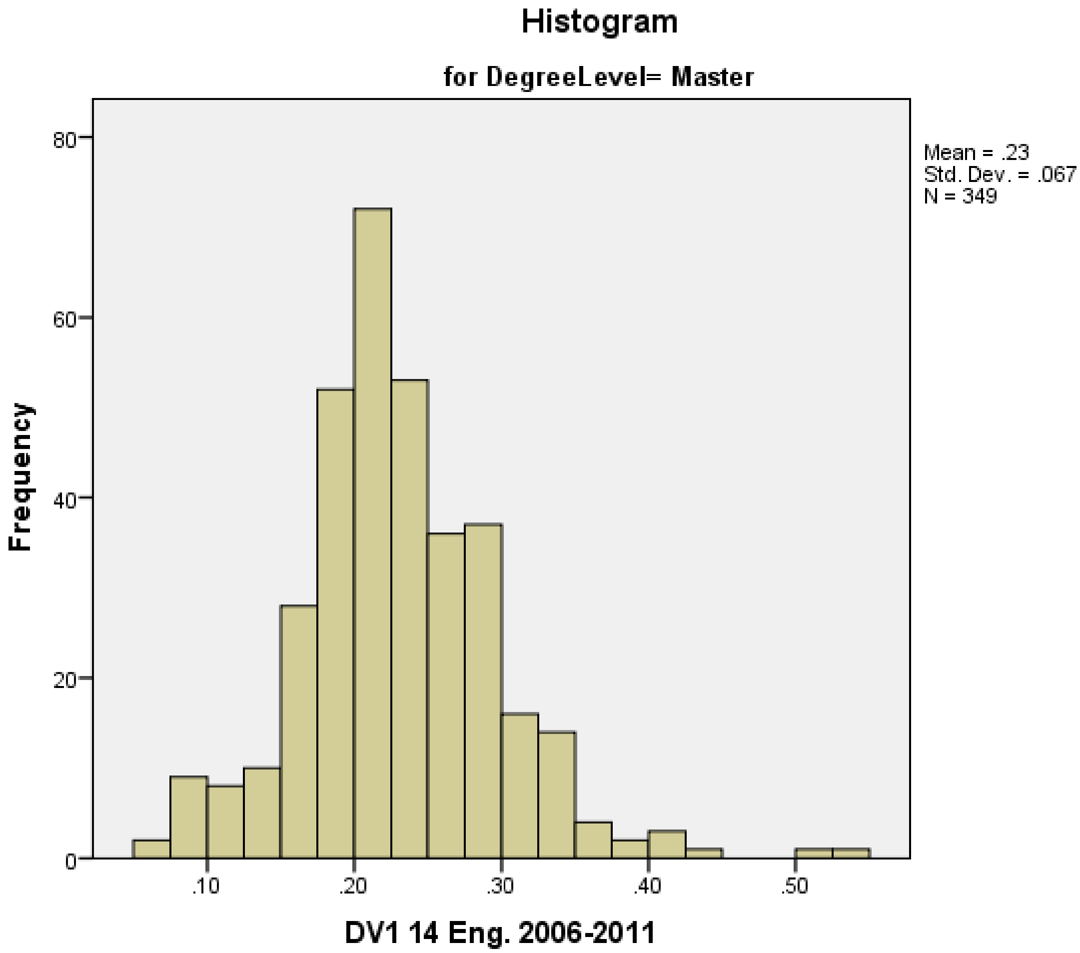


Figure D6. CIP 14 Doctoral Distribution

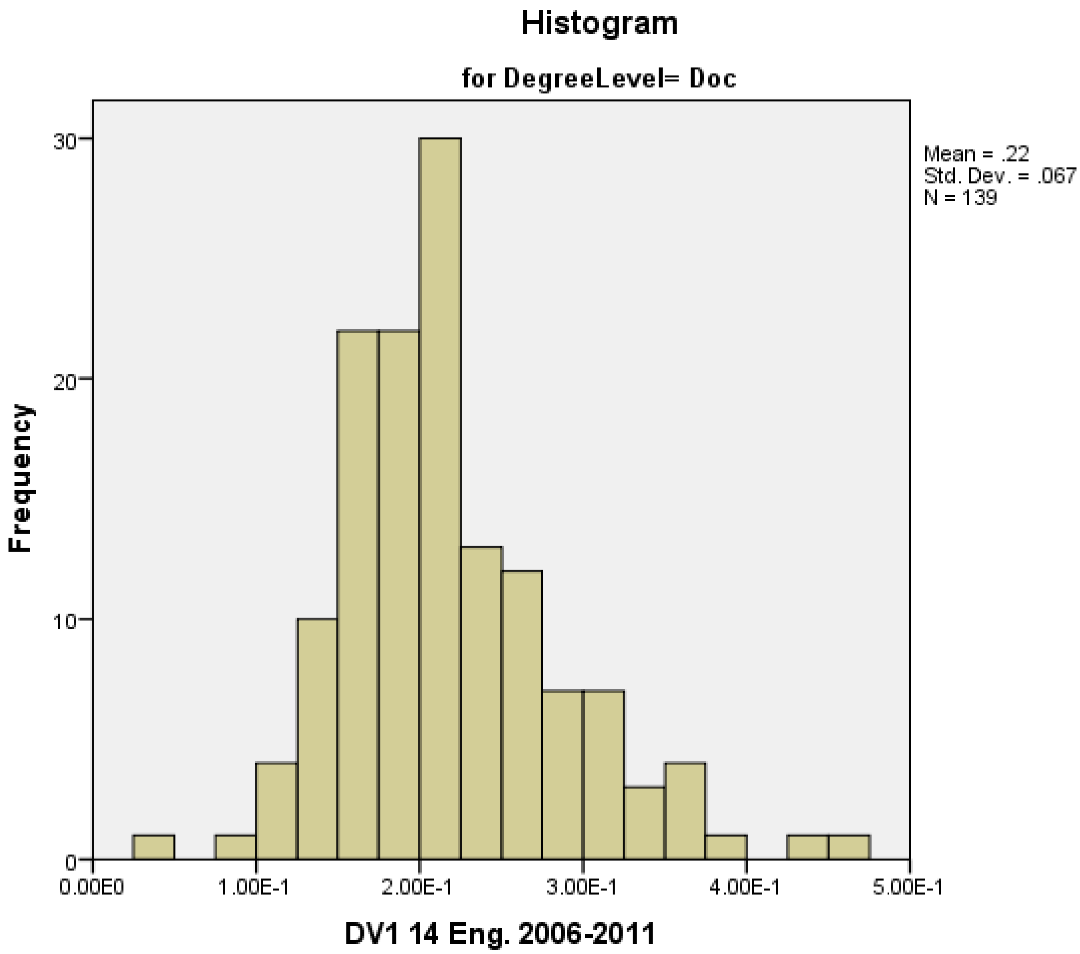


Figure D7. CIP 26 Distribution

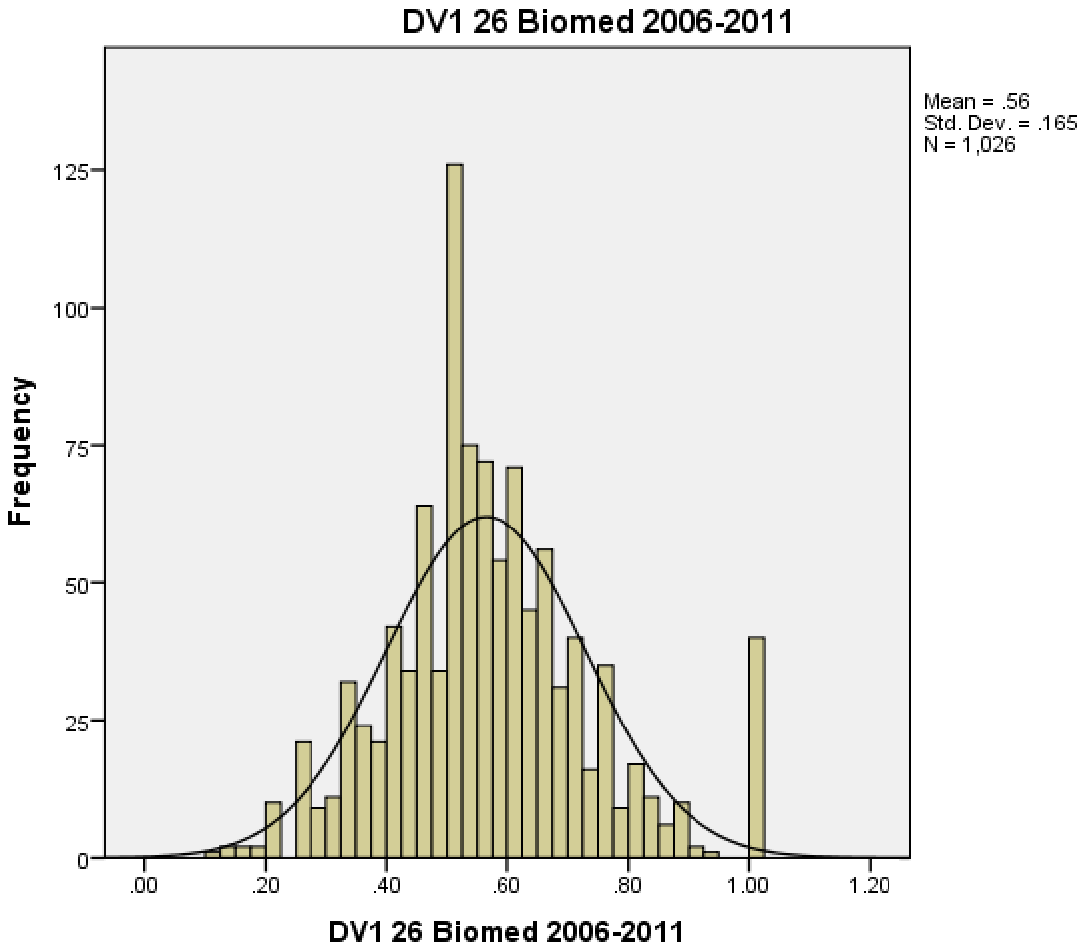


Figure D8. CIP 26 Master Distribution

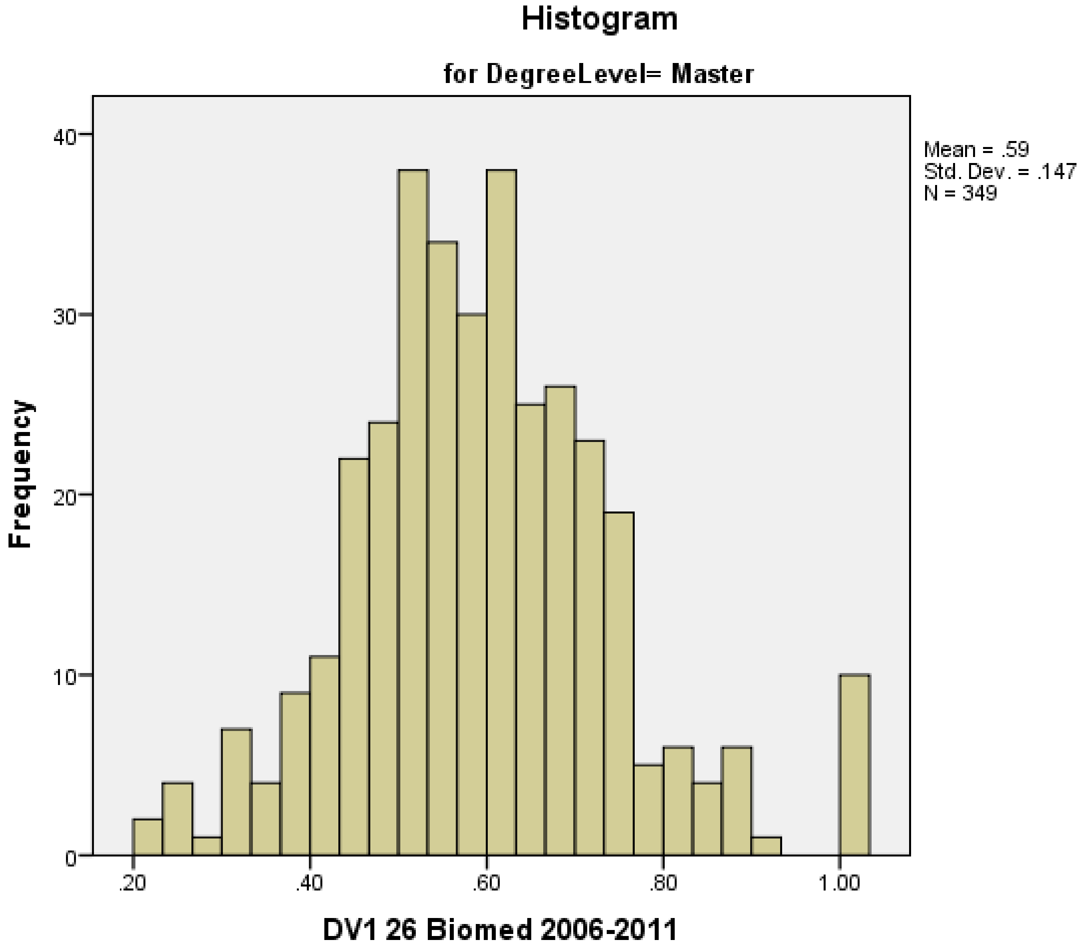


Figure D9. CIP 26 Doctoral Distribution

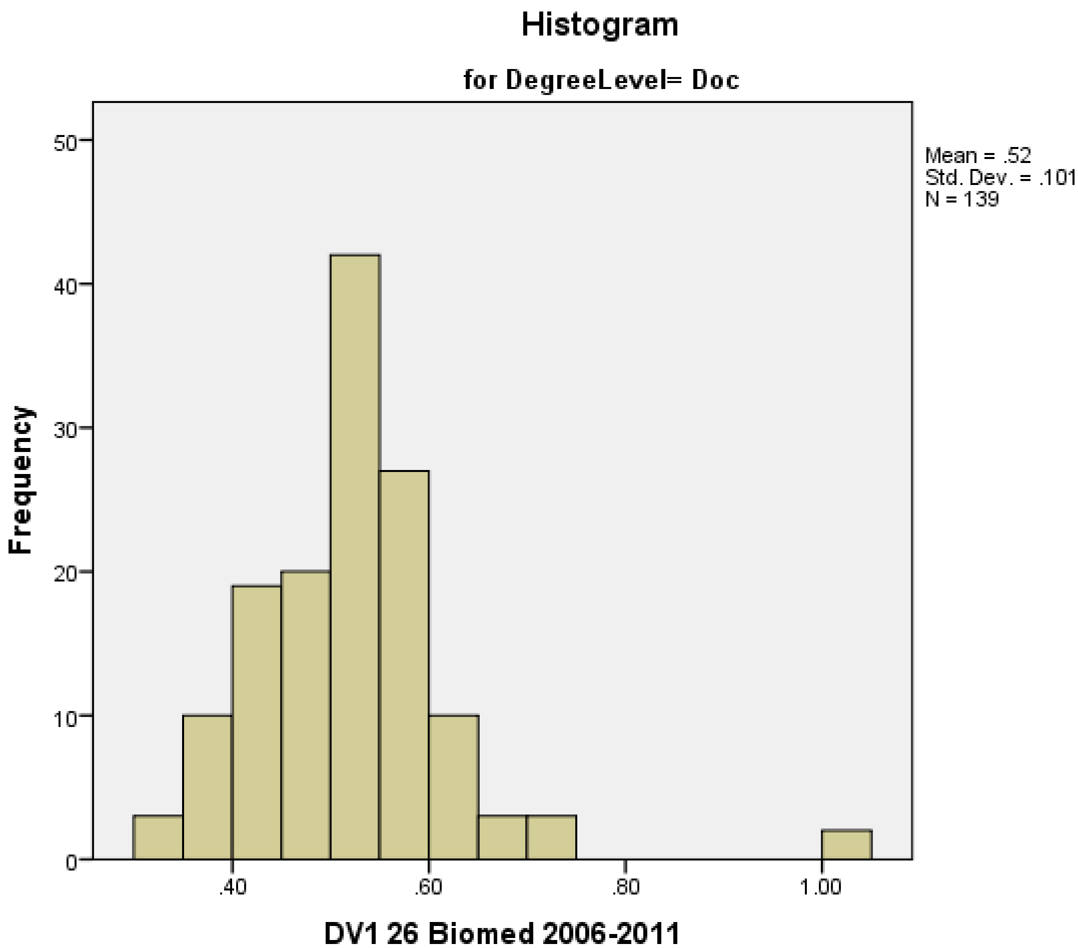


Figure D10. CIP 27 Distribution

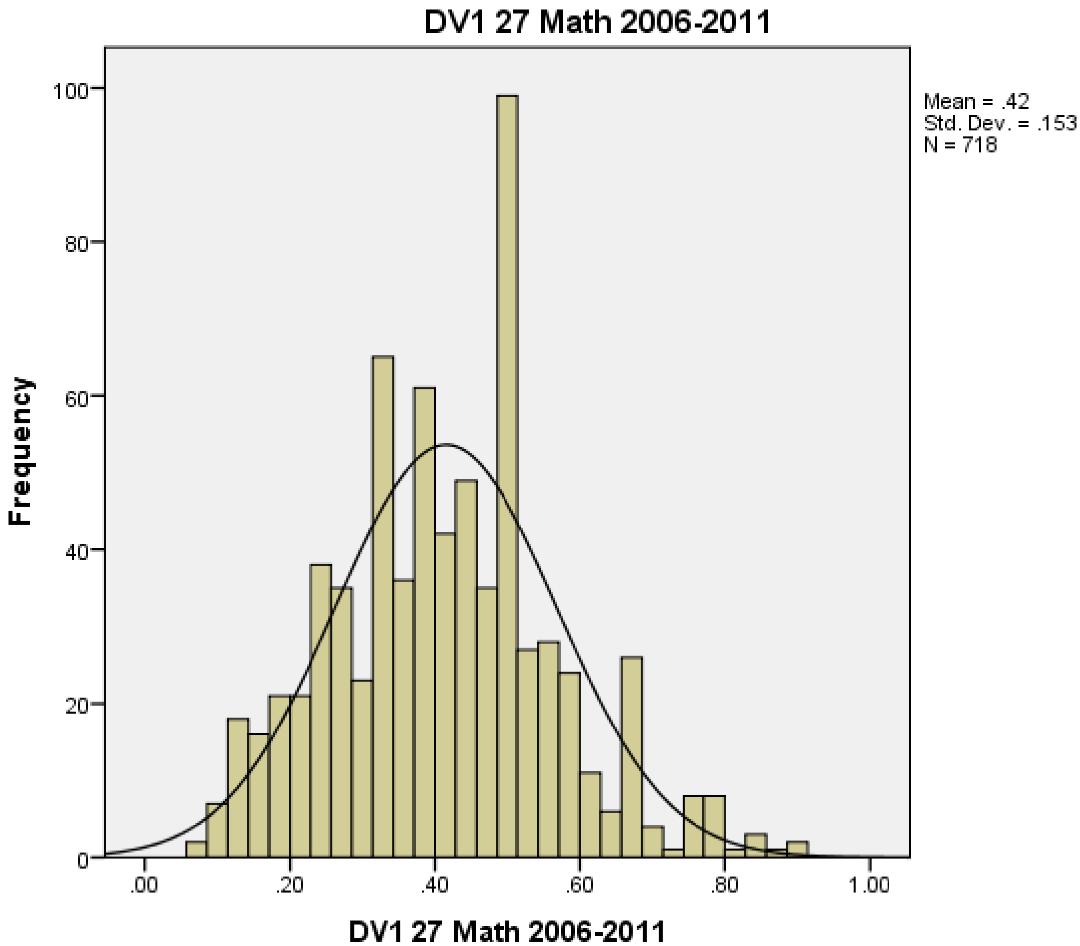


Figure D11. CIP 40 Distribution

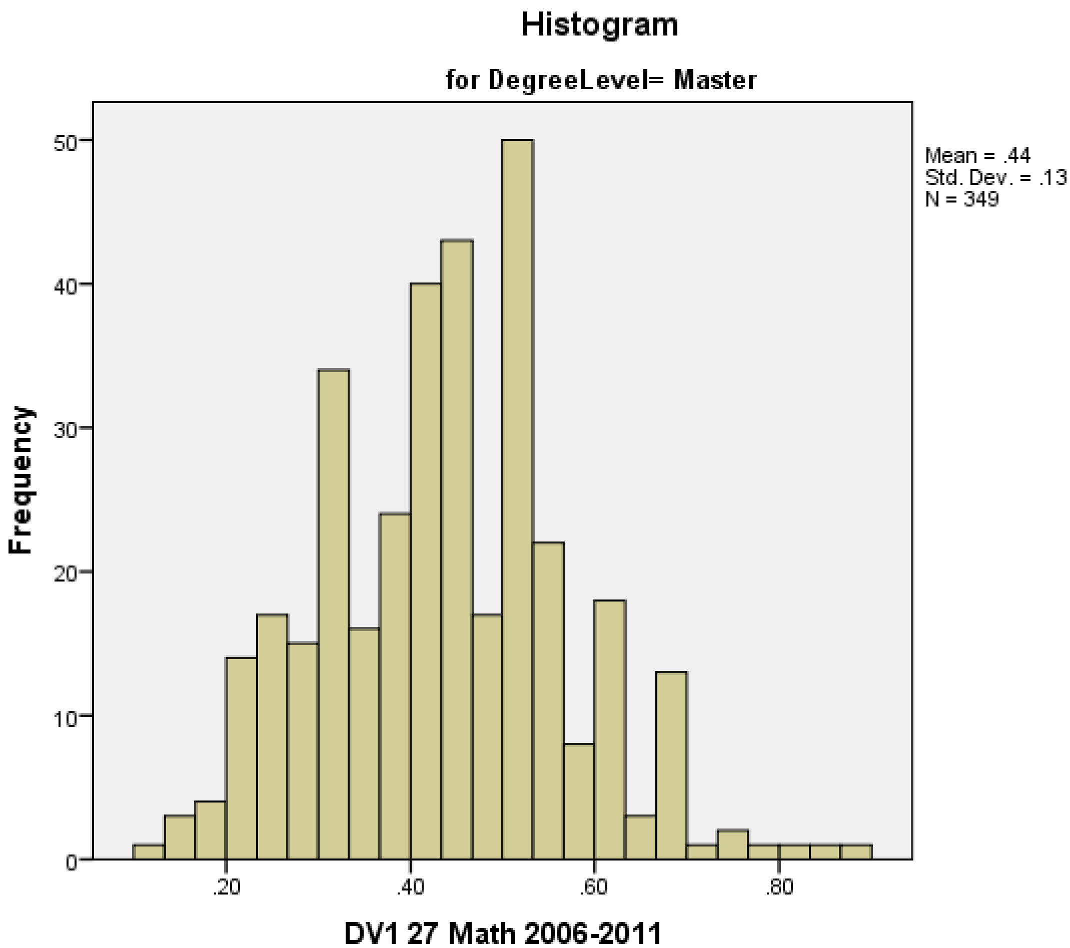


Figure D12. CIP 27 Doctoral Distribution

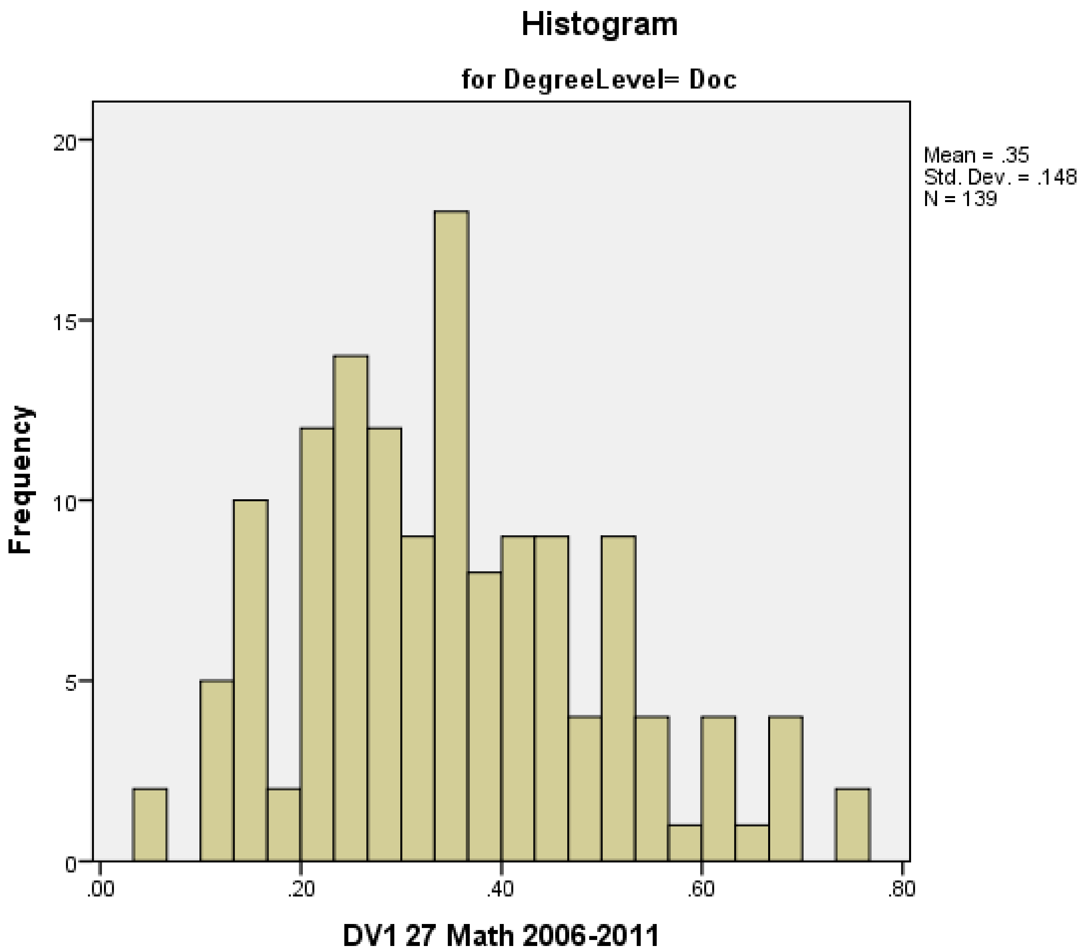


Figure D13. CIP 40 Distribution

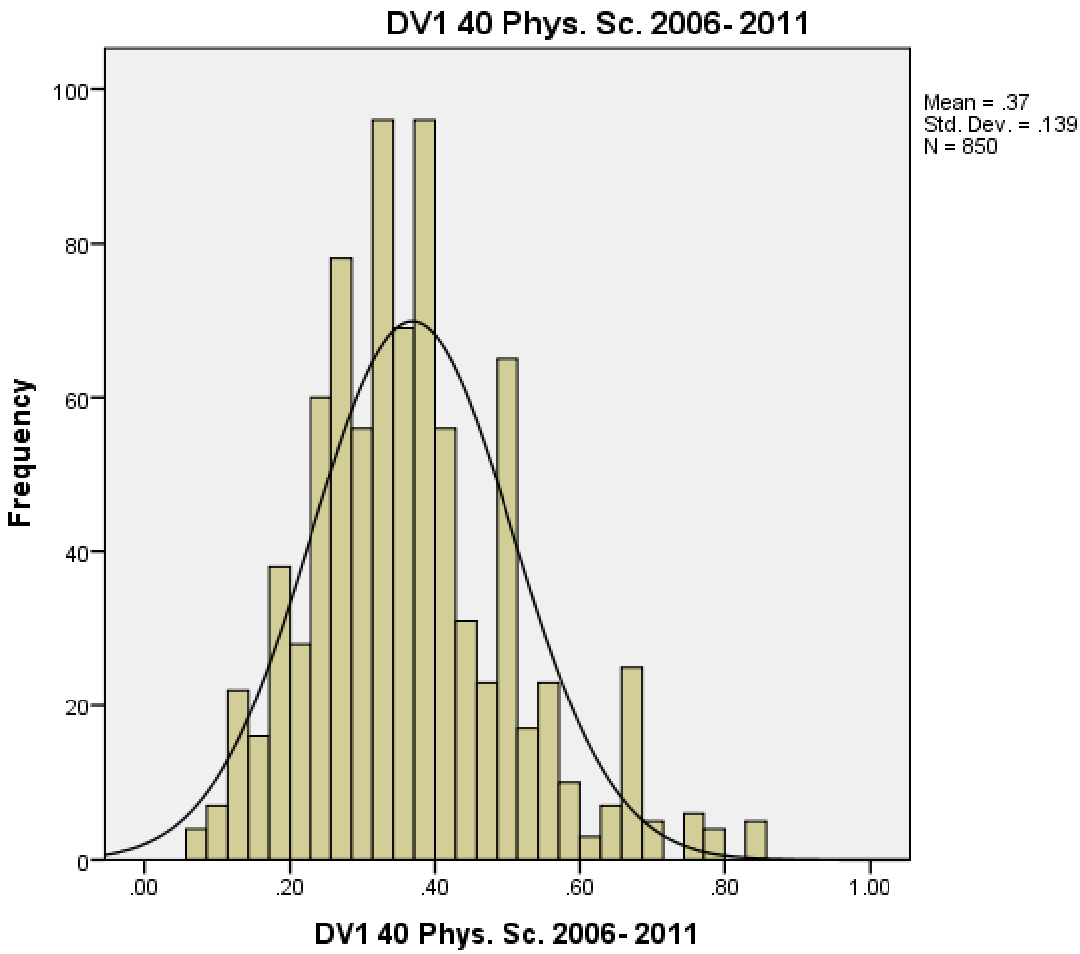


Figure D14. CIP 40 Master Distribution

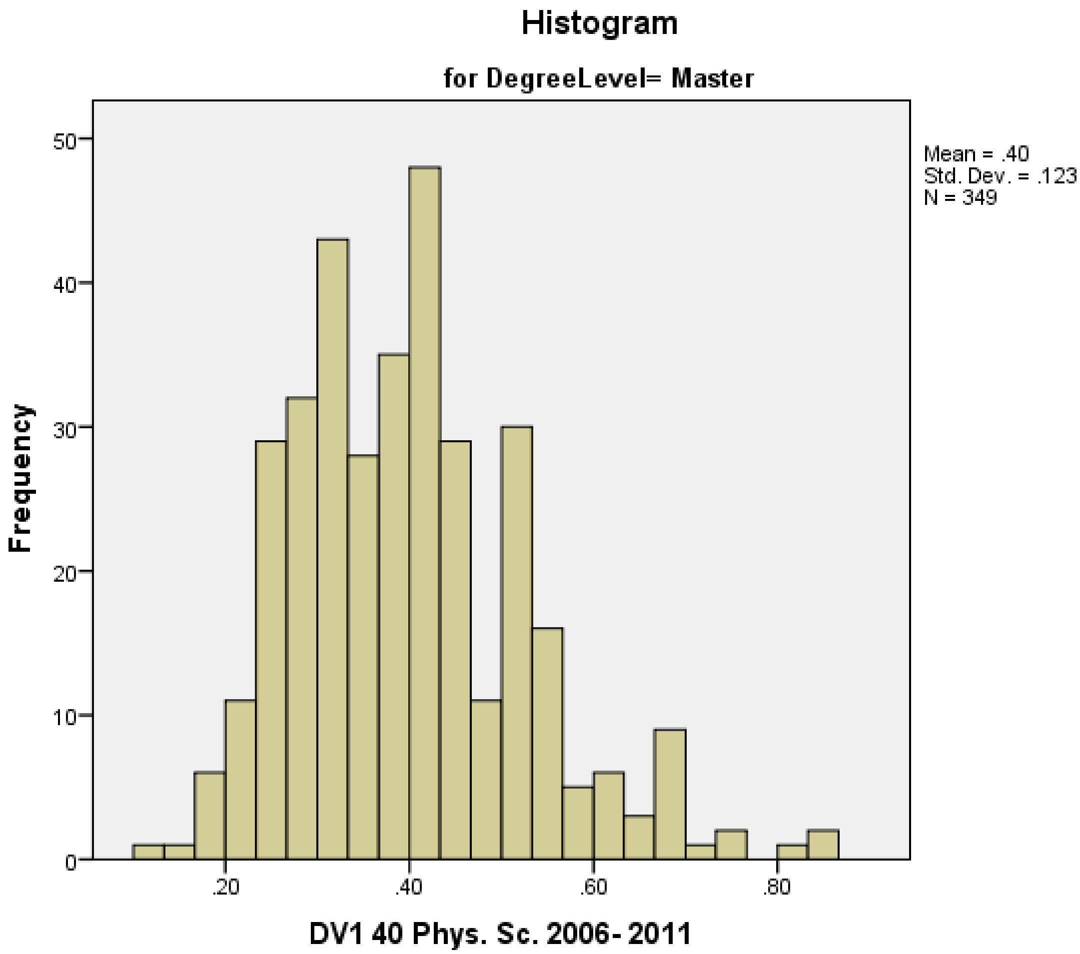


Figure D15. CIP 40 Doctoral Distribution

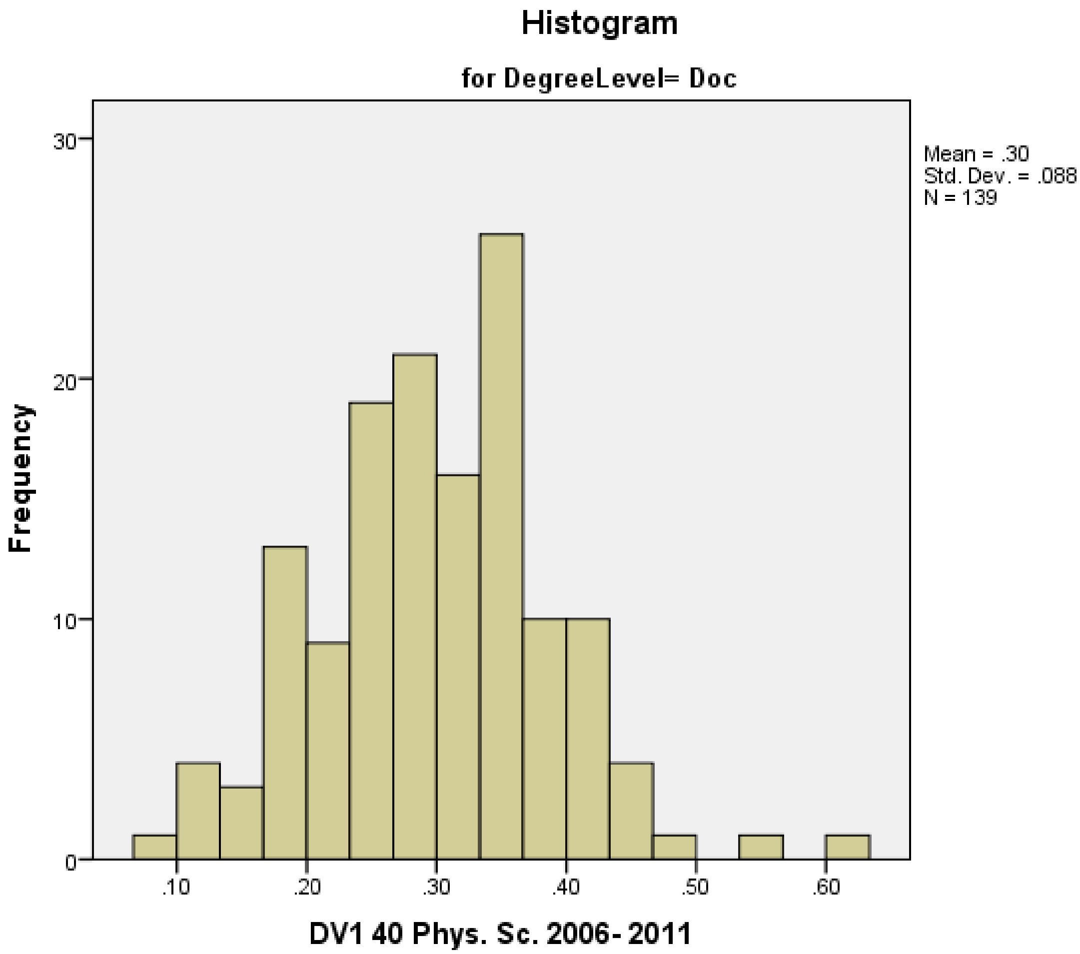


Table D4

Research Question One Kruskal-Wallis Mean Ranks by CIP Field and Degree Level

	Degree Level	N	Mean Rank
	Master	528	377.80
11 Comp Sc. 2006-2011	Doc	204	337.26
	Total	732	
	Master	466	409.00
14 Eng. 2006-2011	Doc	328	381.16
	Total	794	
	Master	605	583.96
26 Biomed 2006-2011	Doc	421	412.24
	Total	1026	
	Master	465	400.57
Math 2006-2011	Doc	253	284.01
	Total	718	
	Master	490	494.73
40 Phys. Sc. 2006- 2011	Doc	360	331.28
	Total	850	

Appendix E

Research Question Two Statistics

Table E1

Research Question Two Tests of Normality by CIP Field and Land-Grant Status

CIP Field	Land Grant Institution (HD2010) (1=land-grant, 2=non-land-grant)	*df*	Shapiro-Wilkes Test of Normality
11 Comp Sc. master	1	299	.000*
	2	229	.000*
11 Comp Sc. doc	1	145	.000*
	2	59	.002*
14 Eng. master	1	335	.000*
	2	131	.001*
14 Eng. Doc	1	257	.000*
	2	71	.000*
26 Biomed master	1	354	.001*
	2	251	.006*
26 Biomed doc	1	285	.000*
	2	136	.000*
27 Math master	1	315	.006*
	2	150	.005*
27 Math doc	1	193	.001*
	2	60	.012*
40 Phys. Sc. Master	1	326	.000*

	2	164	.000*
40 Phys. Sc. Doc	1	264	.000*
	2	96	.021*

*p < .05.

Table E2

Research Question Two Homogeneity of Variance by CIP Field and Degree Level

	Levene Statistic	df1	df2	Sig.
11 Comp Sc. master 2006- 2011	.002	1	526	.963
11 Comp Sc. doc 2006-2011	.311	1	202	.578
14 Eng. master 2006-2011	3.768	1	464	.053
14 Eng. doc 2006-2011	16.122	1	326	.000*
26 Biomed master 2006-2011	6.080	1	603	.014*
26 Biomed doc 2006-2011	13.190	1	419	.000*
27 Math master 2006-2011	2.467	1	463	.117
27 Math doc 2006-2011	1.441	1	251	.231
40 Phys. Sc. Master 2006-2011	8.808	1	488	.003*
40 Phys. Sc. doc 2006-2011	32.131	1	358	.000*

*p < .05.

Appendix F

Research Question Three Statistics

Table F1

Research Question Three Tests of Normality by CIP Field, Degree Level, and Year

		Shapiro-Wilkes Normality Test		
CIP Field	Year	Statistic	*df*	Significance
11 Comp Sc. master 2006-2011	2006	.939	89	.000*
	2007	.943	87	.001*
	2008	.940	88	.000*
	2009	.937	91	.000*
	2010	.934	85	.000*
	2011	.981	88	.237
11 Comp Sc. doc 2006-2011	2006	.926	35	.022*
	2007	.934	43	.016*
	2008	.909	30	.014*
	2009	.889	21	.021*
	2010	.896	35	.003*
	2011	.911	40	.004*
14 Eng. Master 2006-2011	2006	.974	78	.113
	2007	.923	78	.000*
	2008	.971	75	.081
	2009	.939	77	.001*
	2010	.965	80	.029*
	2011	.945	78	.002*
14 Eng. Doc 2006-2011	2006	.964	54	.105
	2007	.937	61	.004*
	2008	.890	48	.000*
	2009	.923	41	.009*
	2010	.886	64	.000*
	2011	.958	60	.037*
26 Biomed master 2006-2011	2006	.988	101	.513
	2007	.972	100	.033*
	2008	.963	100	.006*
	2009	.987	104	.425
	2010	.991	100	.722

	2011	.969	100	.017*
26 Biomed doc 2006-2011	2006	.933	75	.001*
	2007	.933	73	.001*
	2008	.897	62	.000*
	2009	.945	47	.028*
	2010	.887	80	.000*
	2011	.923	84	.000*
27 Math master 2006-2011	2006	.987	75	.632
	2007	.982	81	.311
	2008	.974	77	.120
	2009	.983	80	.351
	2010	.967	74	.050*
	2011	.976	78	.152
27 Math doc 2006-2011	2006	.947	41	.055
	2007	.939	46	.017*
	2008	.967	35	.360
	2009	.955	29	.251
	2010	.974	56	.266
	2011	.972	46	.335
40 Physical Sc. master 2006-2011	2006	.968	80	.042*
	2007	.953	78	.006*
	2008	.941	80	.001*
	2009	.954	83	.005*
	2010	.947	83	.002*
	2011	.950	86	.002*
40 Physical Sc. Doc 2006-2011	2006	.969	61	.130
	2007	.961	69	.029*
	2008	.967	50	.181
	2009	.931	42	.014*
	2010	.950	69	.008*
	2011	.977	69	.228

* $p < .05$.

Appendix G

Research Question Four Statistics

Table G1

Research Question Four Academic Common Market Tests of Normality by CIP Code and Degree Level

CIP Field	Academic Common Market (1=ACM, 2=non-ACM)	*df*	Shapiro-Wilkes Test of Normality
11 Comp Sc. master 2006- 2011	1	200	.000*
	2	328	.000*
11 Comp Sc. doc 2006-2011	1	75	.000*
	2	129	.000*
14 Eng. master 2006-2011	1	162	.000*
	2	304	.004*
14 Eng. Doc 2006- 2011	1	120	.000*
	2	208	.000*
26 Biomed master 2006-2011	1	252	.005*
	2	353	.008*
26 Biomed doc 2006-2011	1	158	.000*
	2	263	.000*
27 Math master 2006-2011	1	163	.002*
	2	302	.014*
27 Math doc 2006- 2011	1	91	.017*
	2	162	.003*
40 Phys. Sc. Master 2006- 2011	1	172	.000*
	2	318	.000*

40 Phys. Sc. Doc 2006-2011	1	117	.006*
	2	243	.000*

Note. (1=ACM, 2=Non-ACM).

Table G2

Research Question Four Academic Common Market Homogeneity of Variance by CIP Field and Degree Level

	Levene Statistic	df1	df2	Sig.
11 Comp Sc. master 2006- 2011	1.184	1	526	.277
11 Comp Sc. doc 2006-2011	.055	1	202	.815
14 Eng. Master 2006-2011	.025	1	464	.875
14 Eng. Doc 2006-2011	1.616	1	326	.205
26 Biomed master 2006-2011	9.749	1	603	.002*
26 Biomed doc 2006-2011	.422	1	419	.516
27 Math master 2006-2011	.332	1	463	.565
27 Math doc 2006-2011	.600	1	251	.439
40 Phys. Sc. Master 2006-2011	4.540	1	488	.034*
40 Phys. Sc. doc 2006-2011	1.179	1	358	.278

Note. (1=ACM, 2=Non-ACM).

Appendix H

Research Question Five Statistics

Figure H1. CIP 11 Master's Means

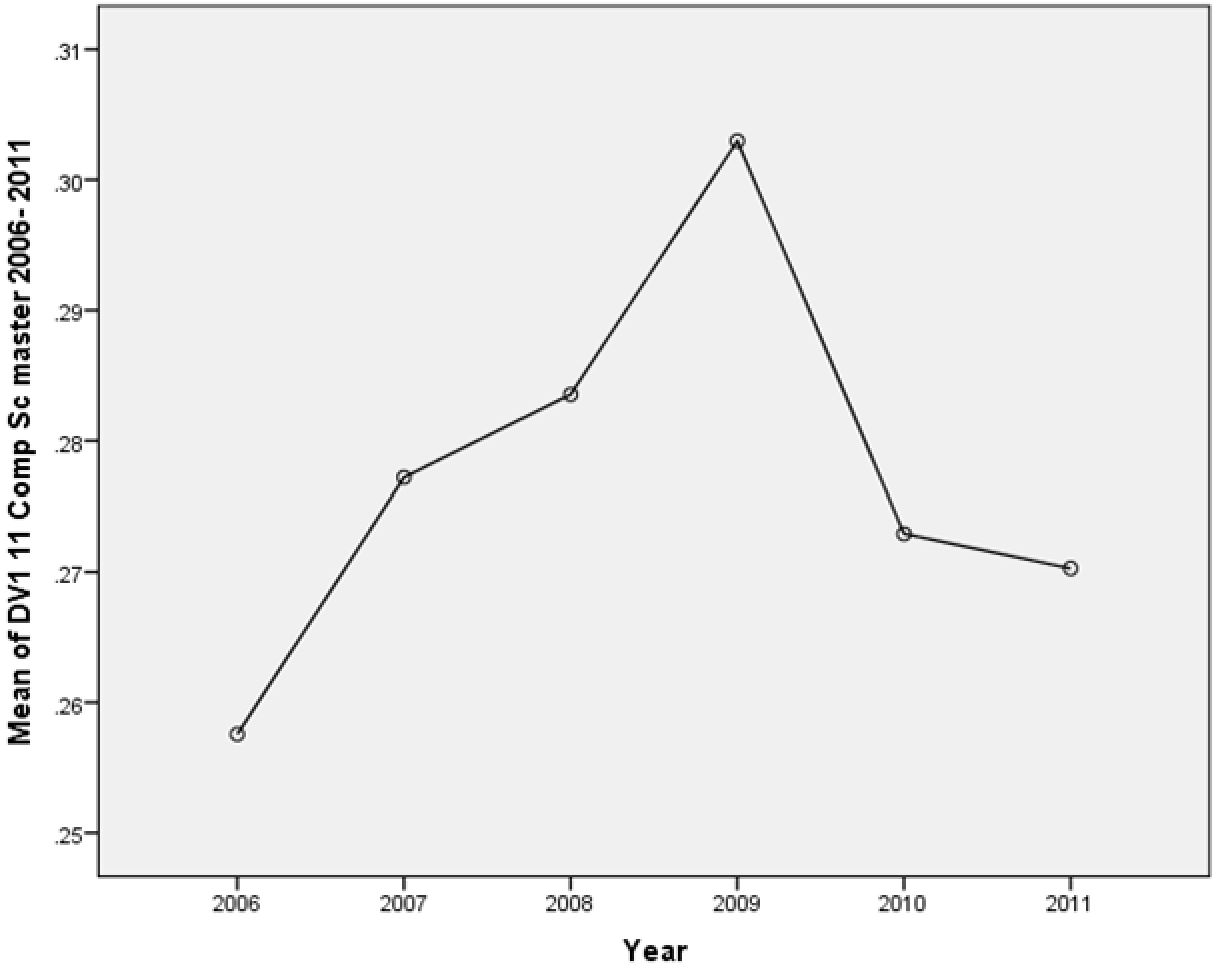


Figure H2. CIP 11 Doctoral Means

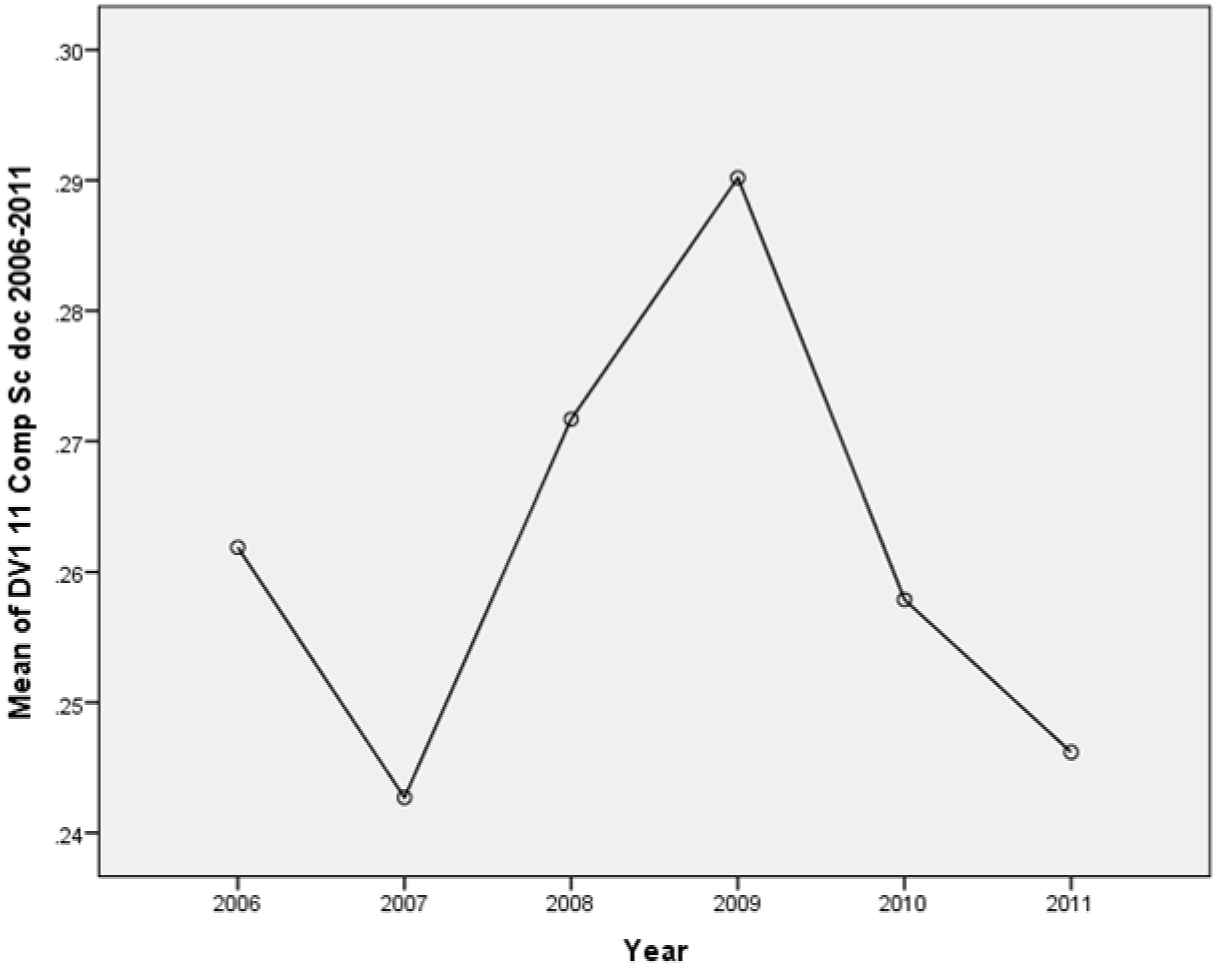


Figure H3. CIP 14 Master's Means

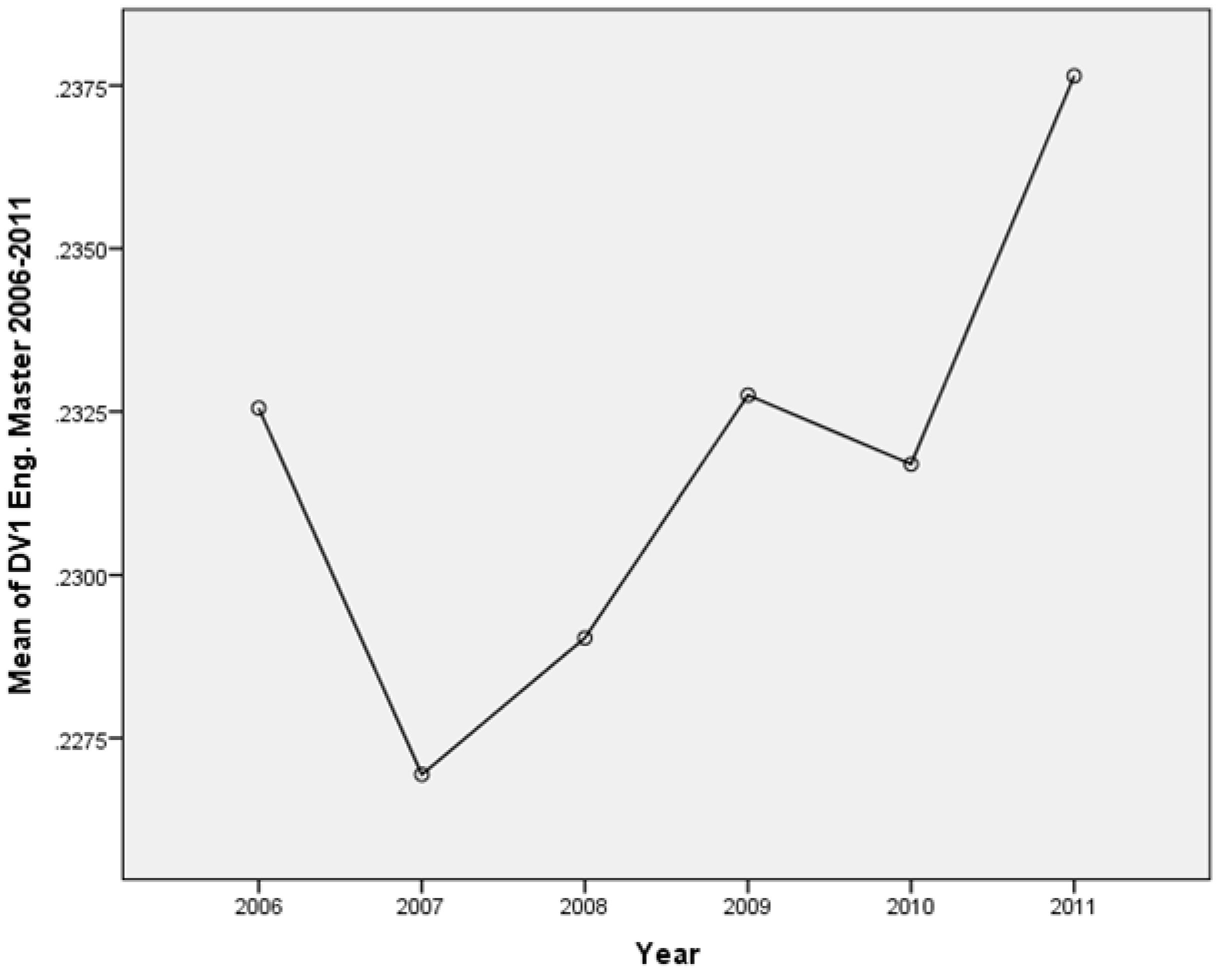


Figure H4. CIP 14 Doctoral Means

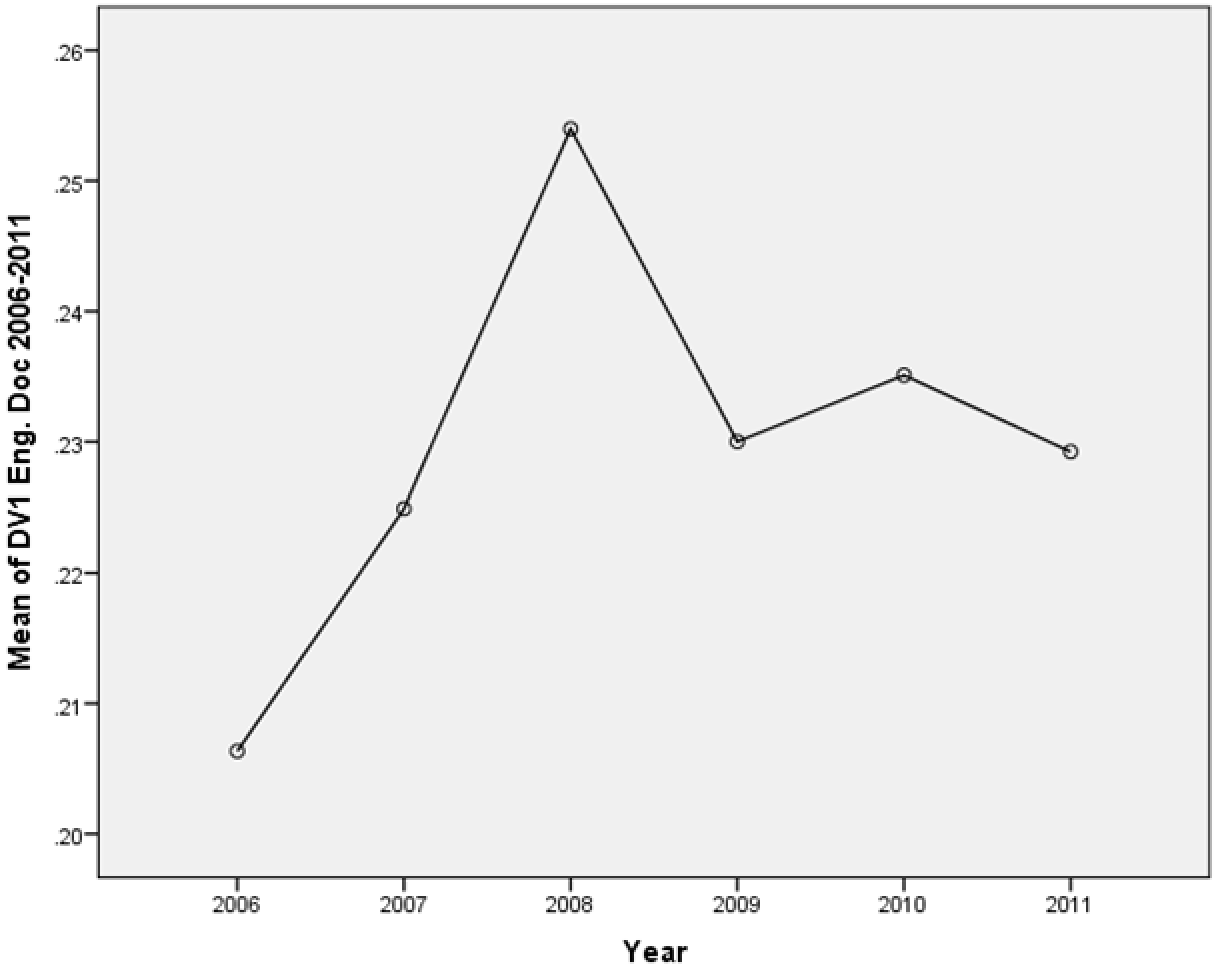


Figure H5. CIP 26 Master's Means

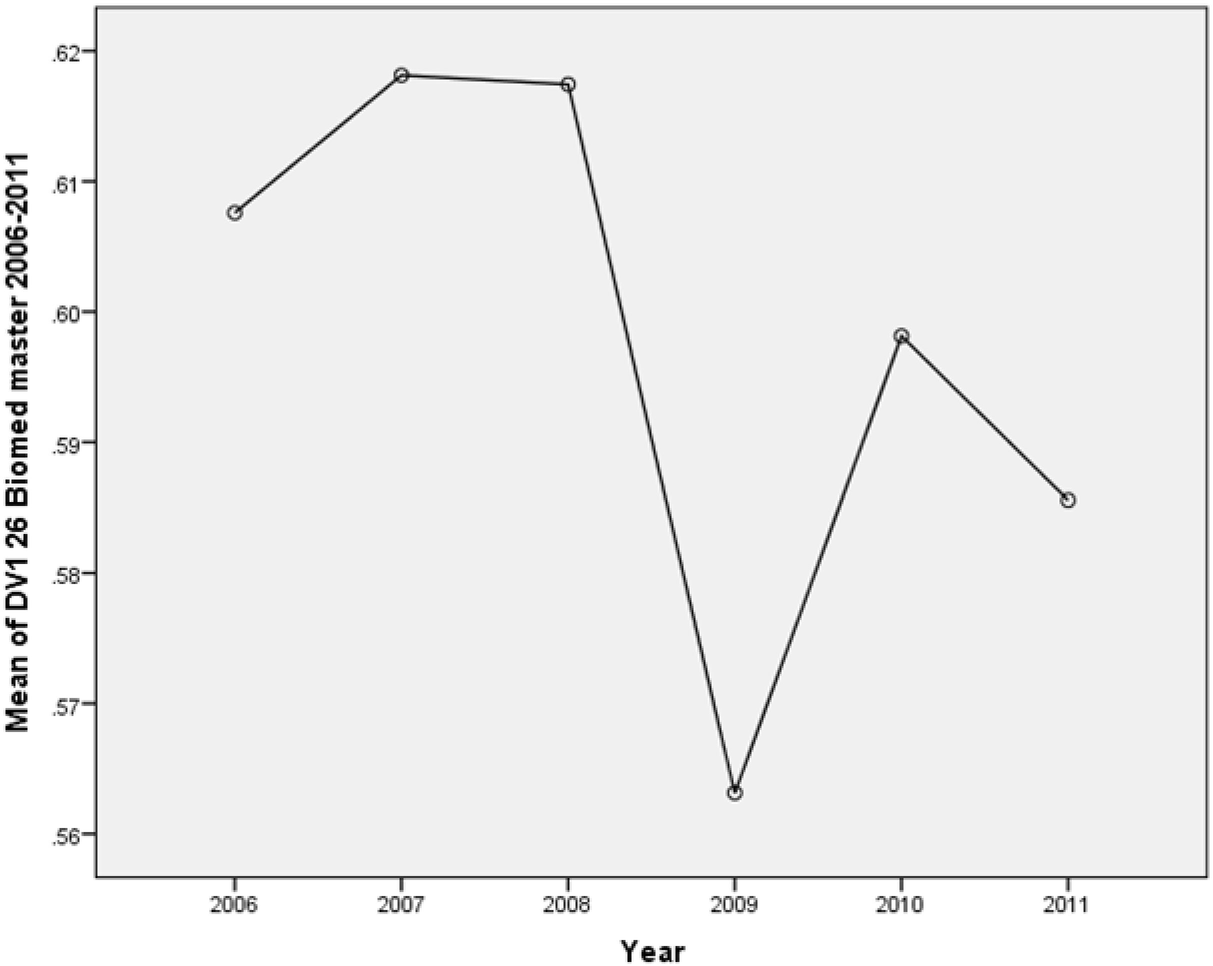


Figure H6. CIP 26 Doctoral Means

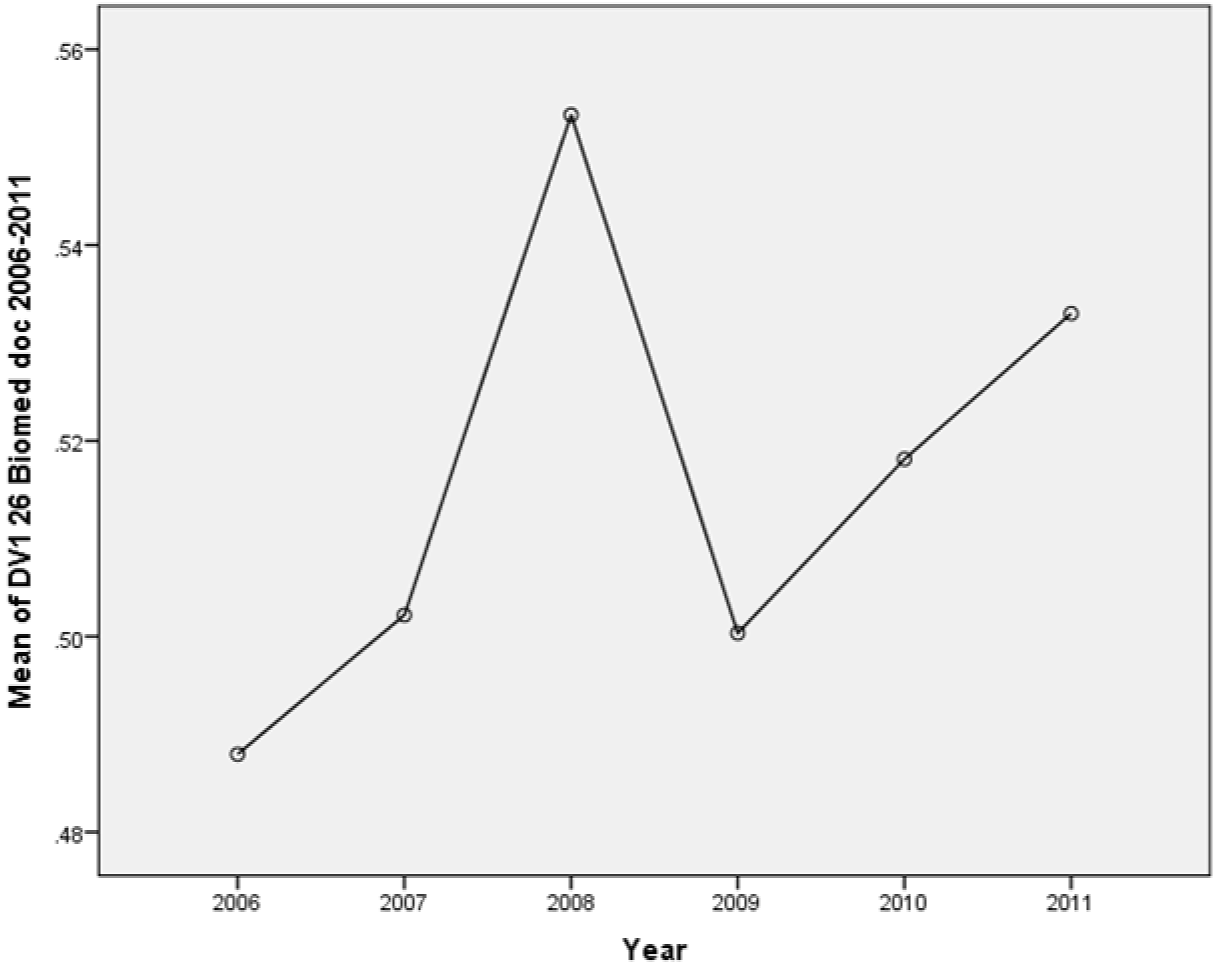


Figure H7. CIP 27 Master's Means

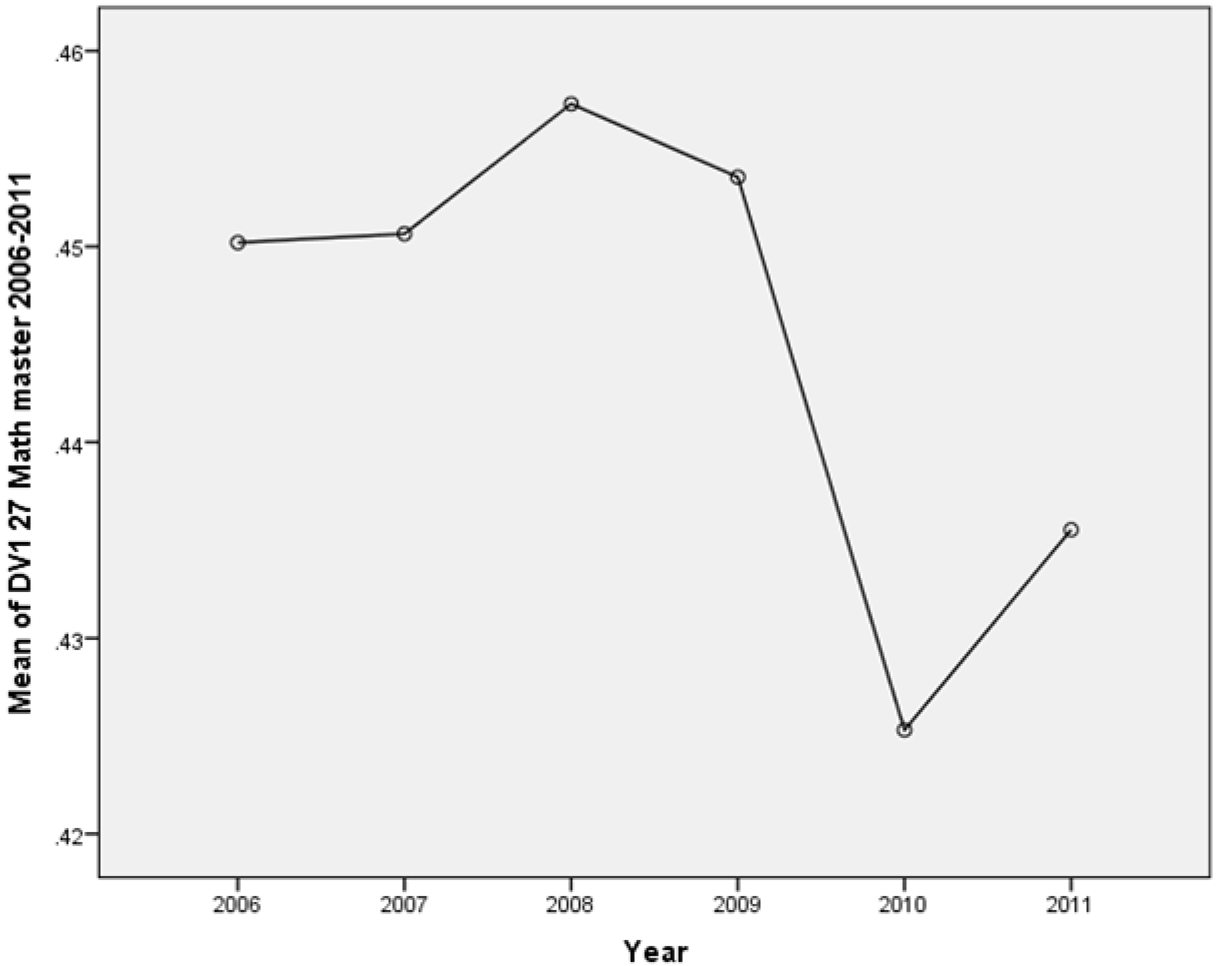


Figure H8. CIP 27 Doctoral Means

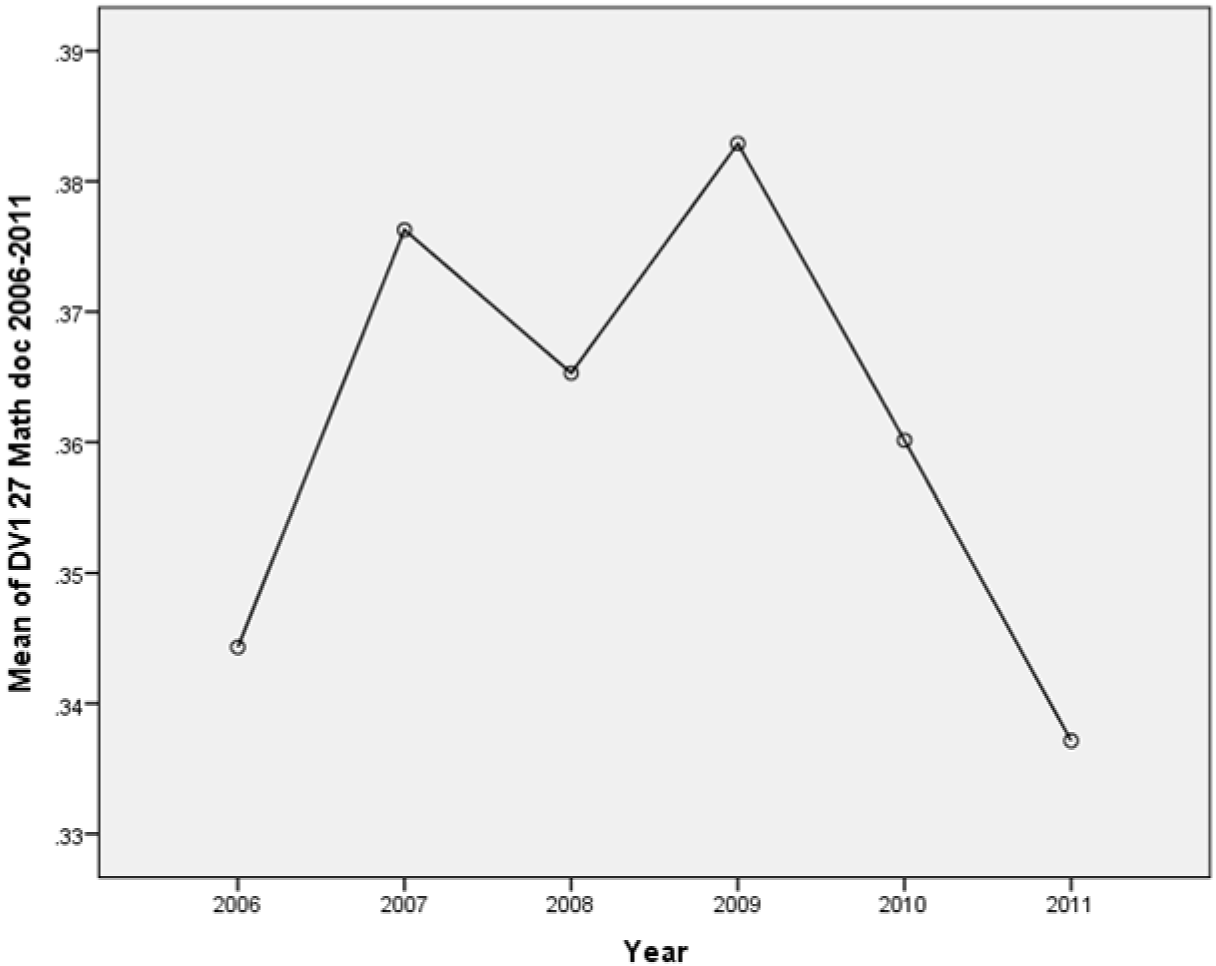


Figure H9. CIP 40 Master's Means

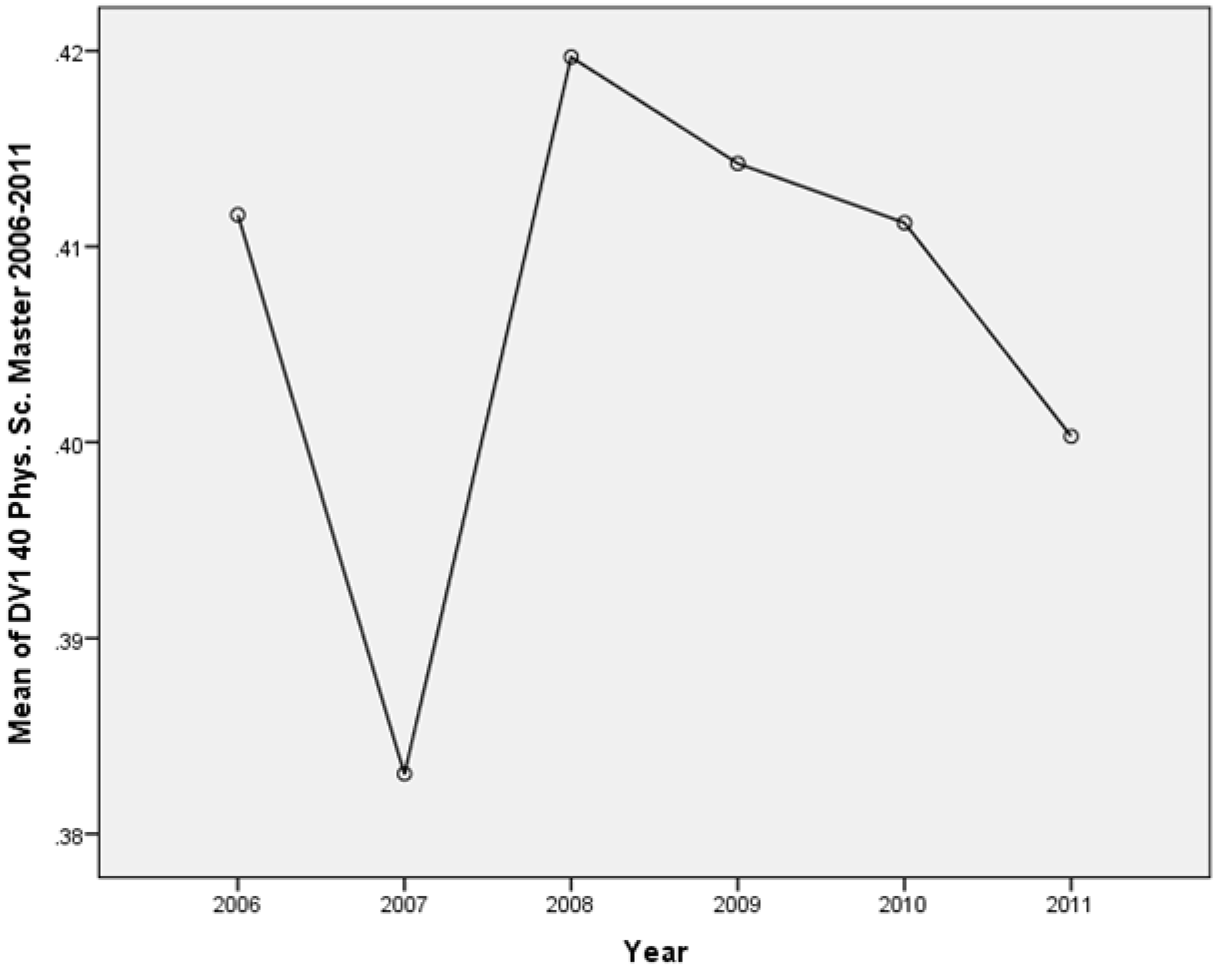
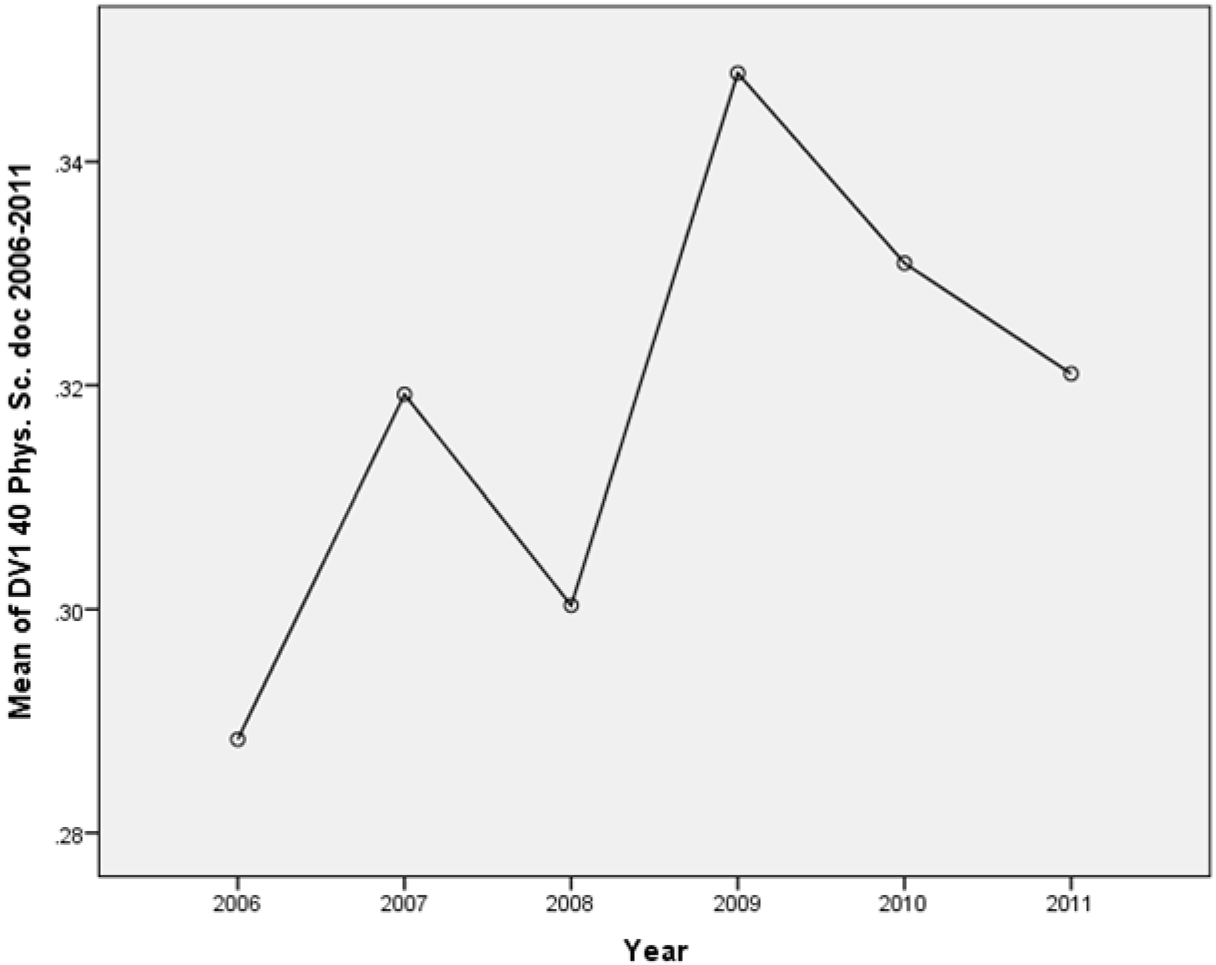


Figure H10. CIP 40 Doctoral Means



Appendix I

Research Question Six Statistics

Assumption for Linear Relationship Scatterplots
Figure I1. CIP 11 Master by Ratio Female Graduate Students

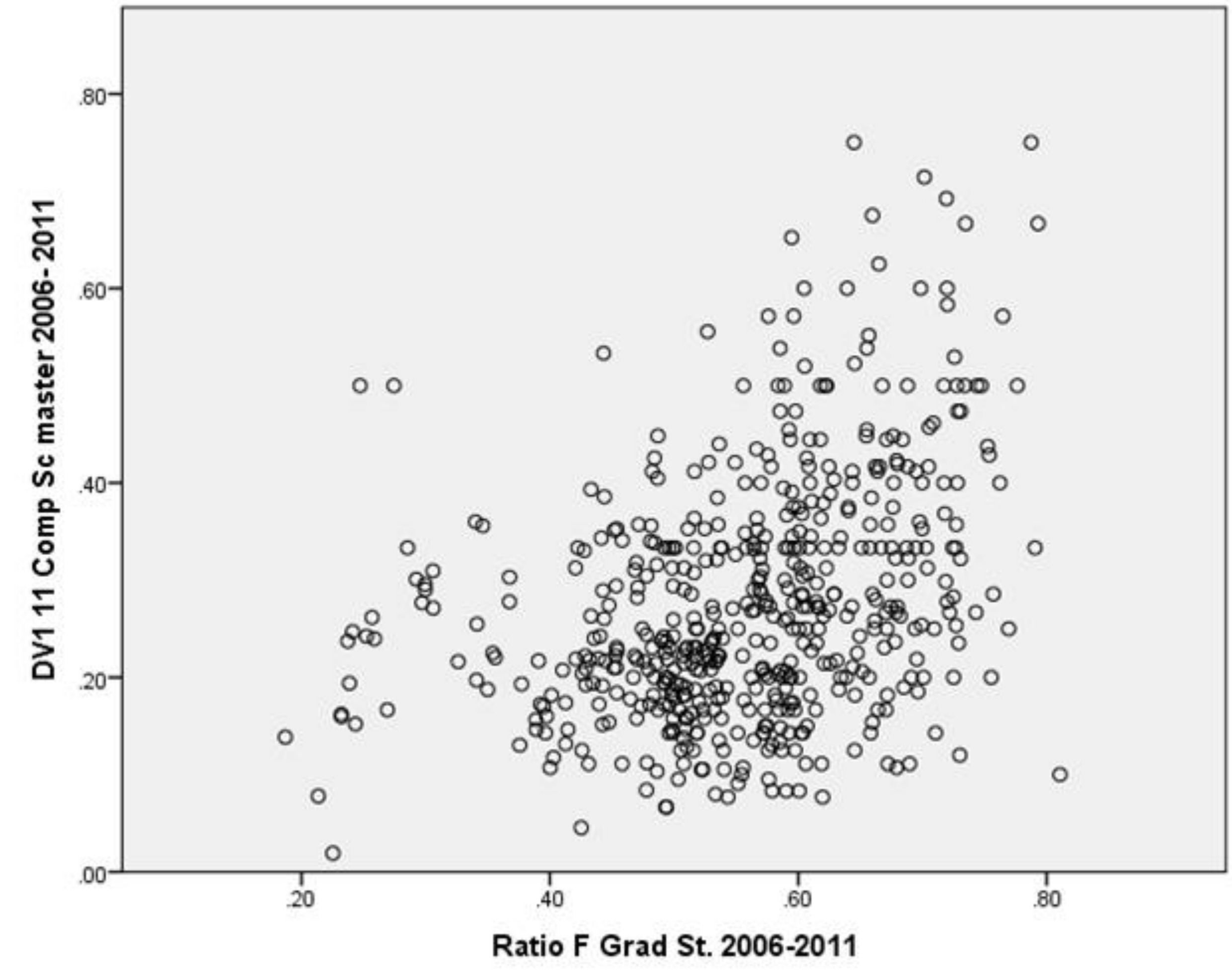


Figure I2. CIP 11 Master by Ratio Female Undergraduate Students

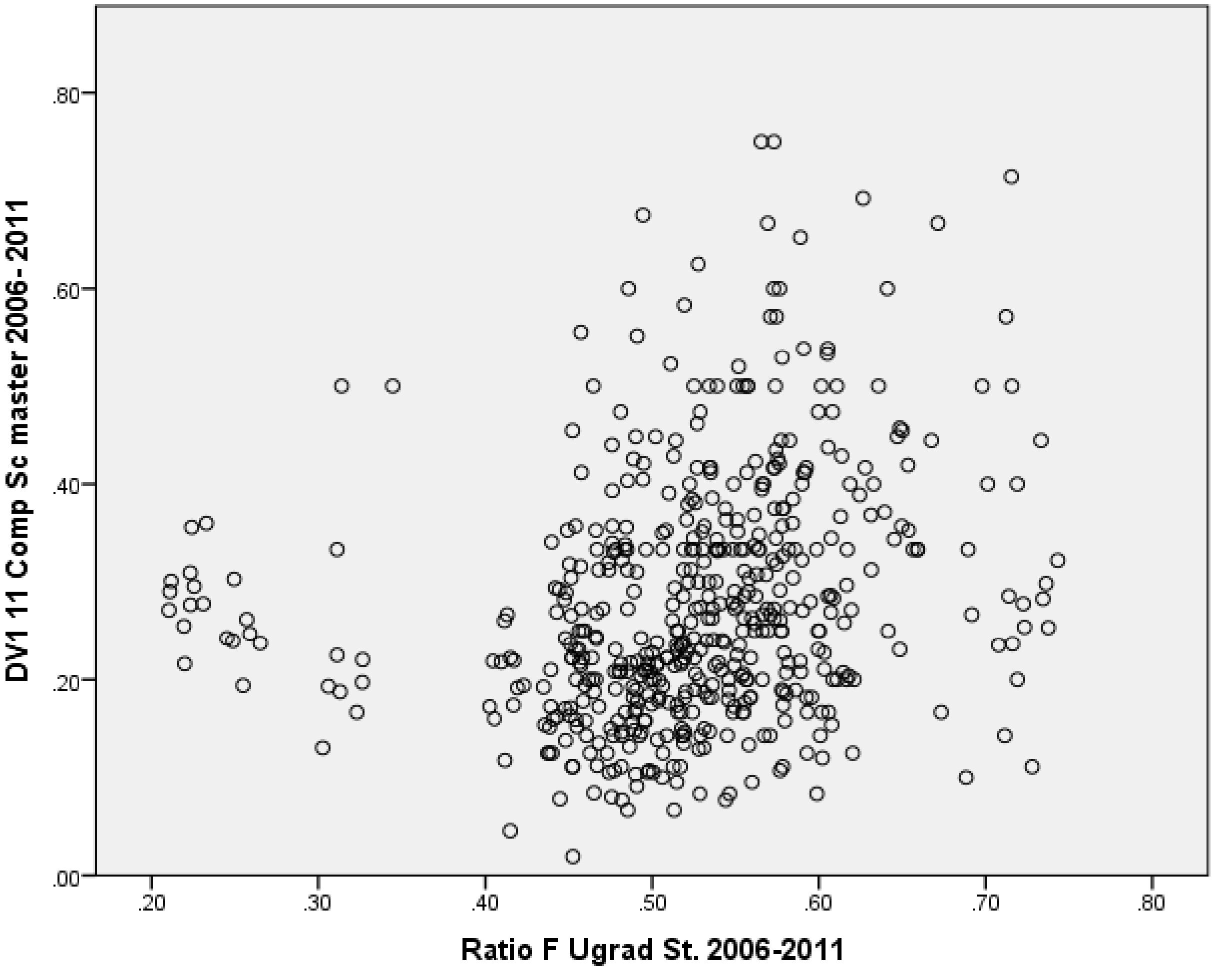


Figure I3. CIP 11 Master by Ratio Female Graduate Assistants

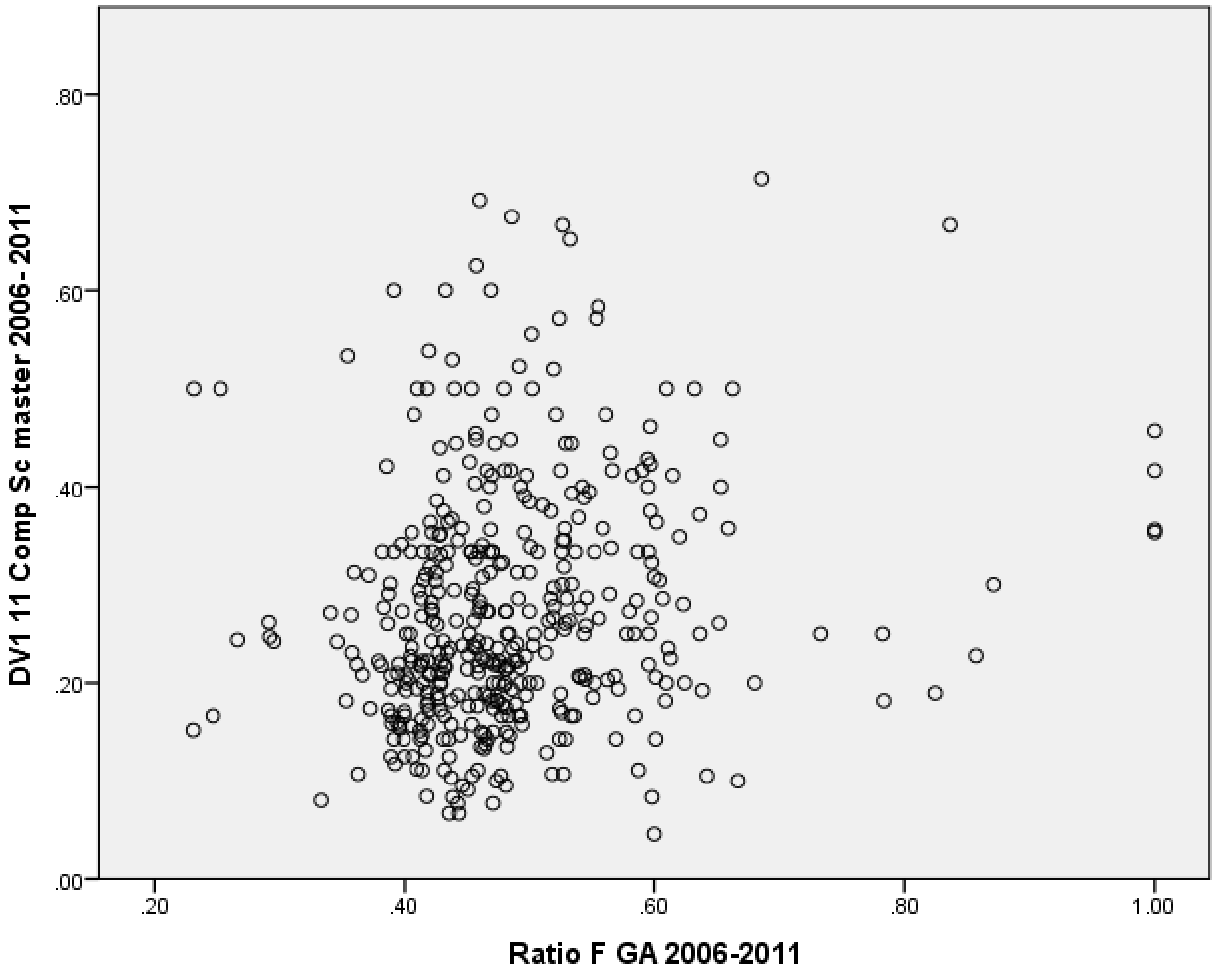


Figure I4. CIP 11 Master by Ratio Female Faculty

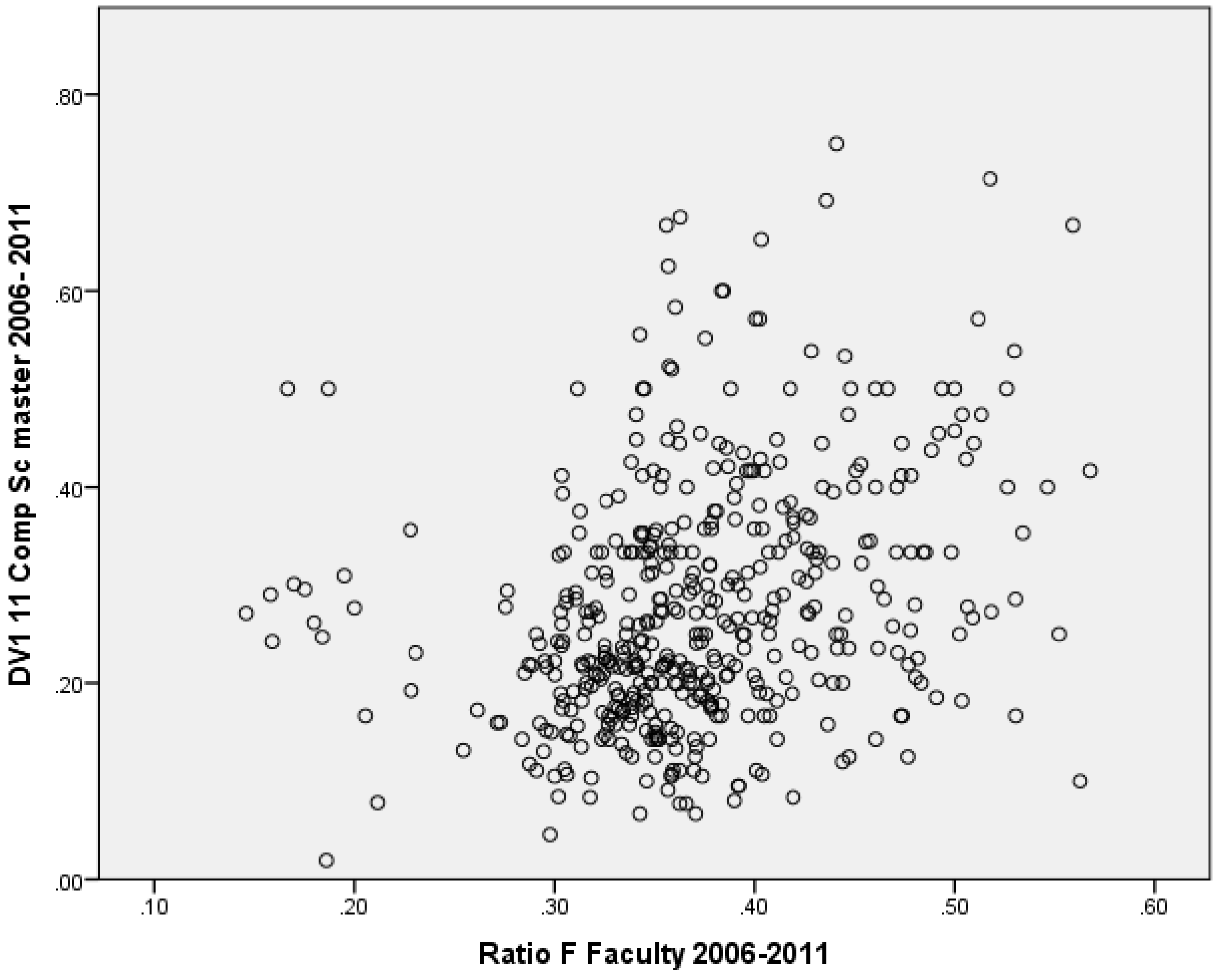


Figure I5. CIP 11 Master by Ratio Female Administrators

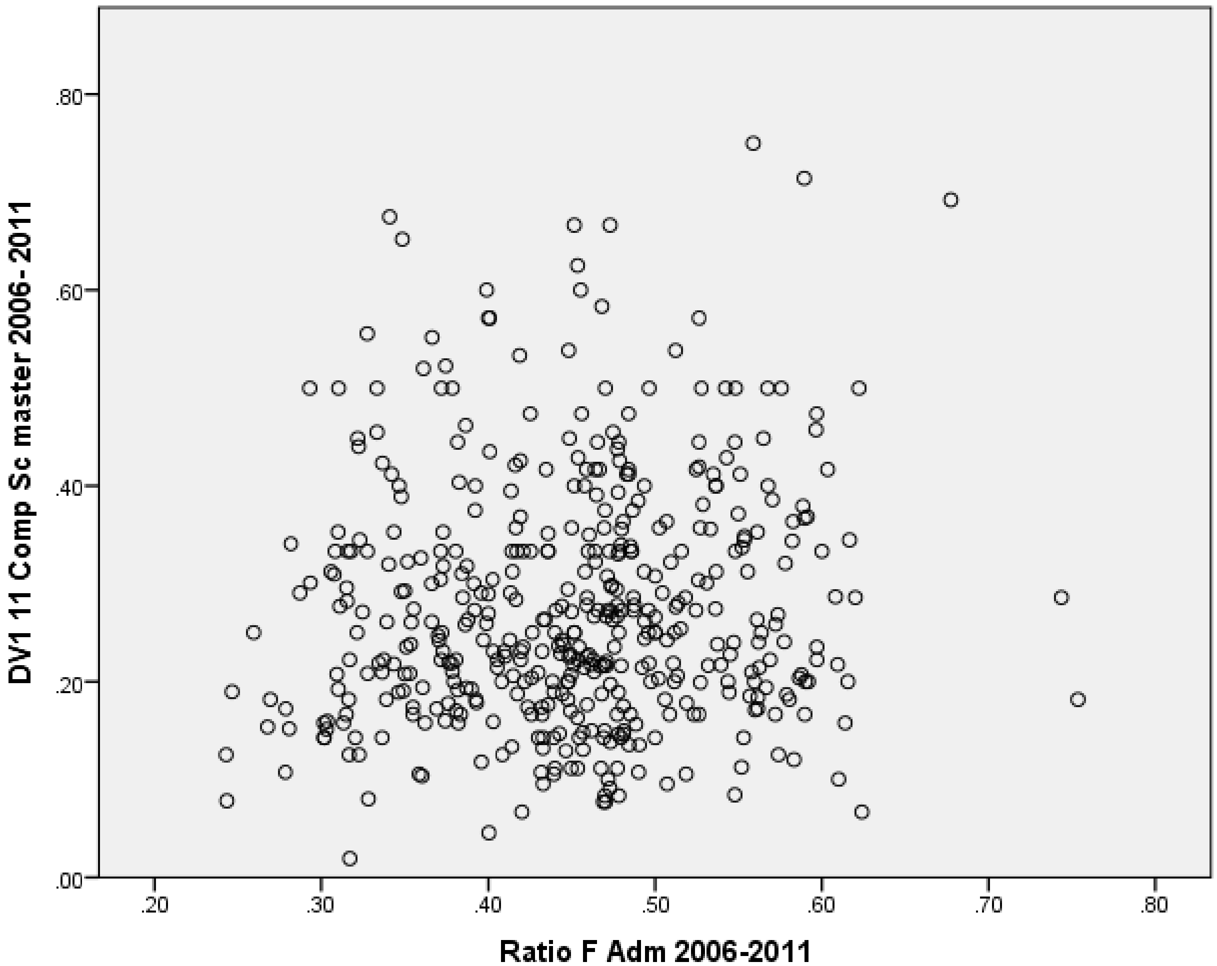


Figure I6. CIP 11 Master by Enrollment

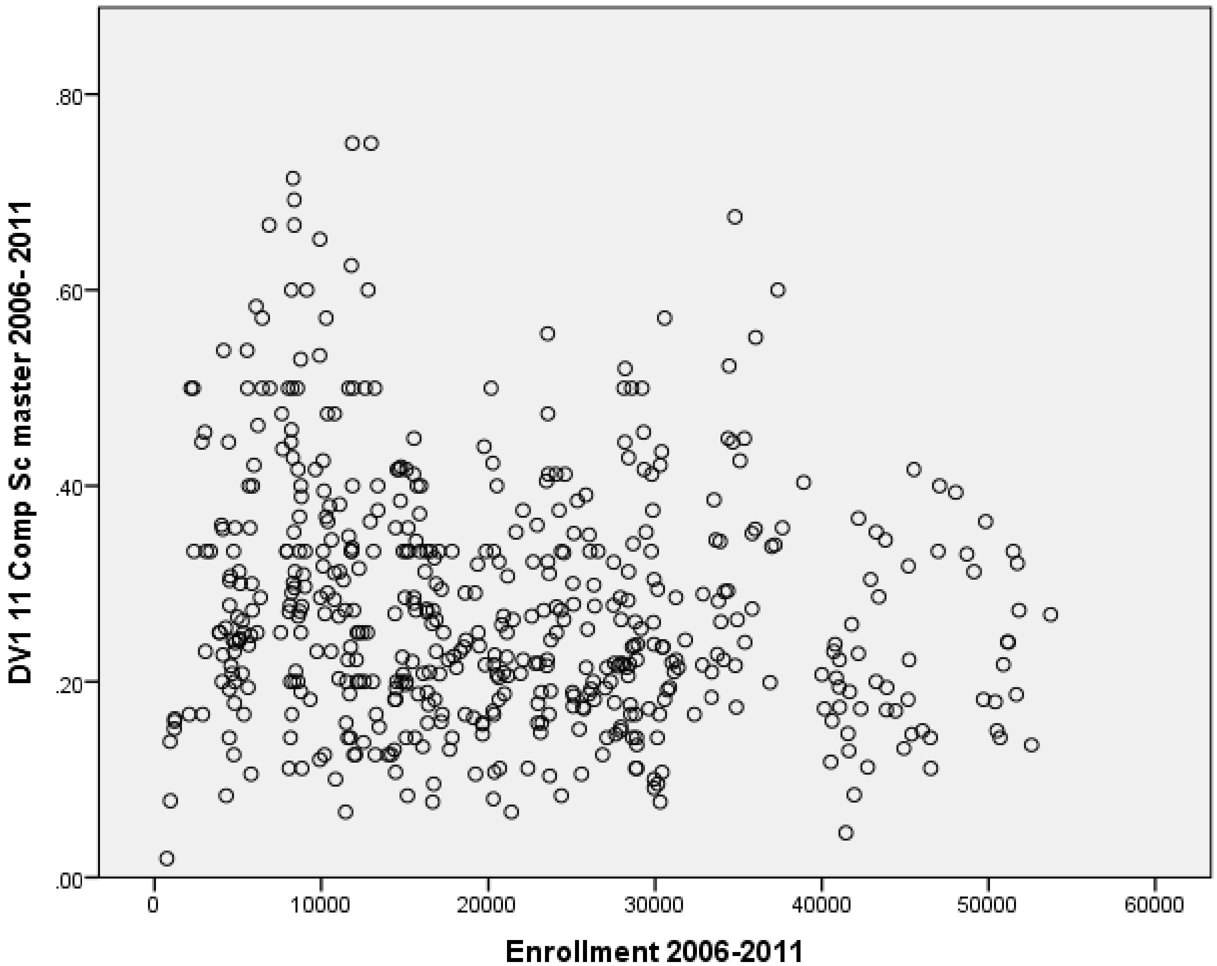


Figure I7. CIP 11 by Research Expenditures

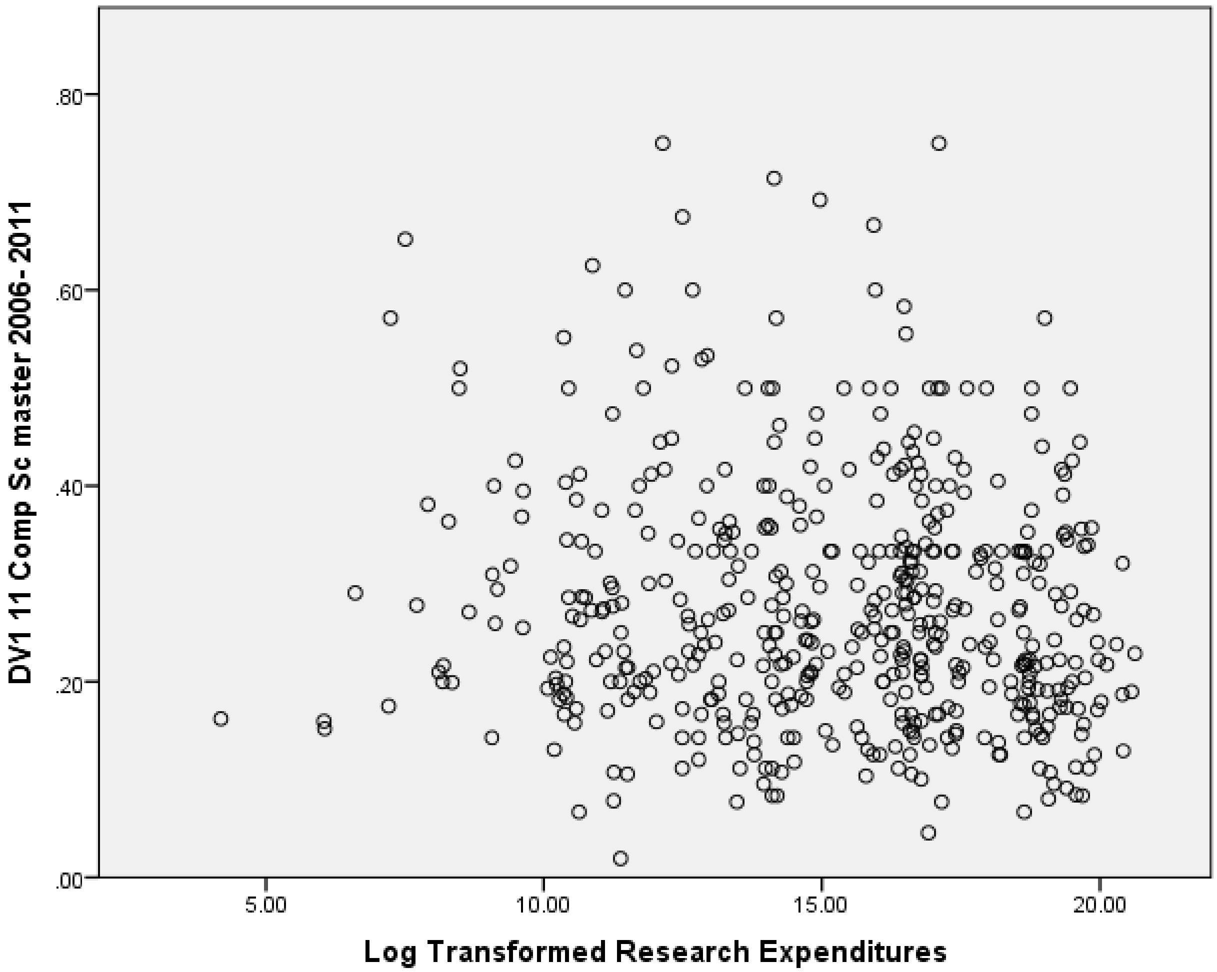


Figure I8. CIP 11 Doctoral by Ratio Female Graduate Students

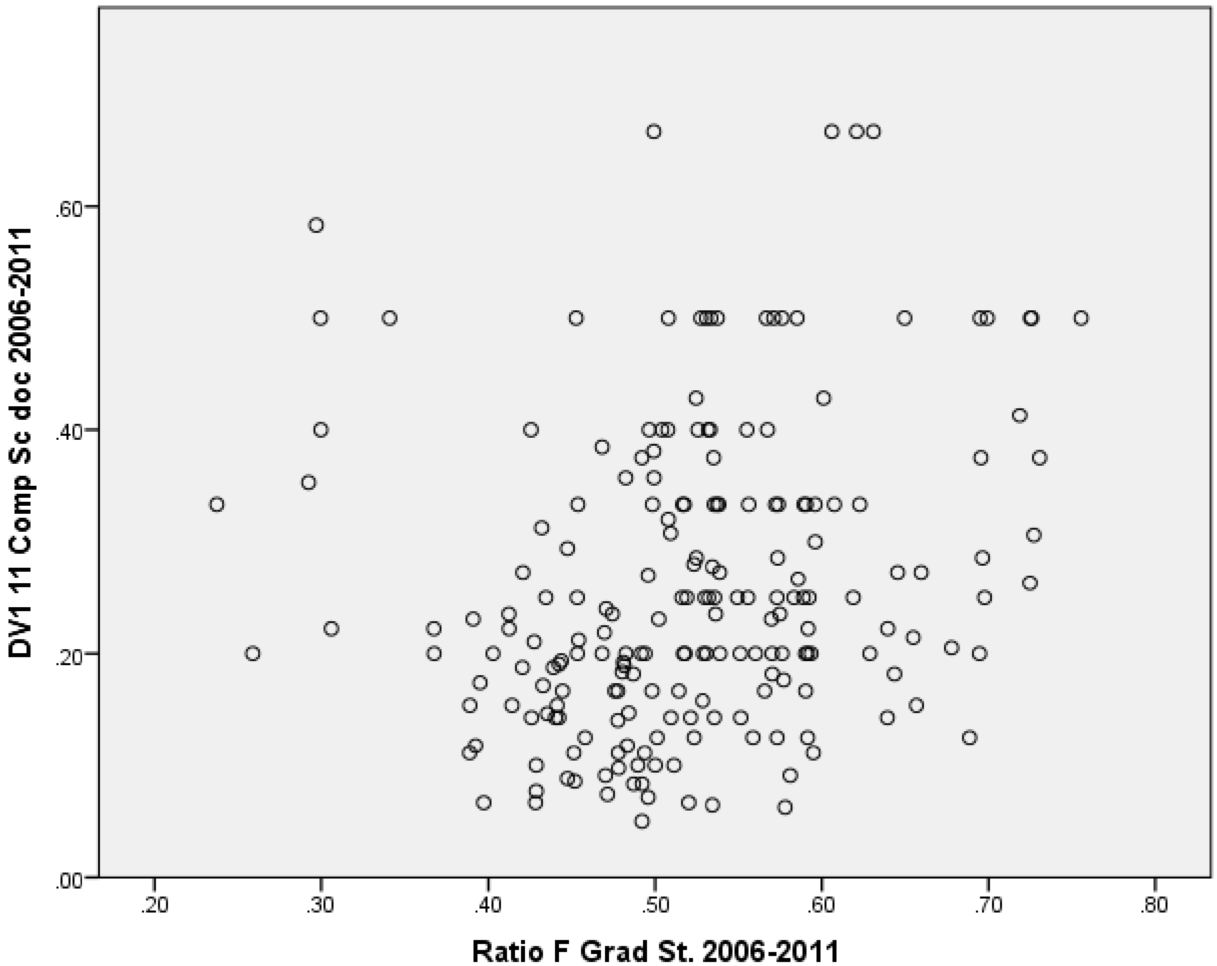


Figure I9. CIP 11 Doctoral by Ratio Female Undergraduate Students

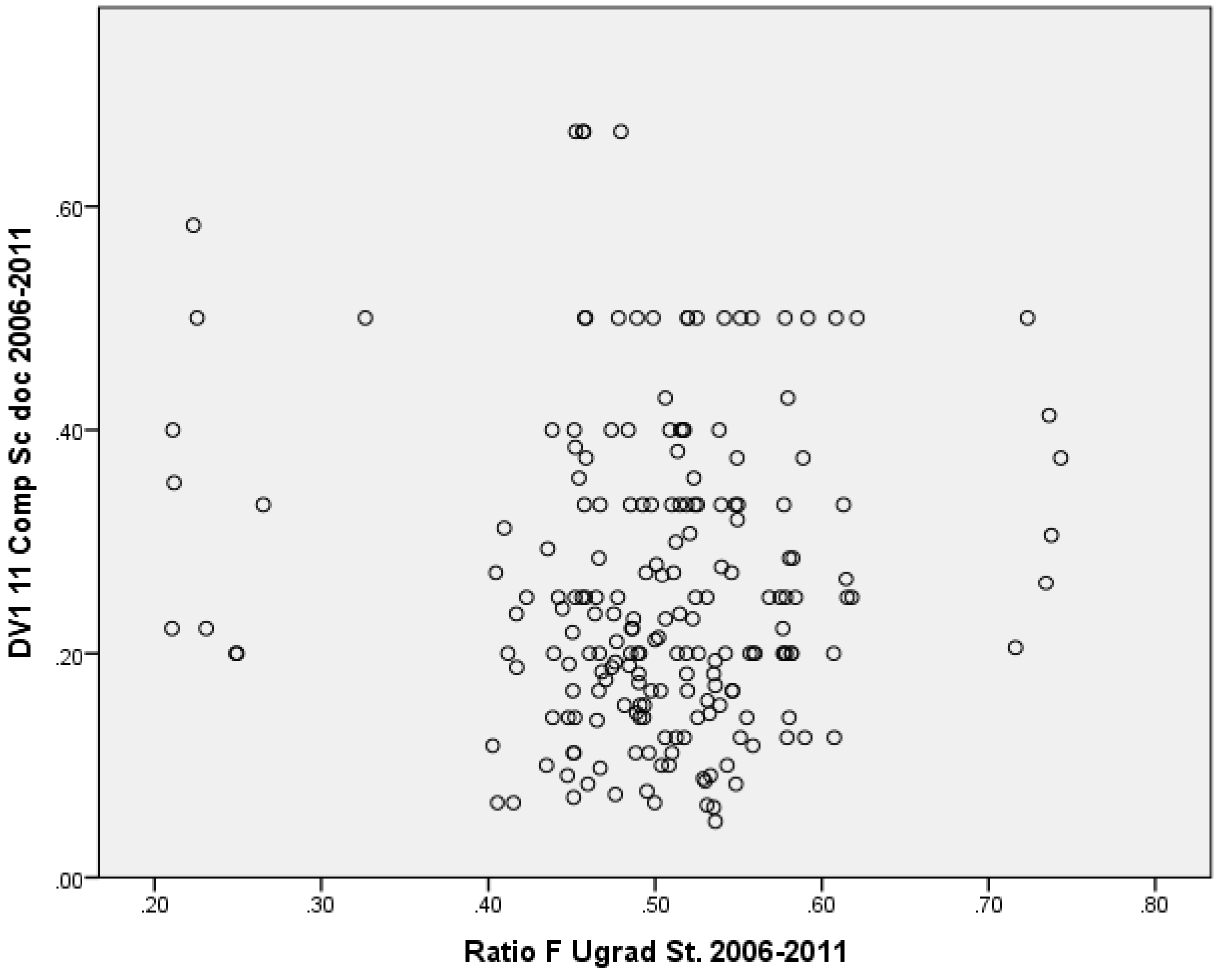


Figure I10. CIP 11 Doctoral by Ratio Female Graduate Assistants

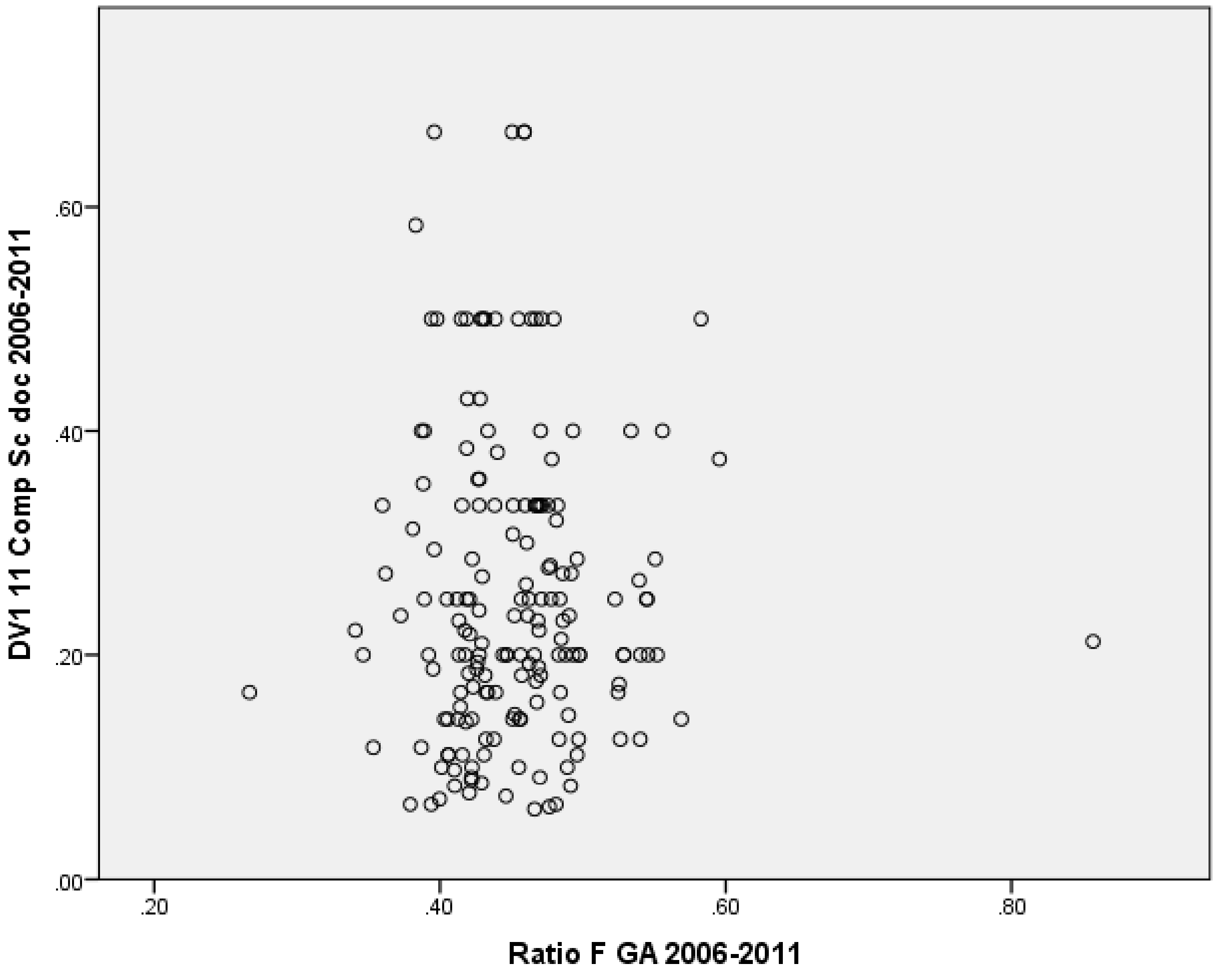


Figure I11. CIP 11 Doctoral by Ratio Female Faculty

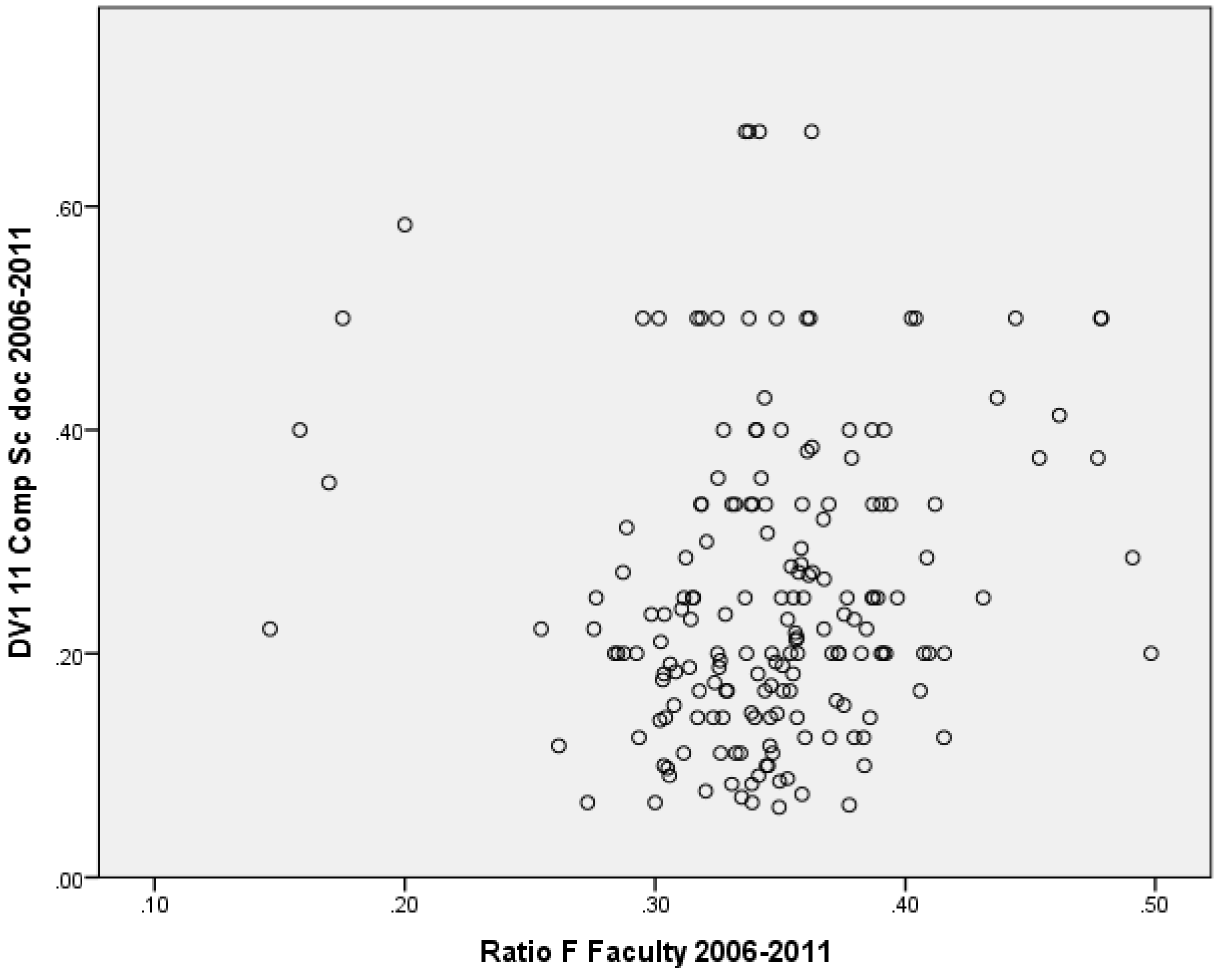


Figure I12. CIP 11 Doctoral by Ratio Female Administrators

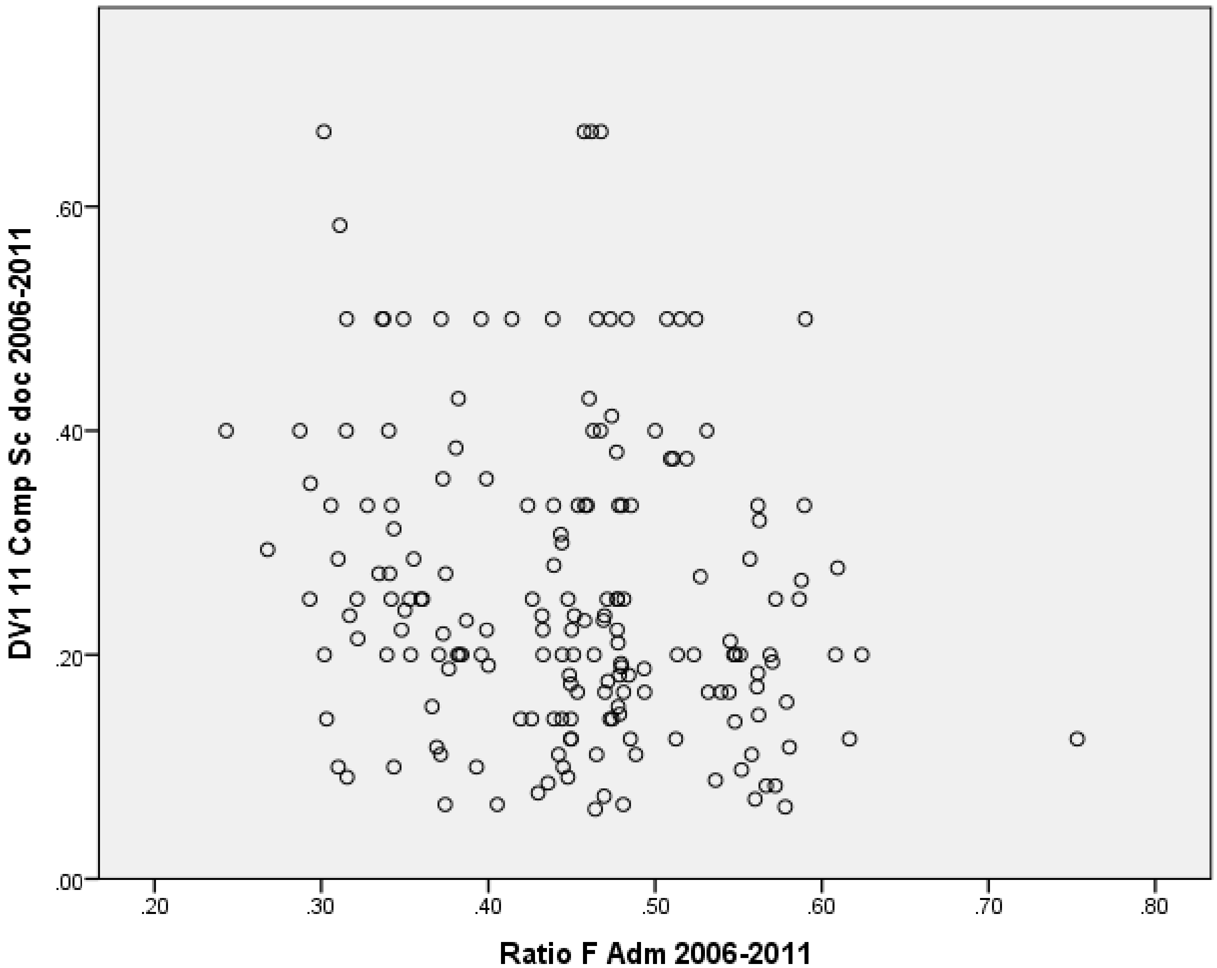


Figure I13. CIP 11 Doctoral by Enrollment

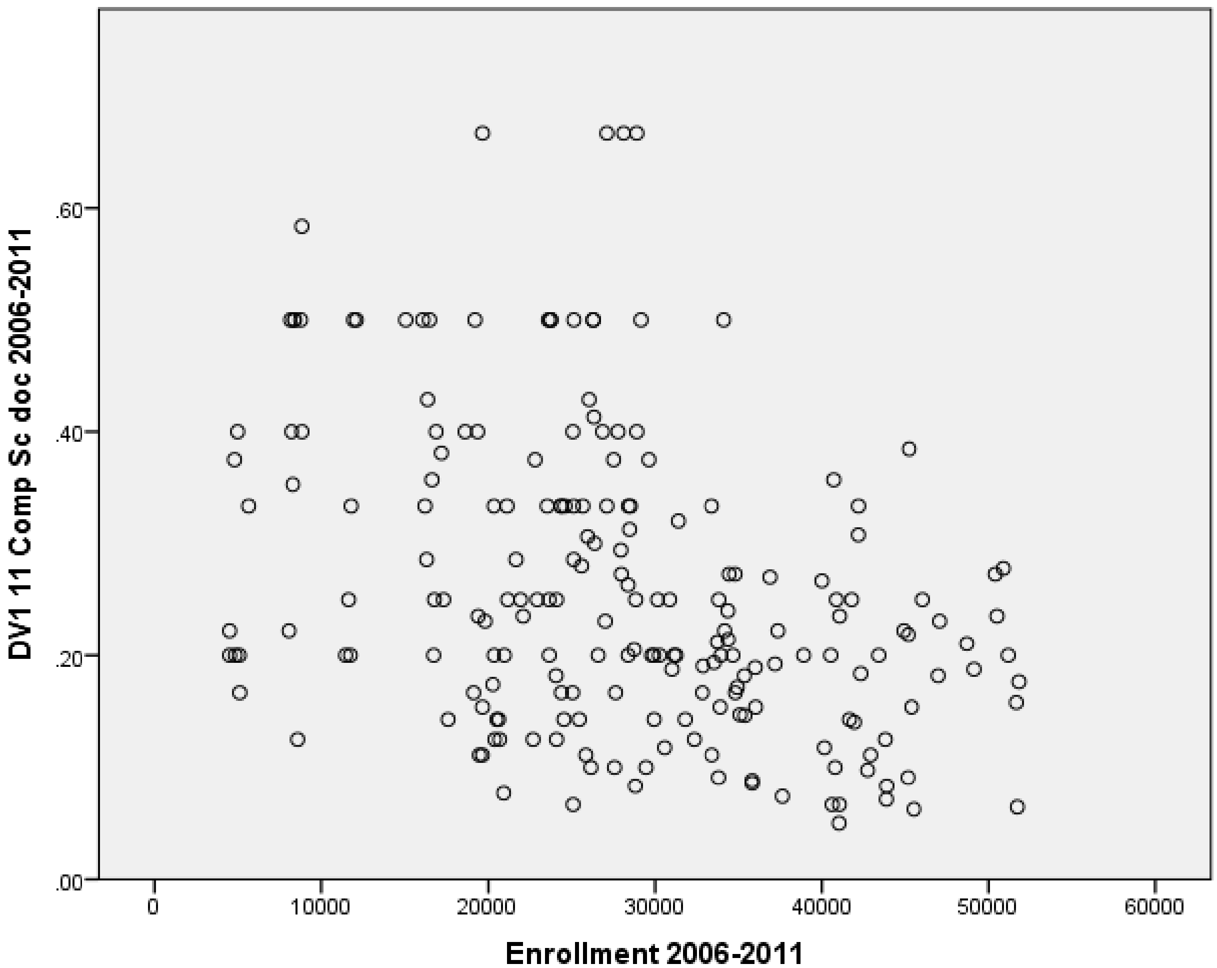


Figure I14. CIP 11 Doctoral by Research Expenditures

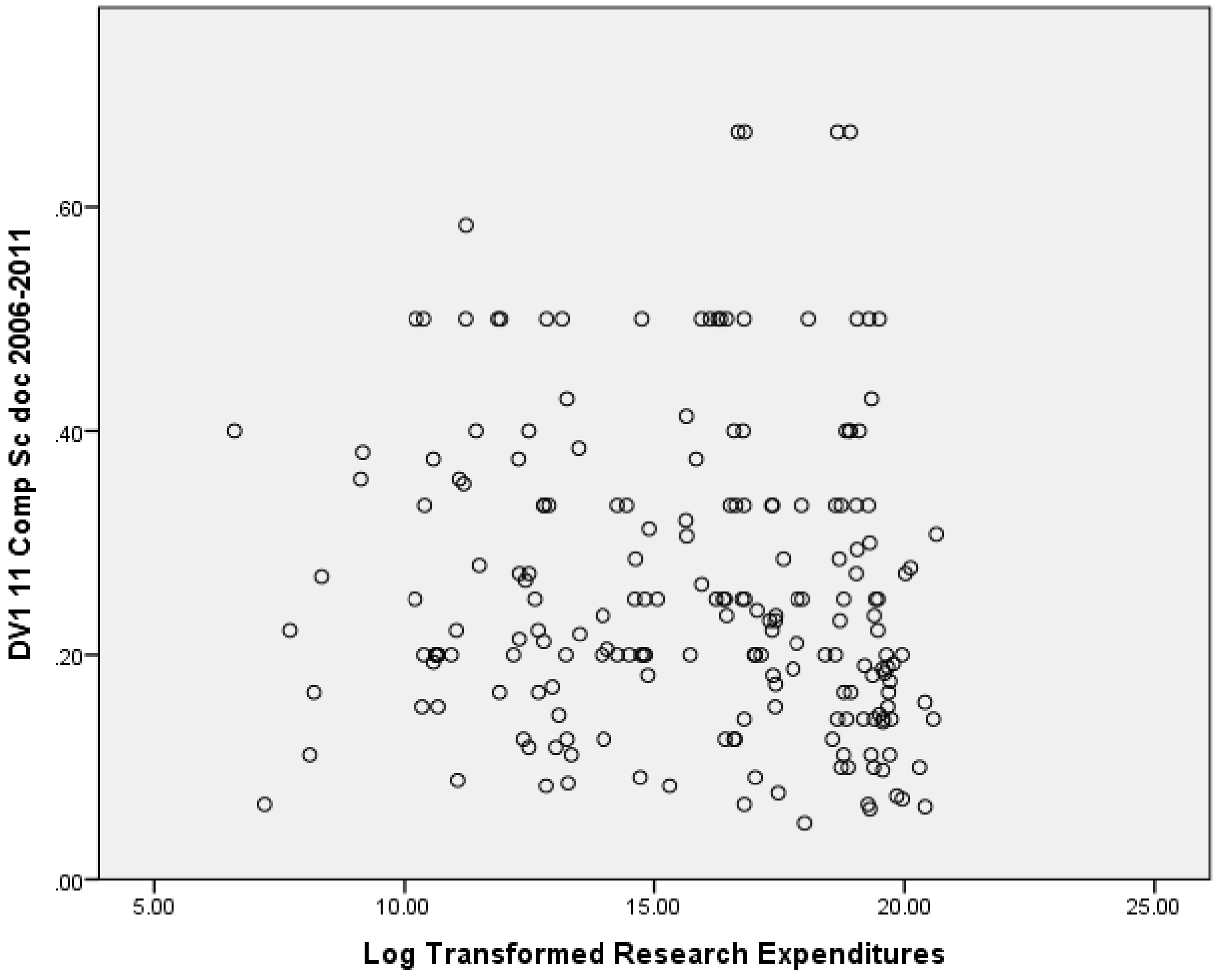


Figure I15. CIP 14 Master by Ratio Female Graduate Students

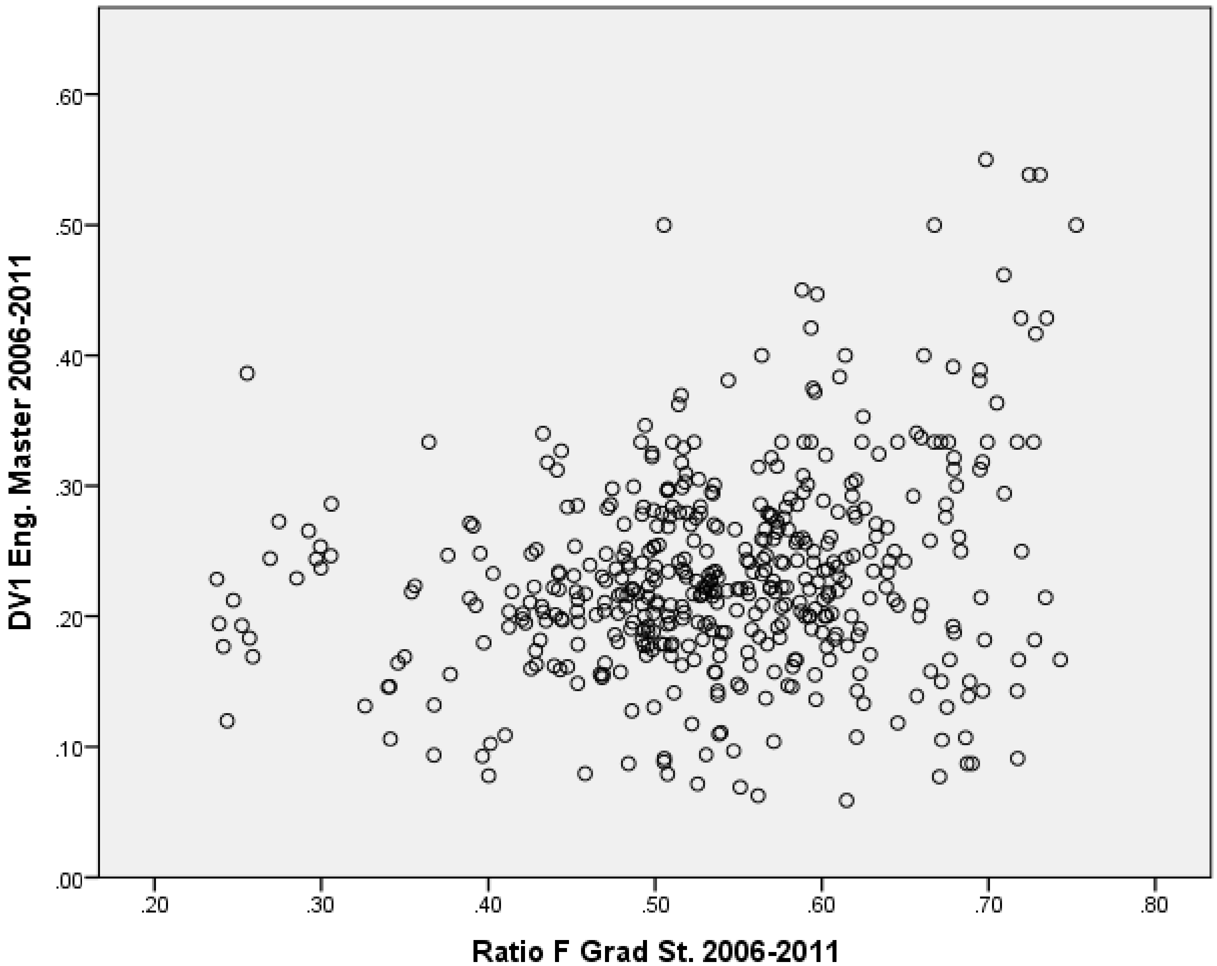


Figure I16. CIP 14 Master by Ratio Female Undergraduate Students

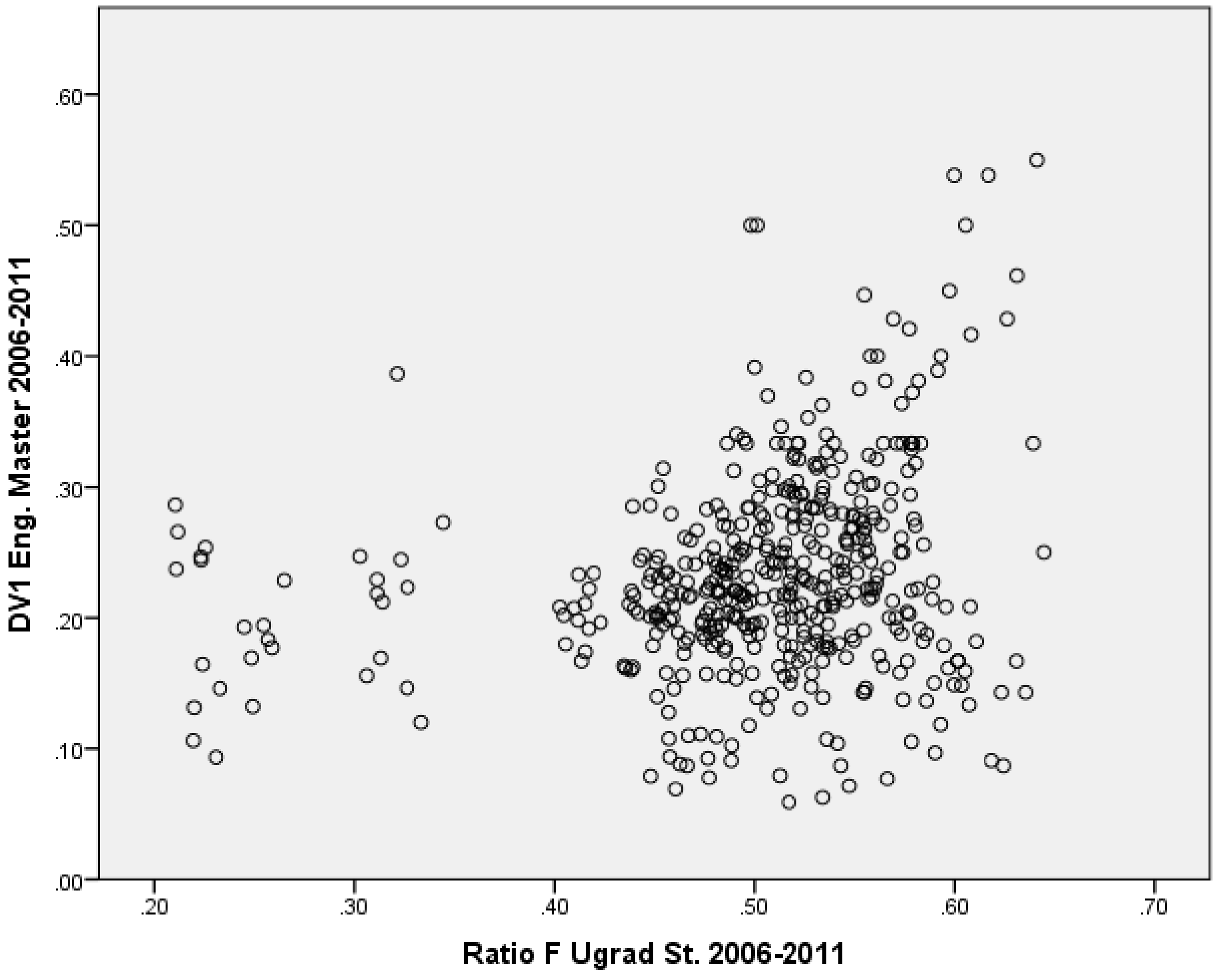


Figure I17. CIP 14 Master by Ratio Female Graduate Assistants

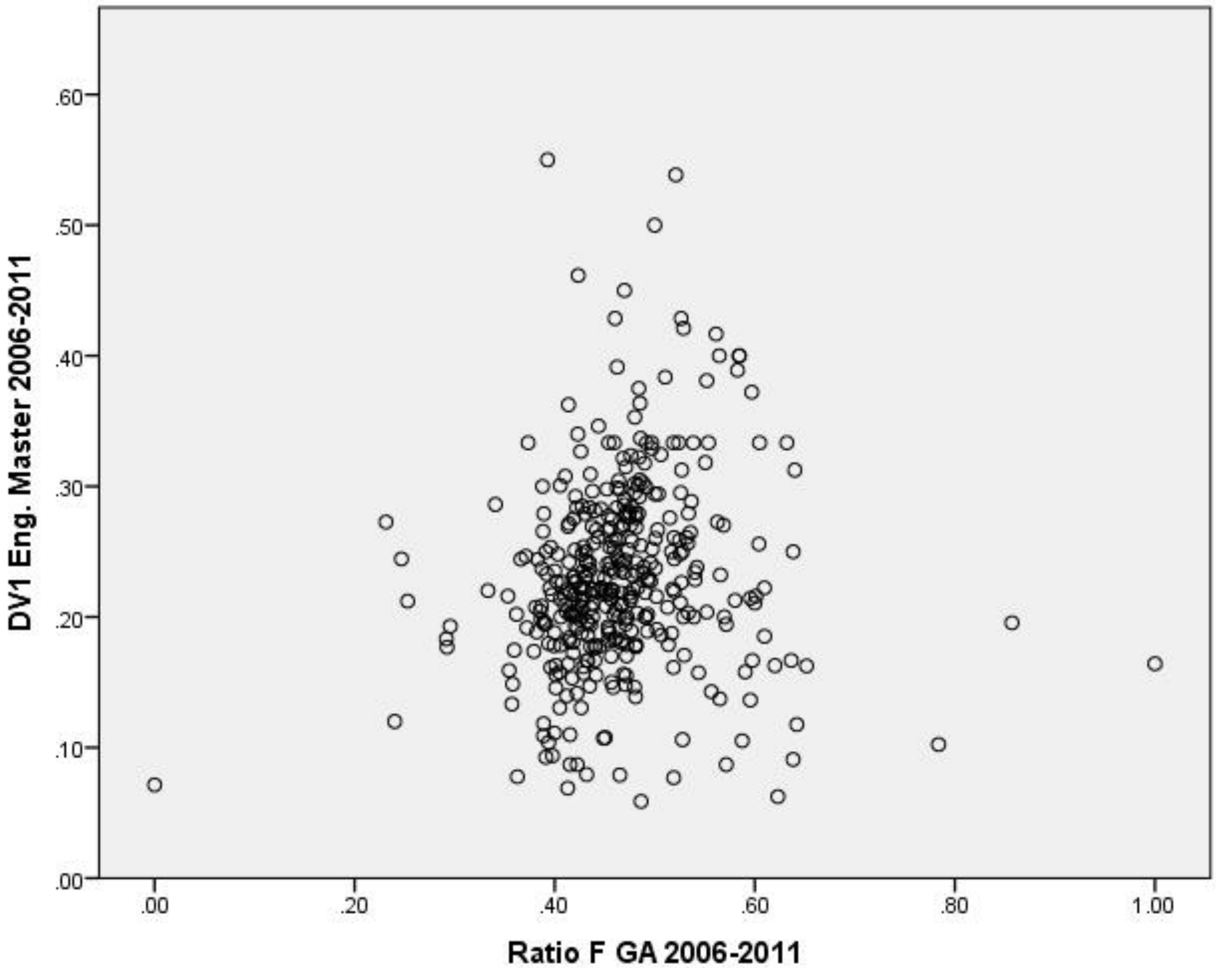


Figure I18. CIP 14 Master by Ratio Female Faculty

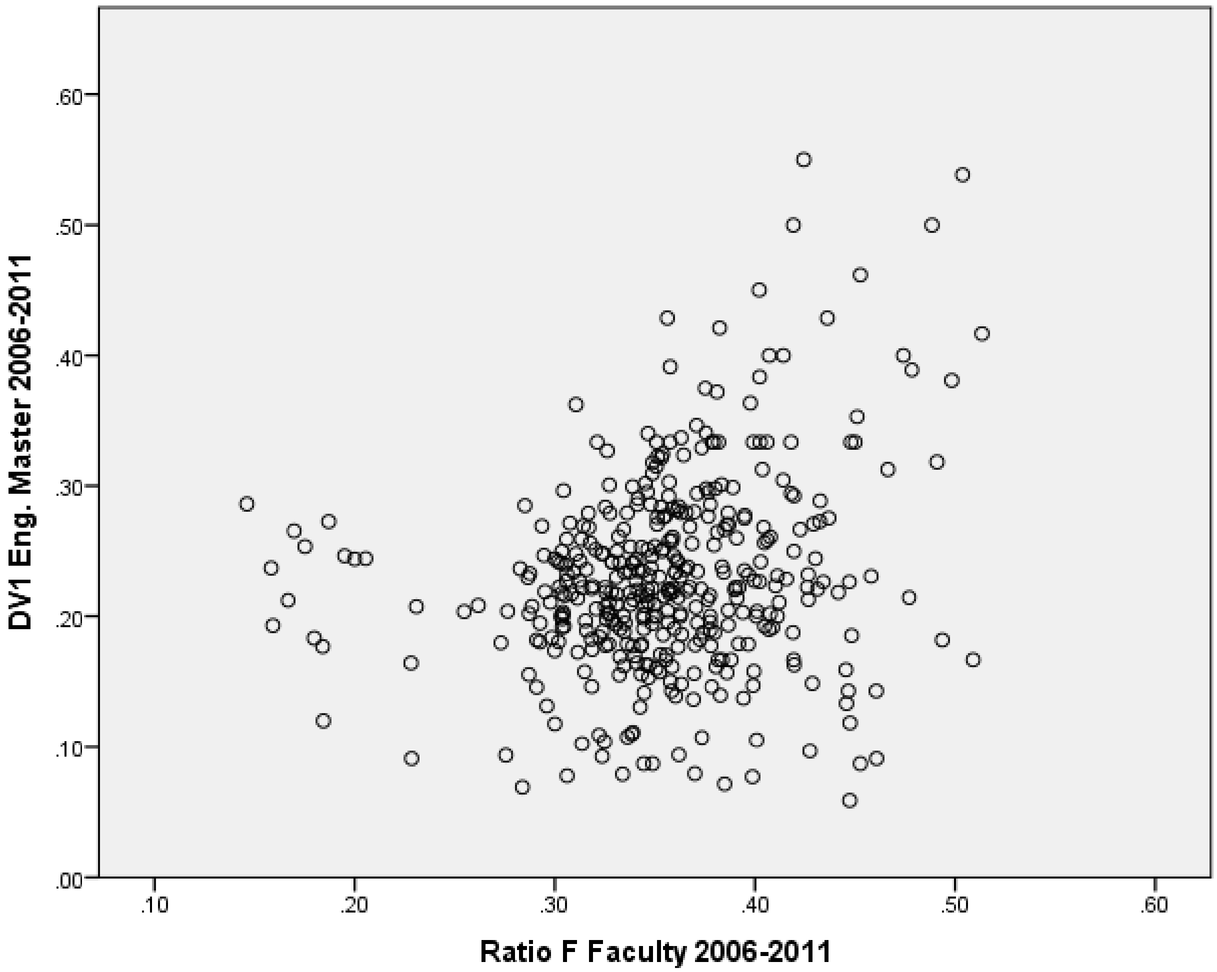


Figure I19. CIP 14 Master by Ratio Female Administrators

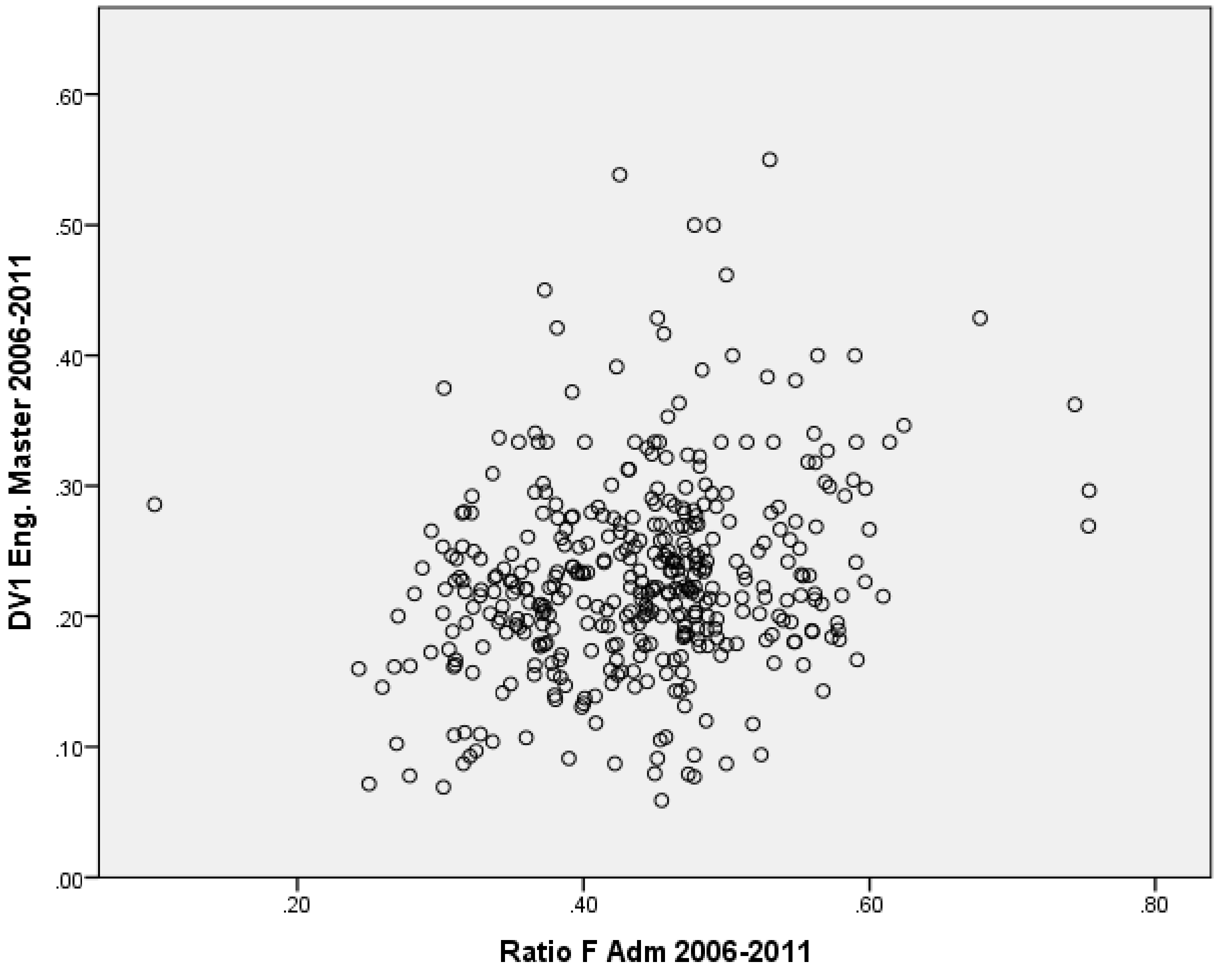


Figure I20. CIP 14 Master by Enrollment

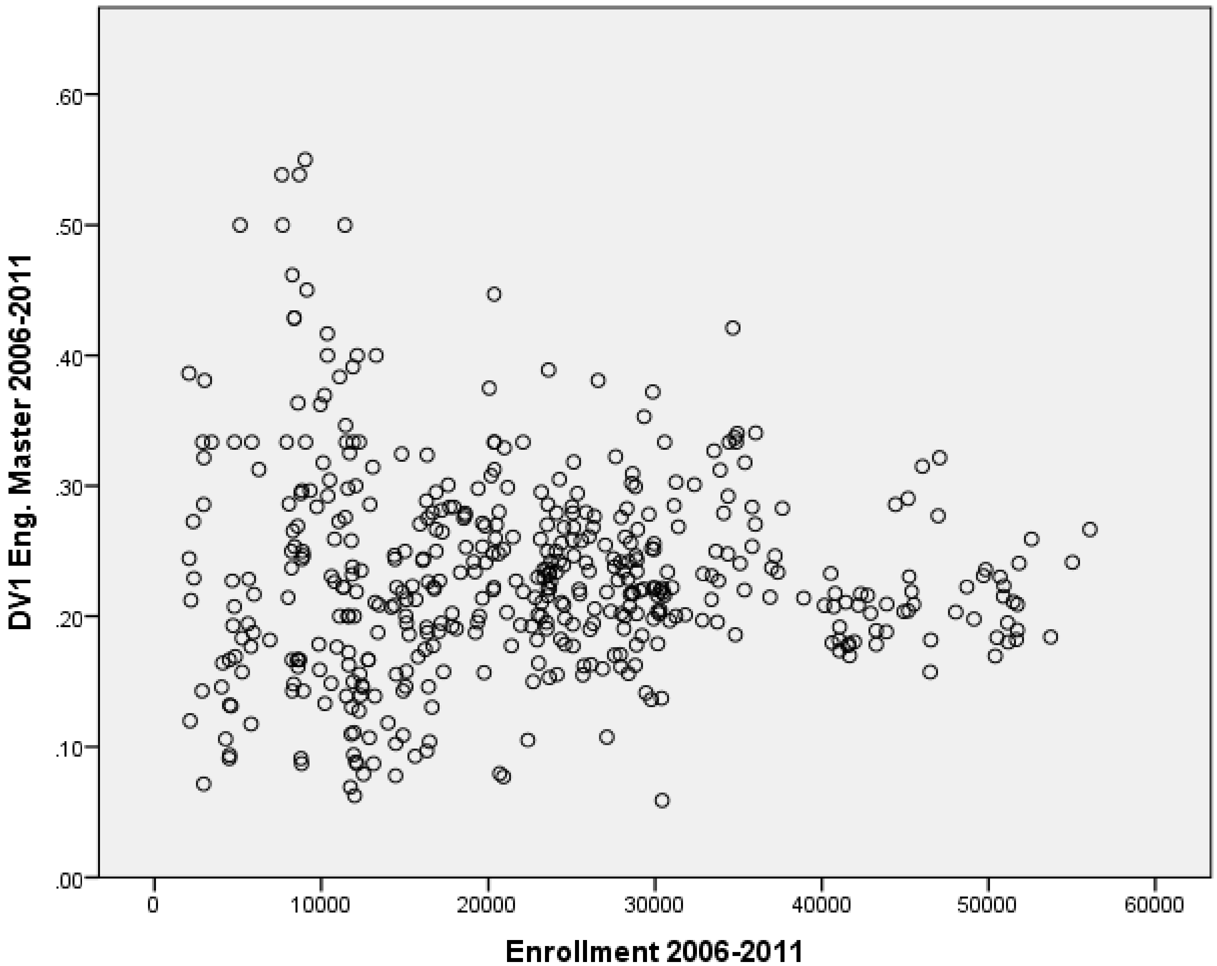


Figure I21. CIP 14 Master by Research Expenditures

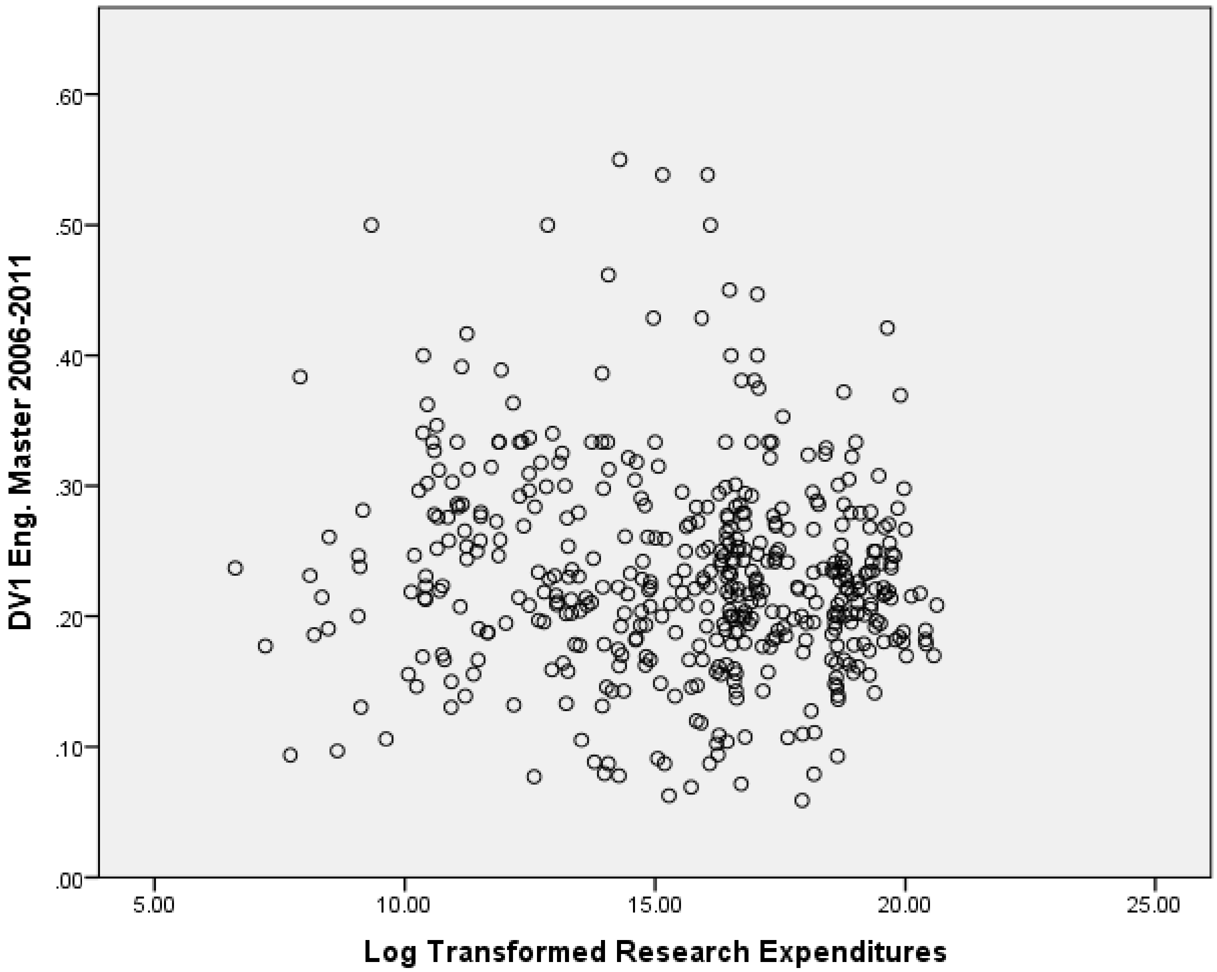


Figure I22. CIP 14 Doctoral by Ratio Female Graduate Students

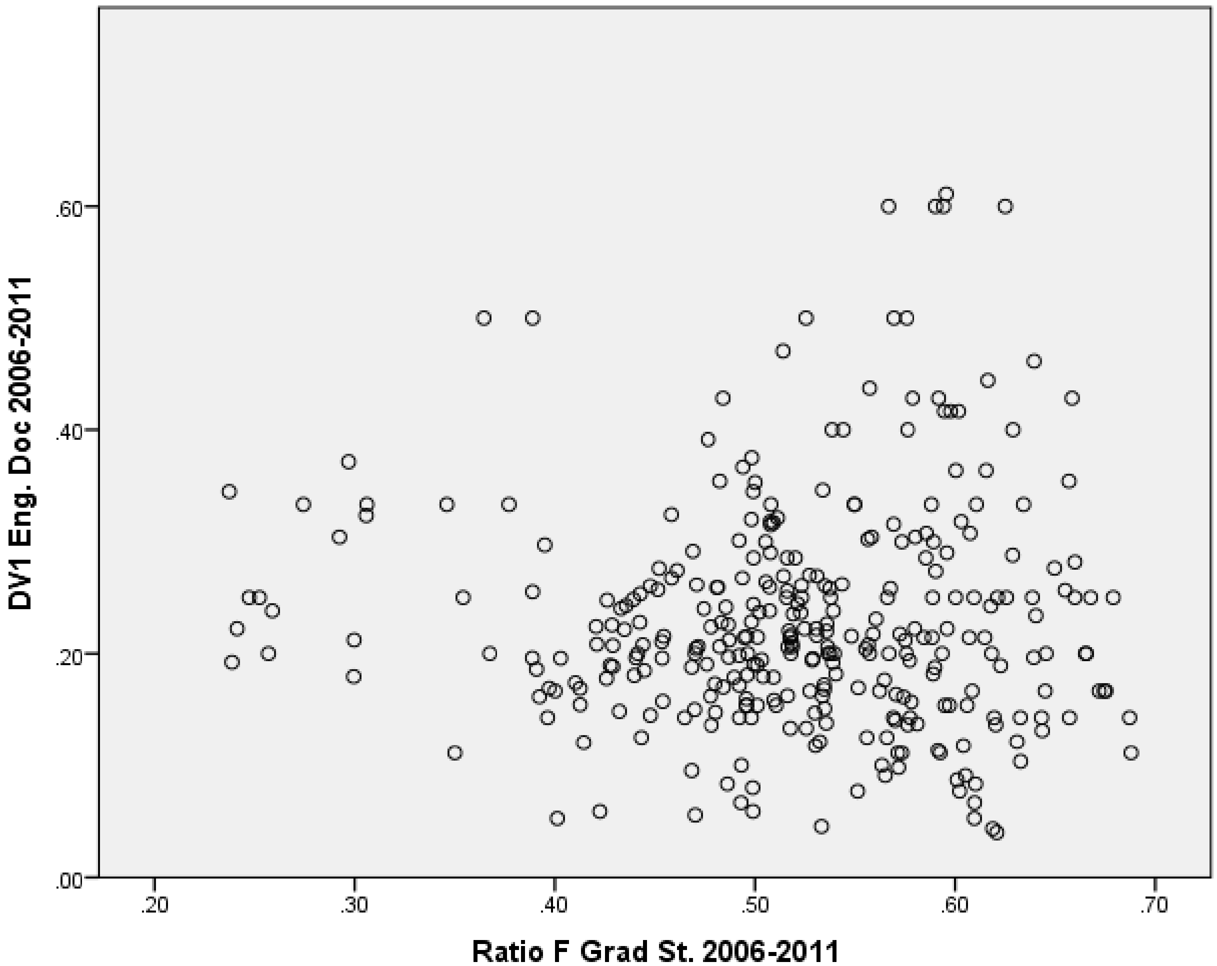


Figure I23. CIP 14 Doctoral by Ratio Female Undergraduate Students

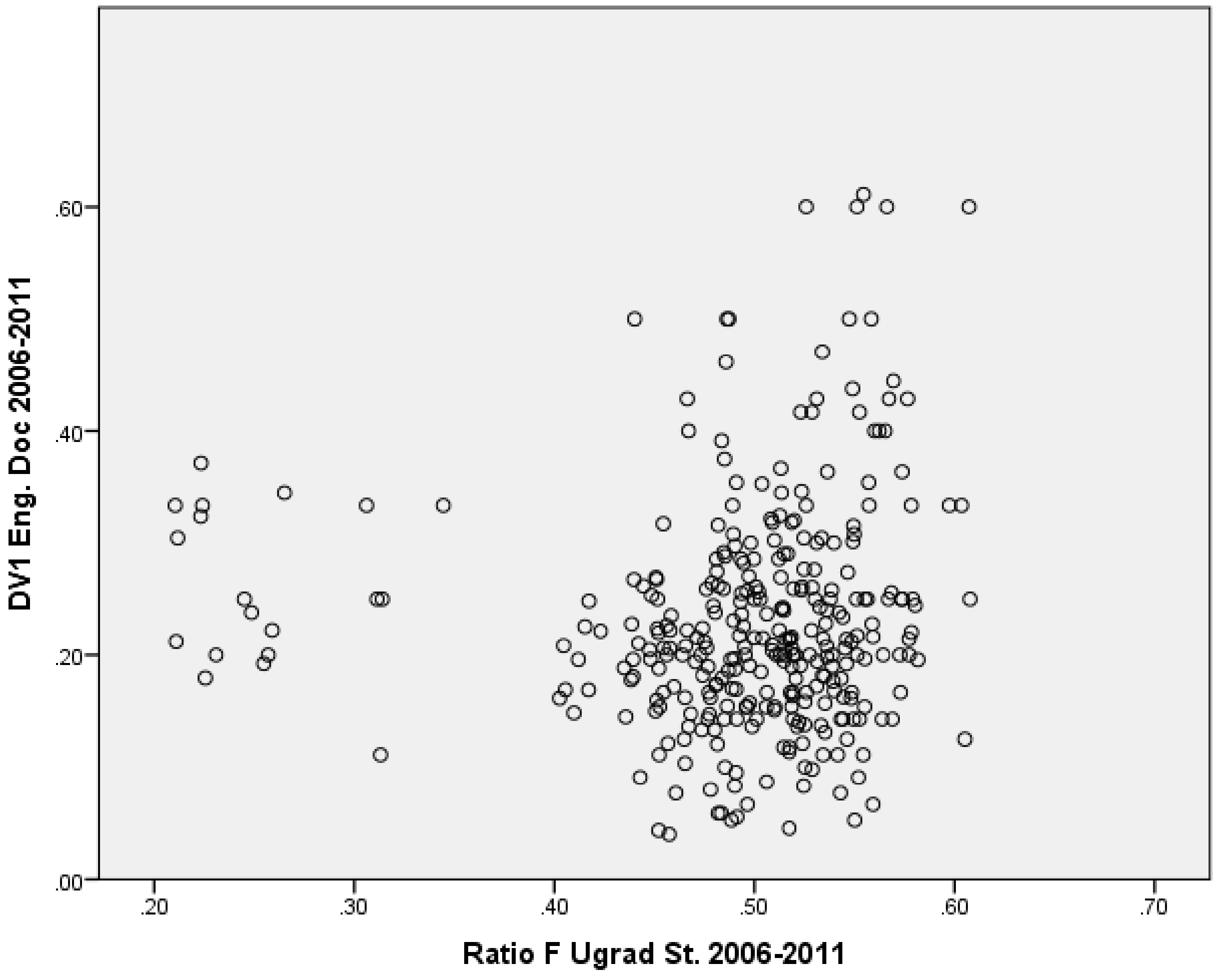


Figure I24. CIP 11 Doctoral by Ratio Female Graduate Assistants

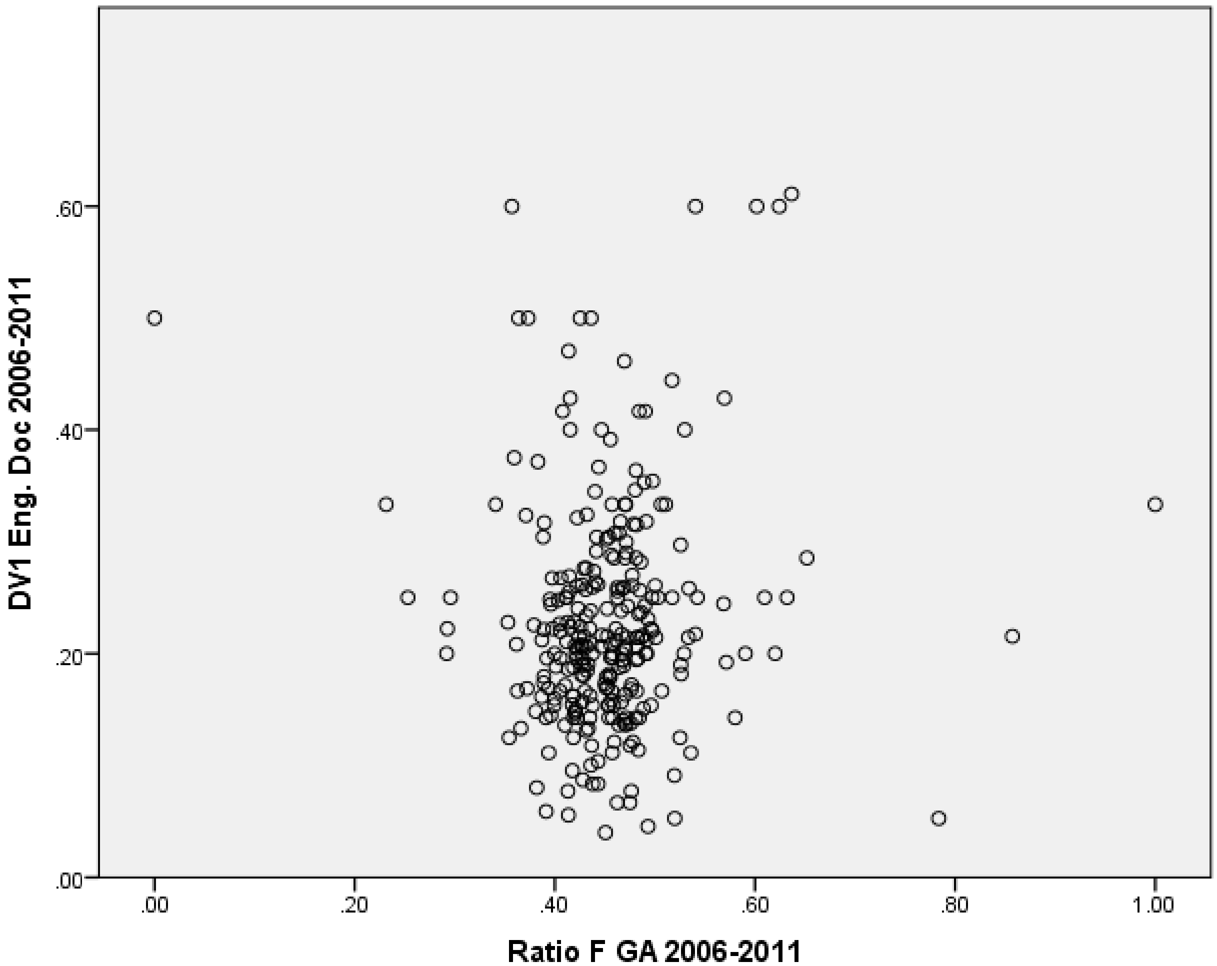


Figure I25. CIP 11 Doctoral by Ratio Female Faculty

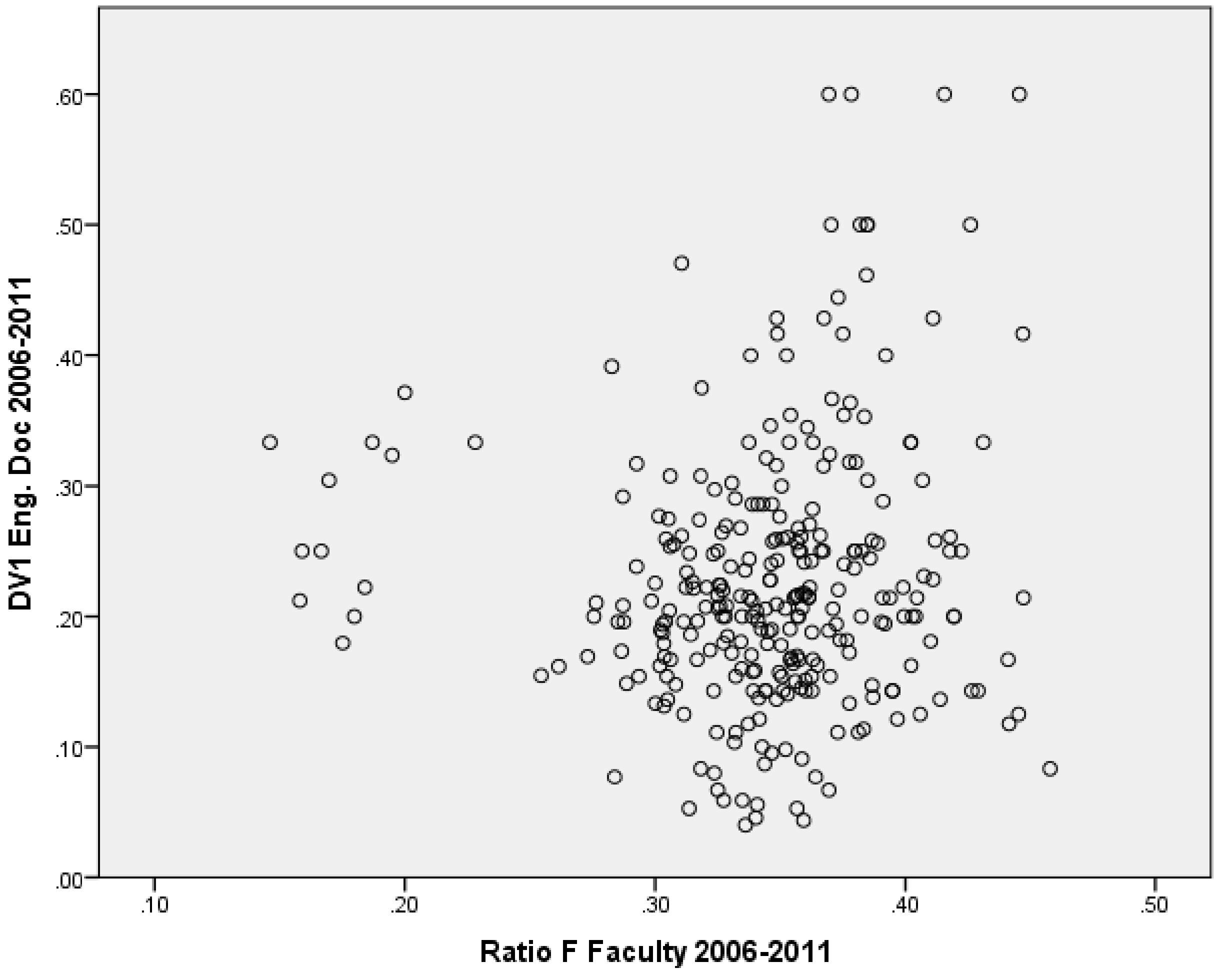


Figure I26. CIP 14 Doctoral by Ratio Female Administrators

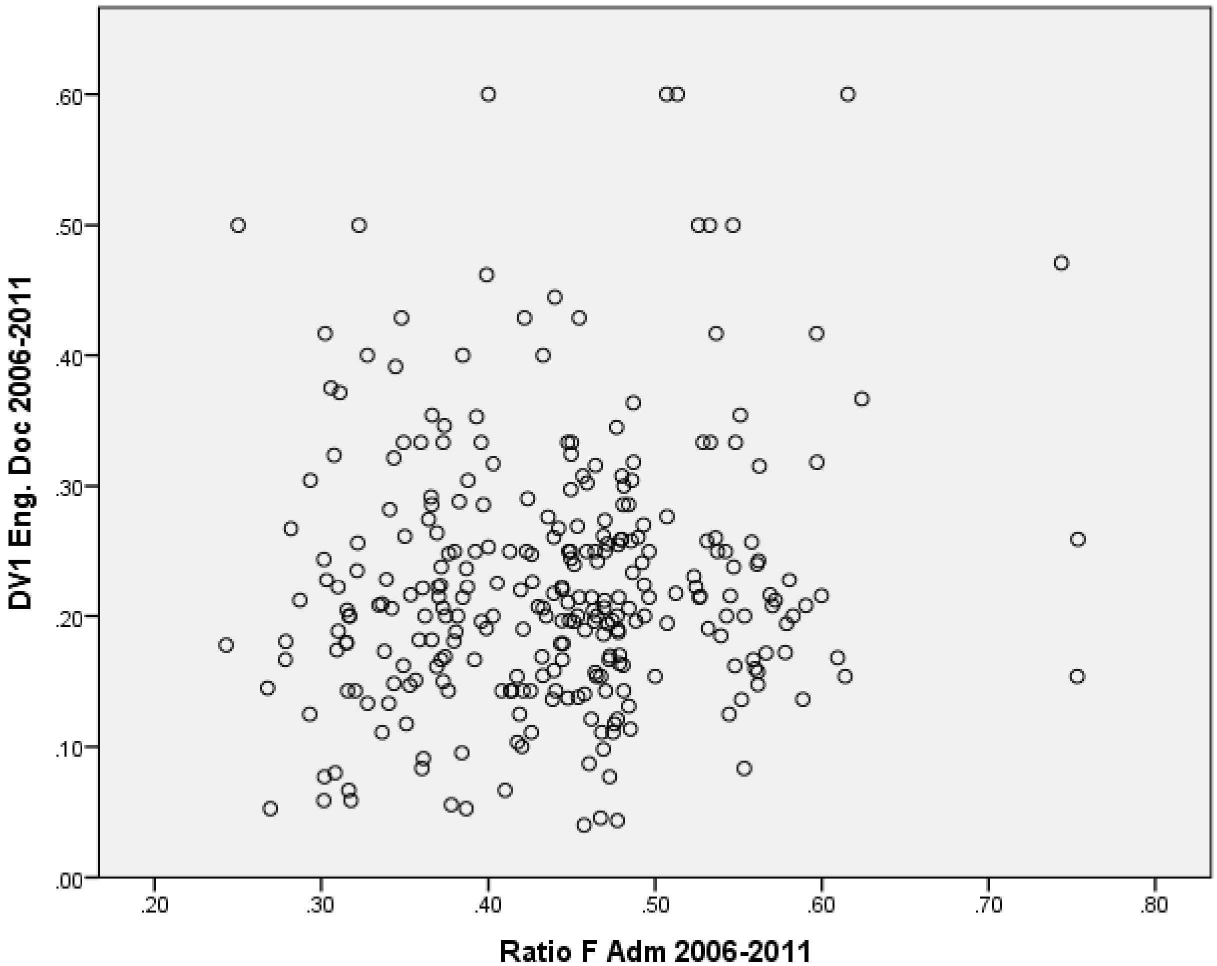


Figure I27. CIP 14 Doctoral by Enrollment

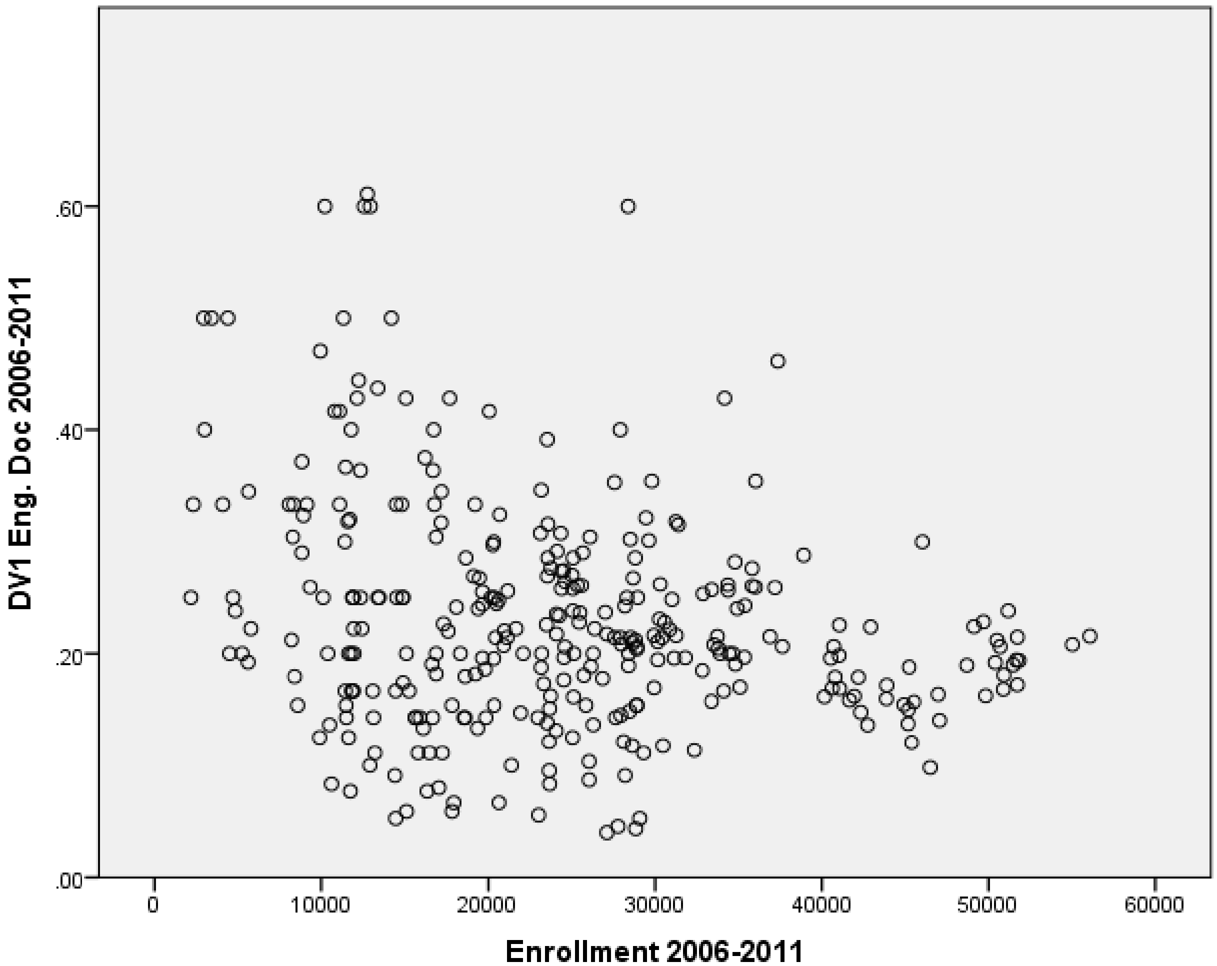


Figure I28. CIP 14 Doctoral by Research Expenditures

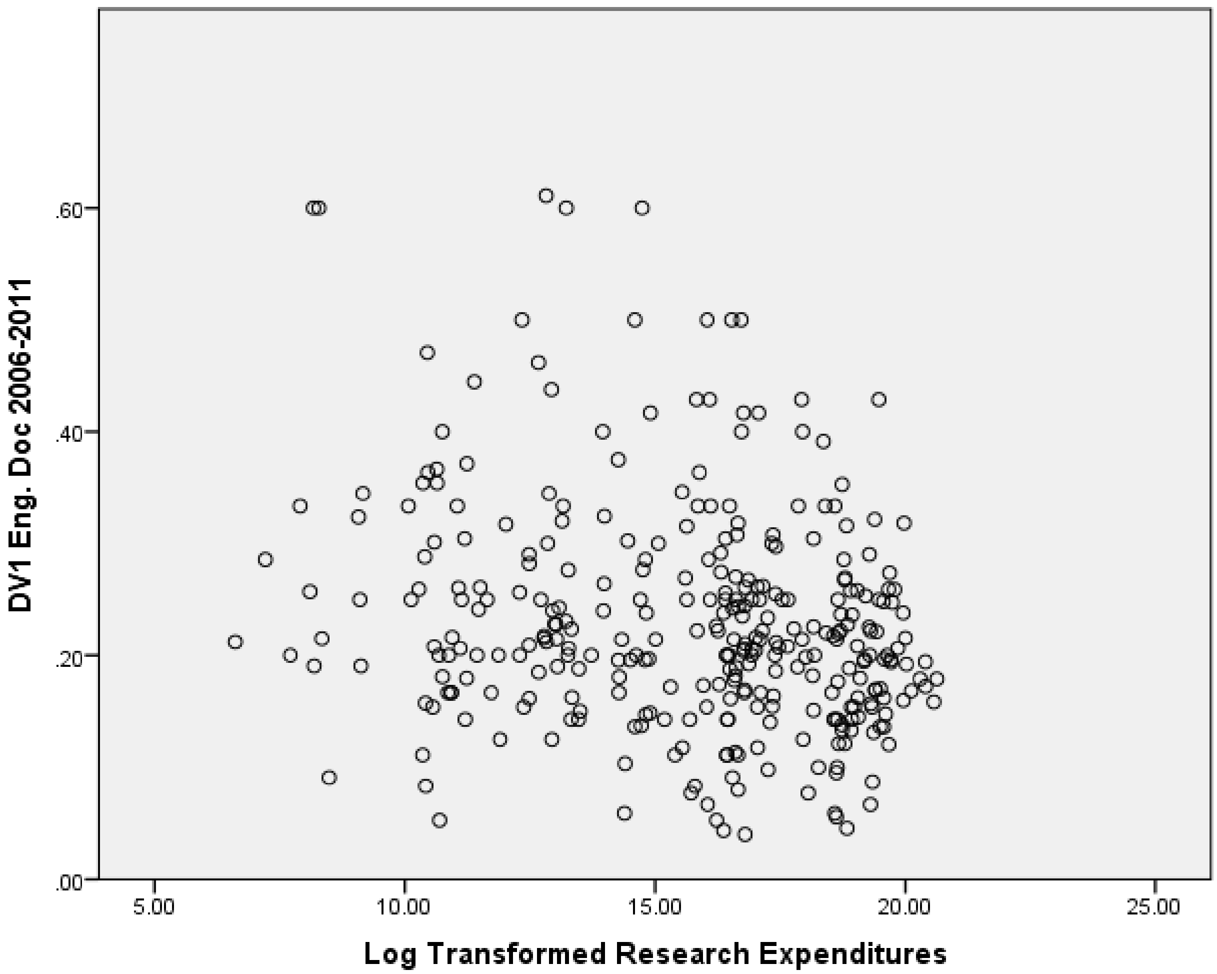


Figure I29. CIP 26 Master by Ratio Female Graduate Students

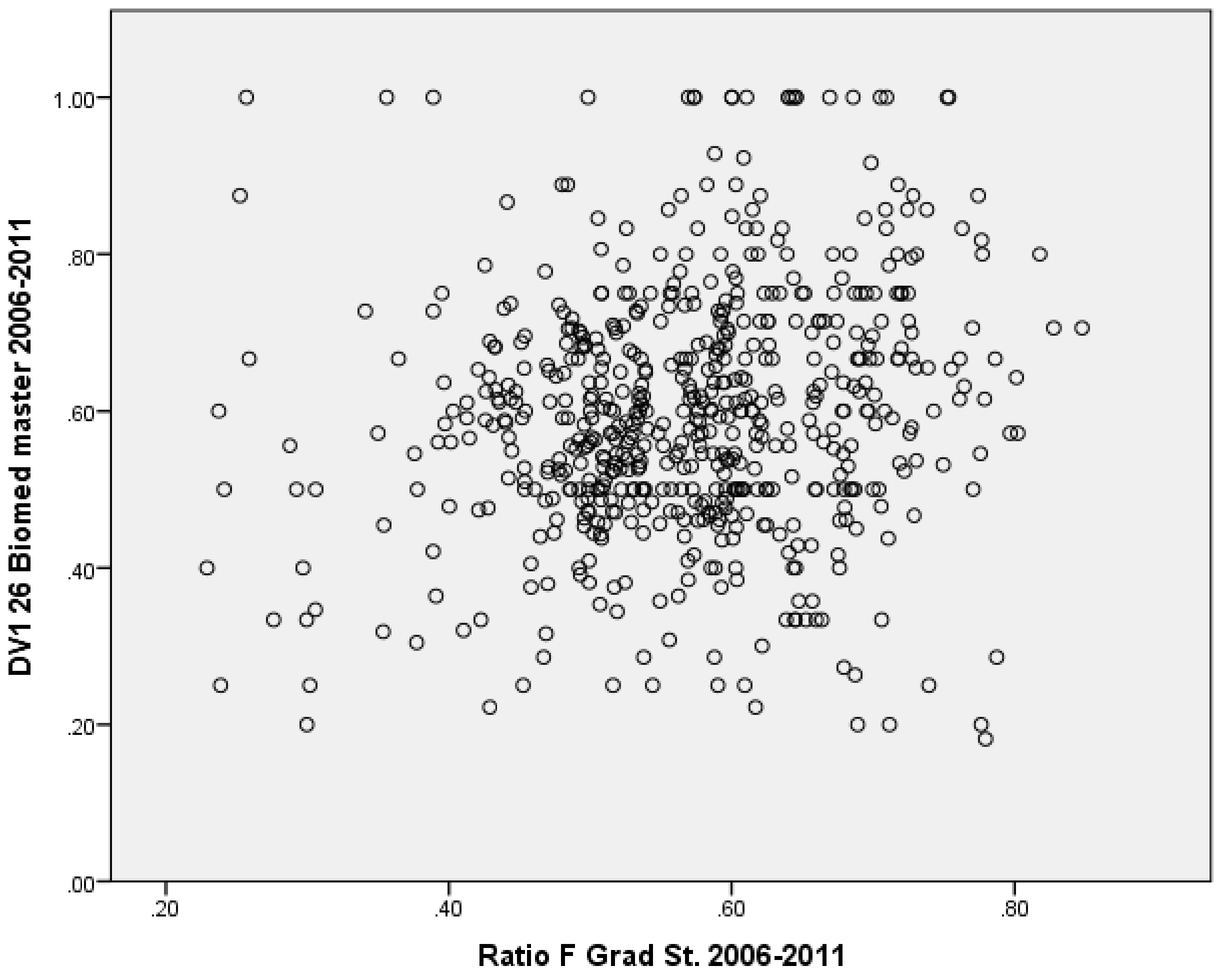


Figure I30. CIP 26 Master by Ratio Female Undergraduate Students

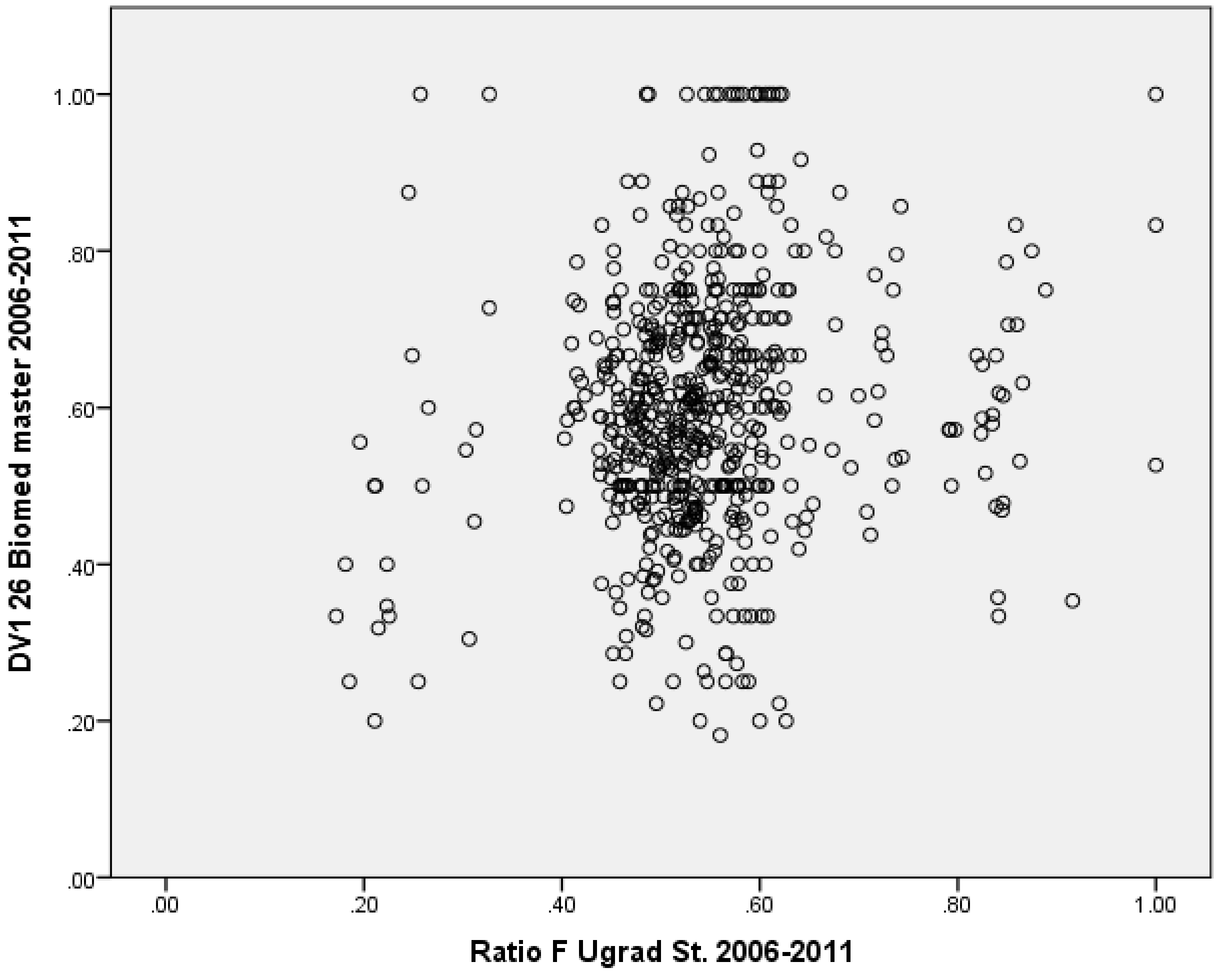


Figure I31. CIP 26 Master by Ratio Female Graduate Assistants

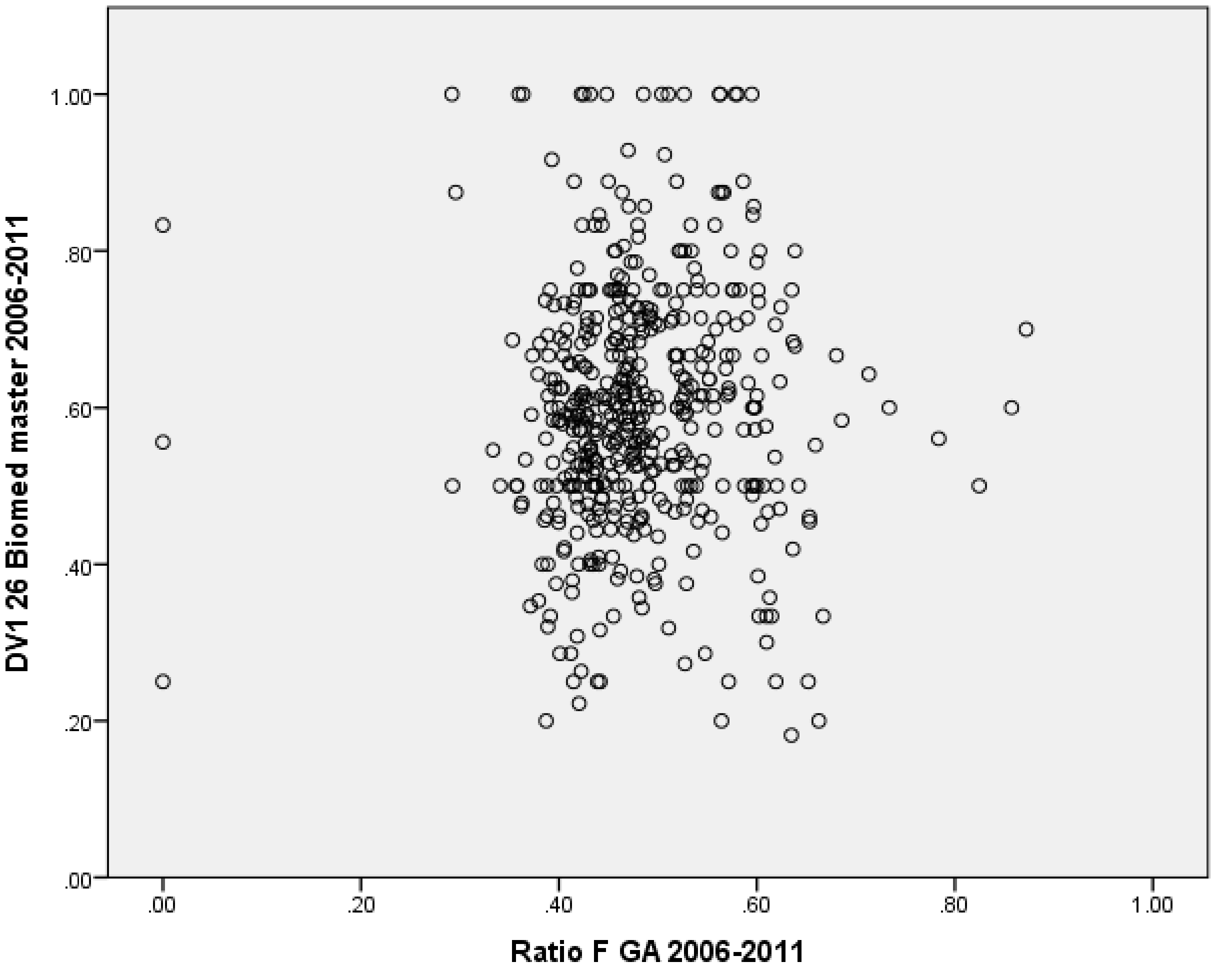


Figure I32. CIP 26 Master by Ratio Female Faculty

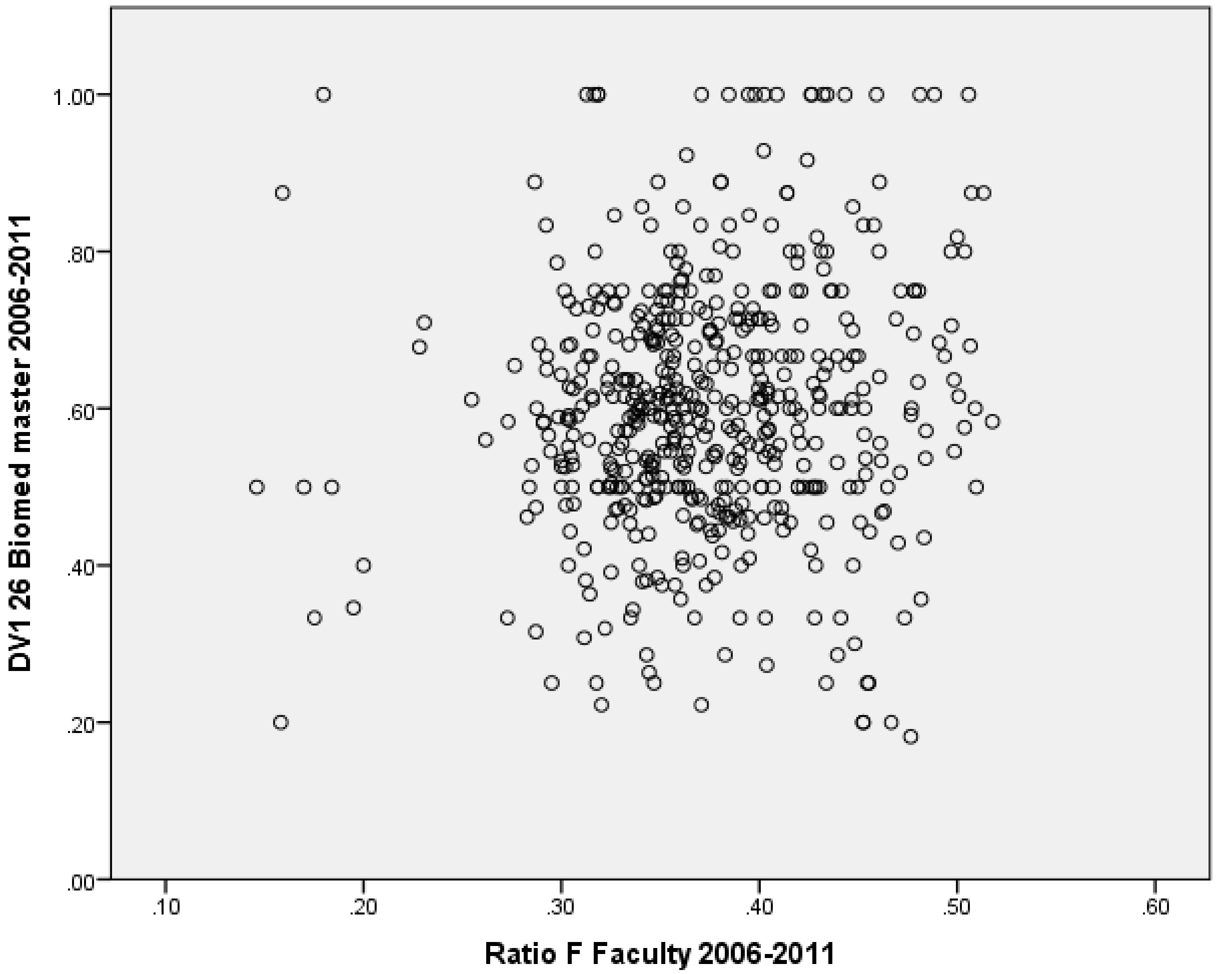


Figure I33. CIP 26 by Ratio Female Administrators

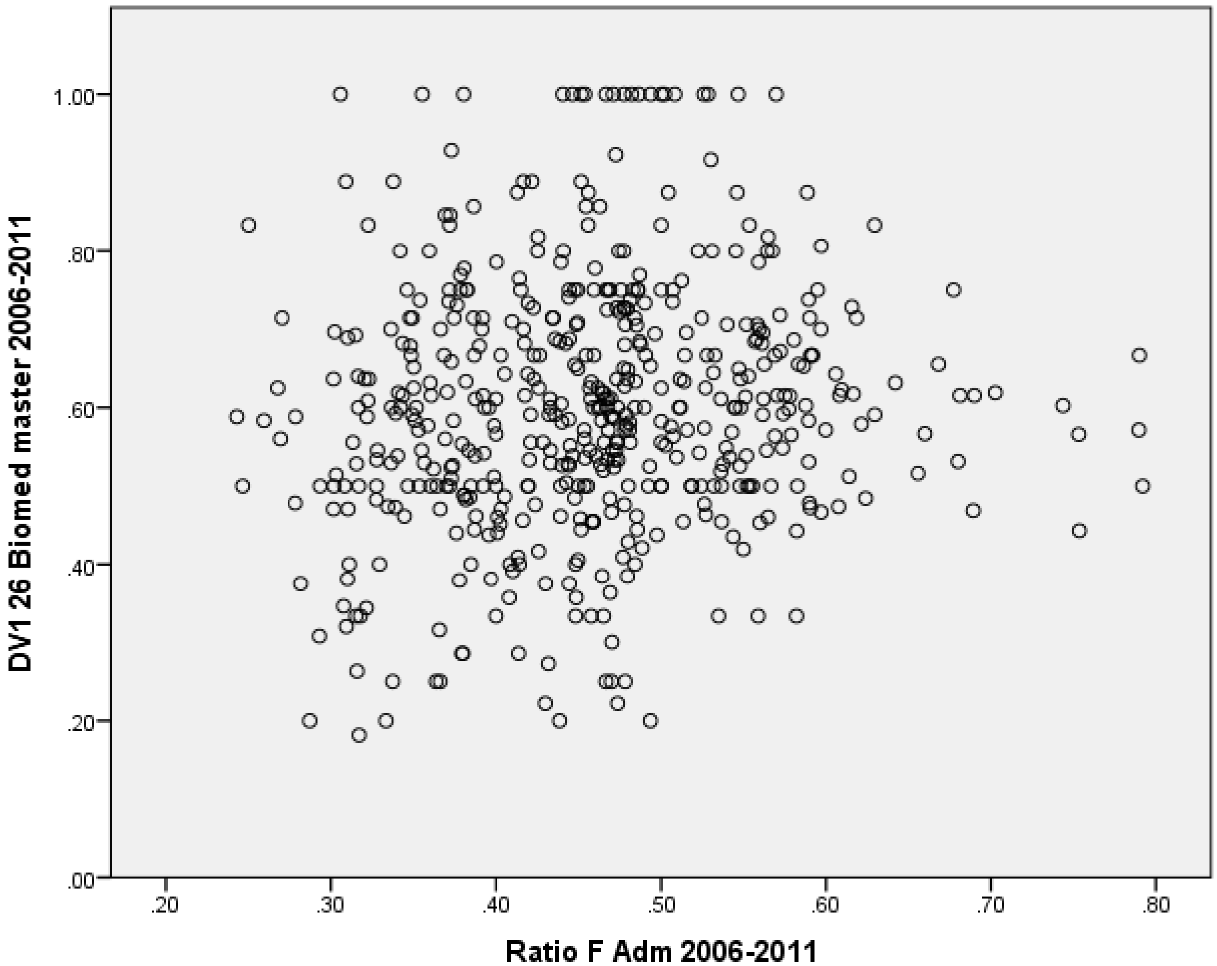


Figure I34. CIP 26 Master by Enrollment

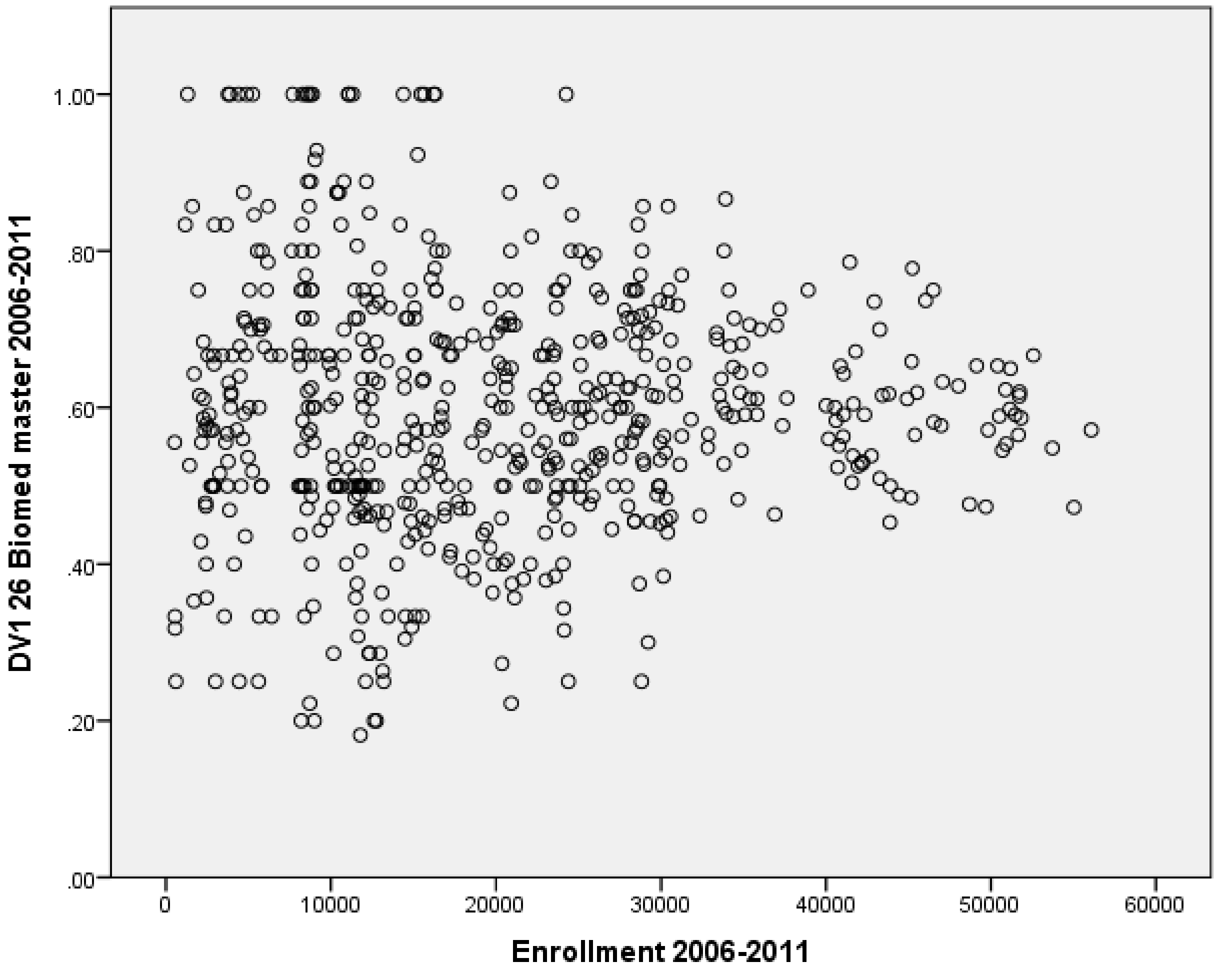


Figure I35. CIP 26 by Research Expenditures

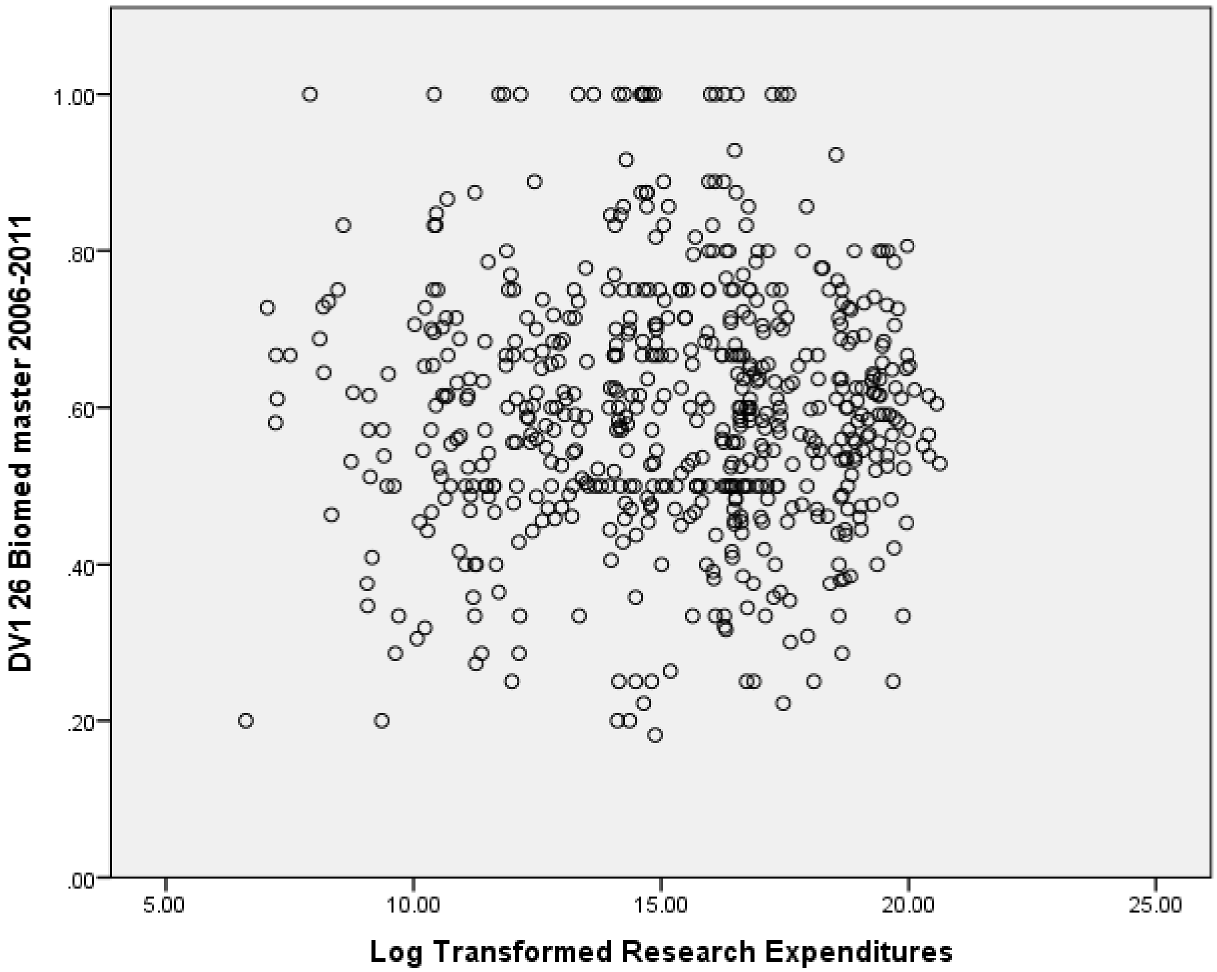


Figure I36. CIP 26 Doctoral by Ratio Female Graduate Students

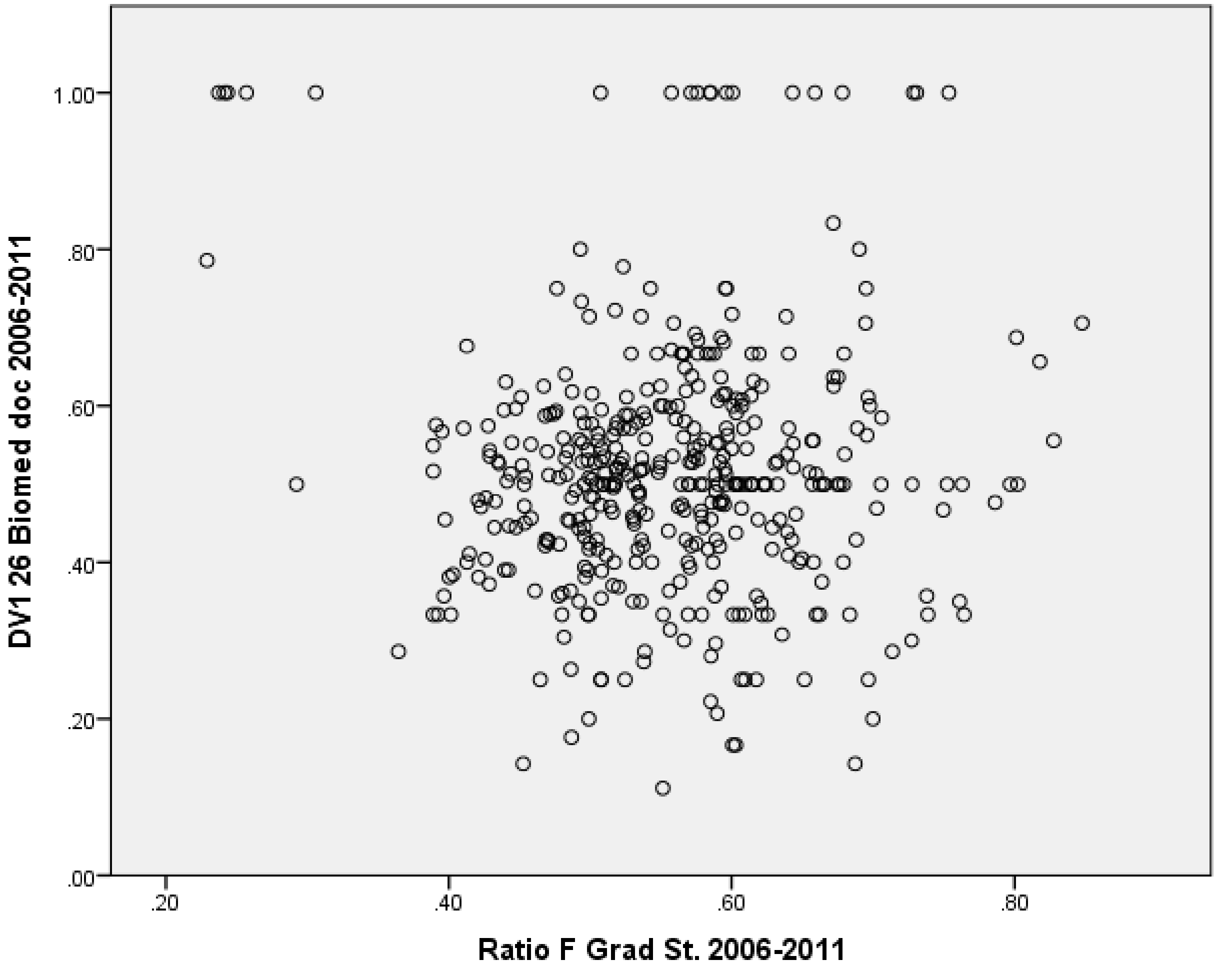


Figure I37. CIP 26 Doctoral by Ratio Female Undergraduate Students

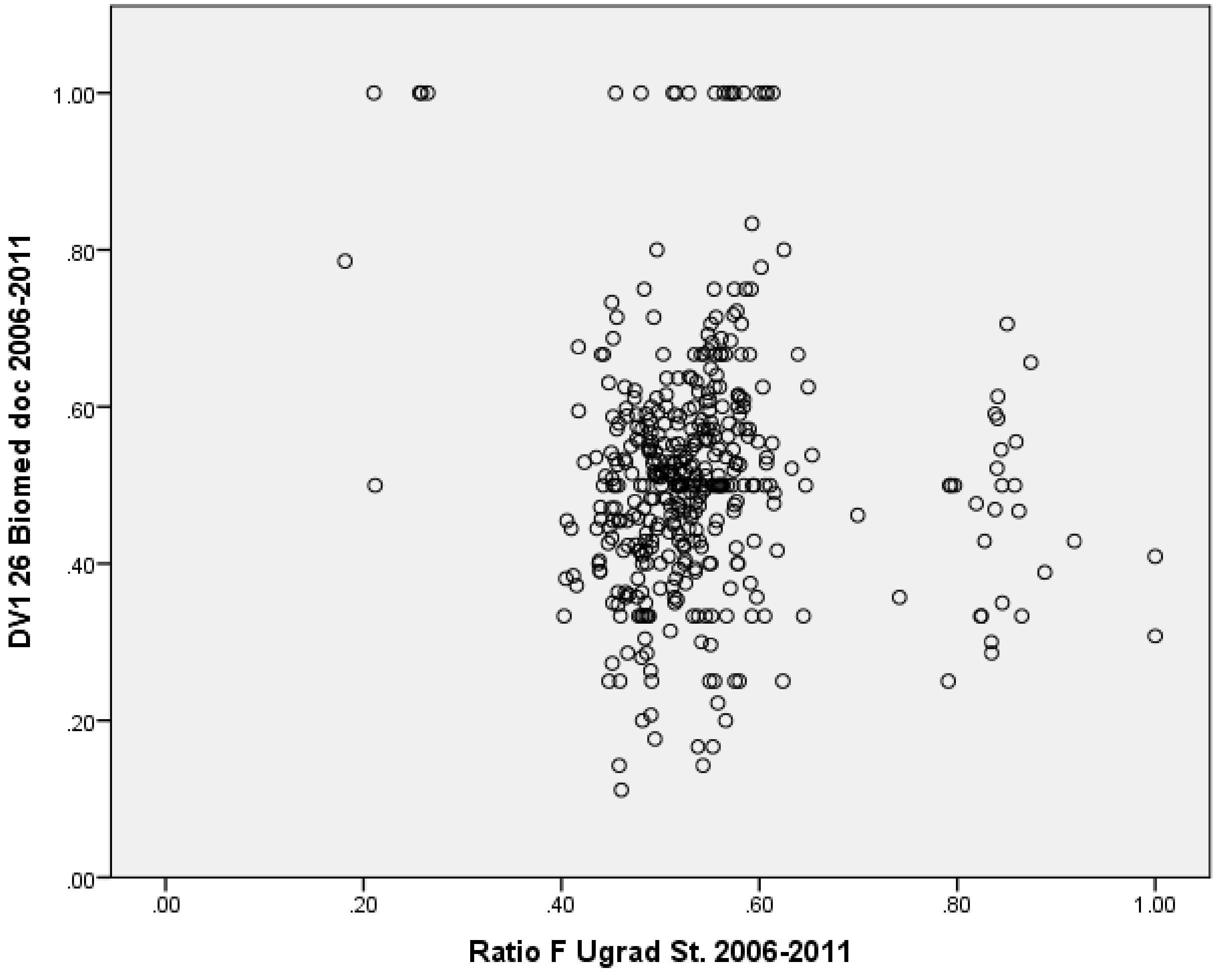


Figure I38. CIP 26 Doctoral by Ratio Female Graduate Assistants

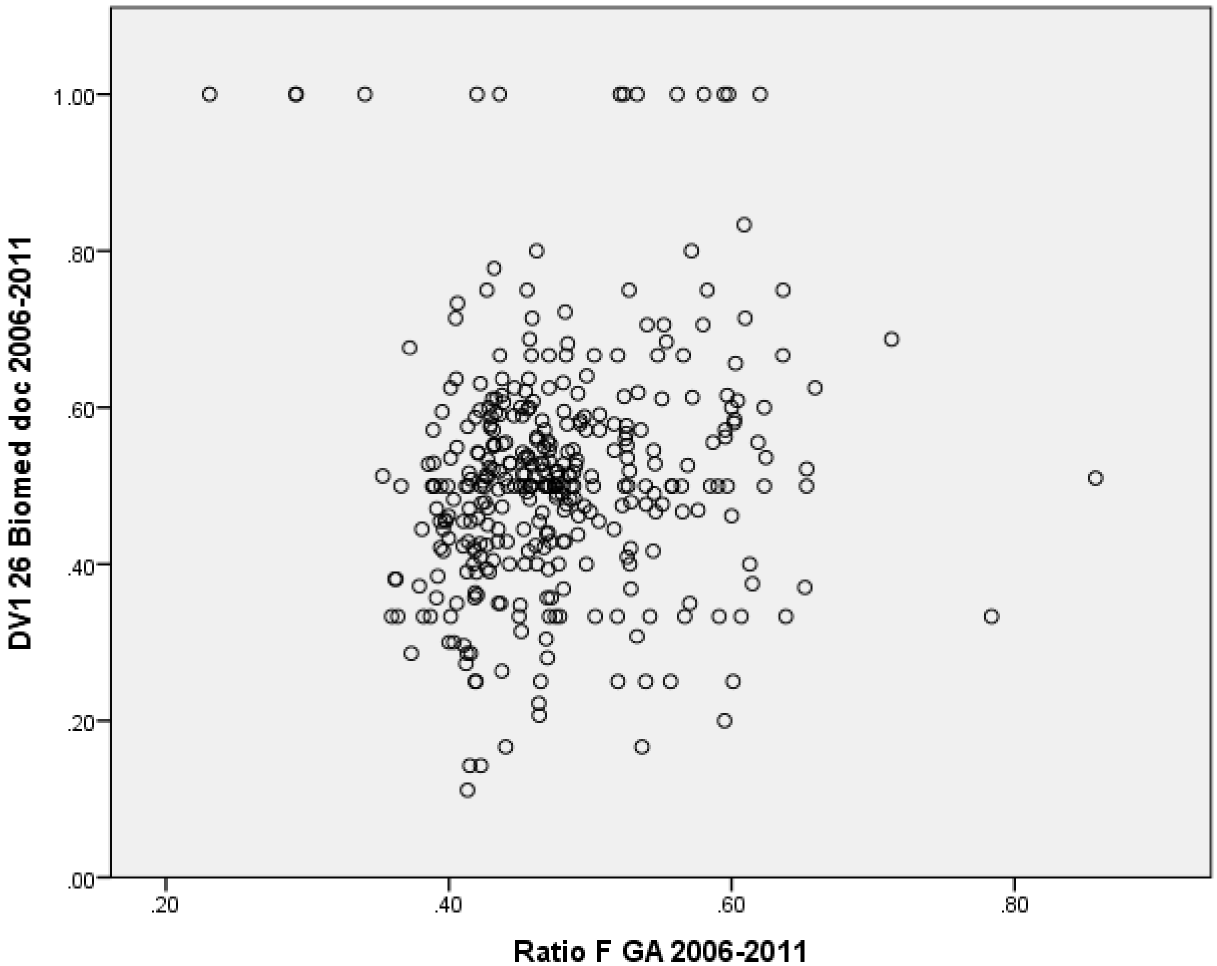


Figure I39. CIP 26 Doctoral by Ratio Female Faculty

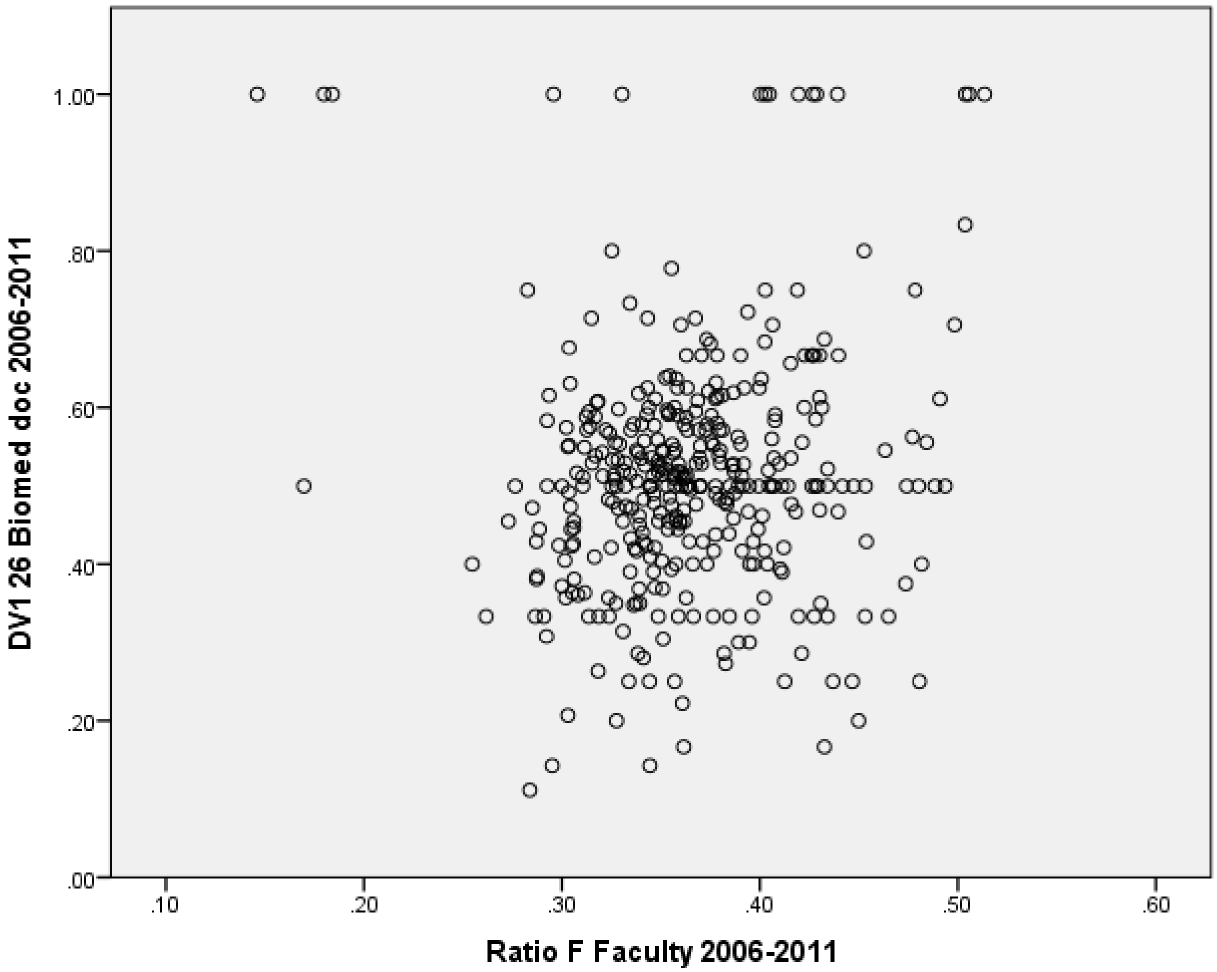


Figure I40. CIP 26 Doctoral by Ratio Female Administrators

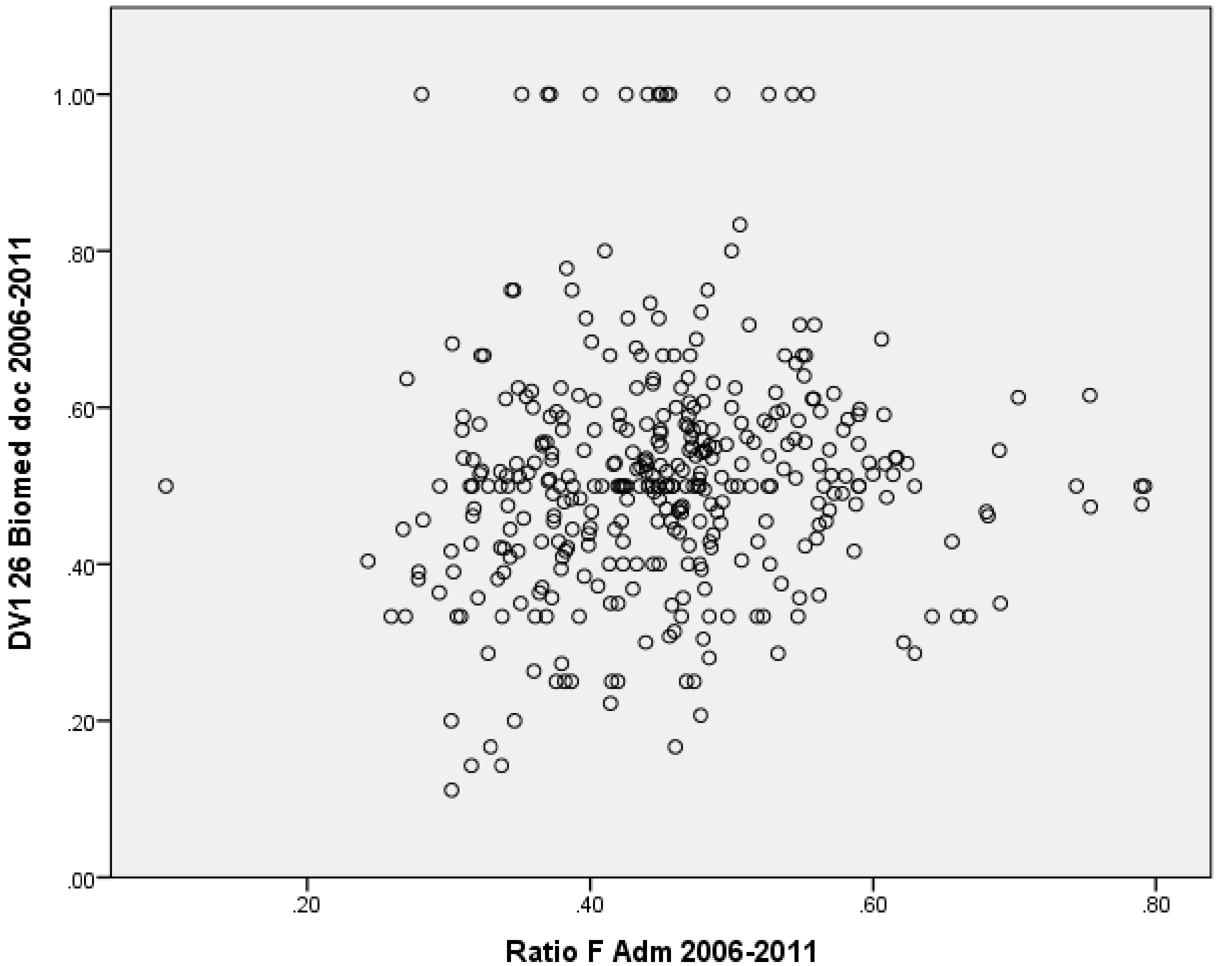


Figure I41. CIP 26 Doctoral by Enrollment

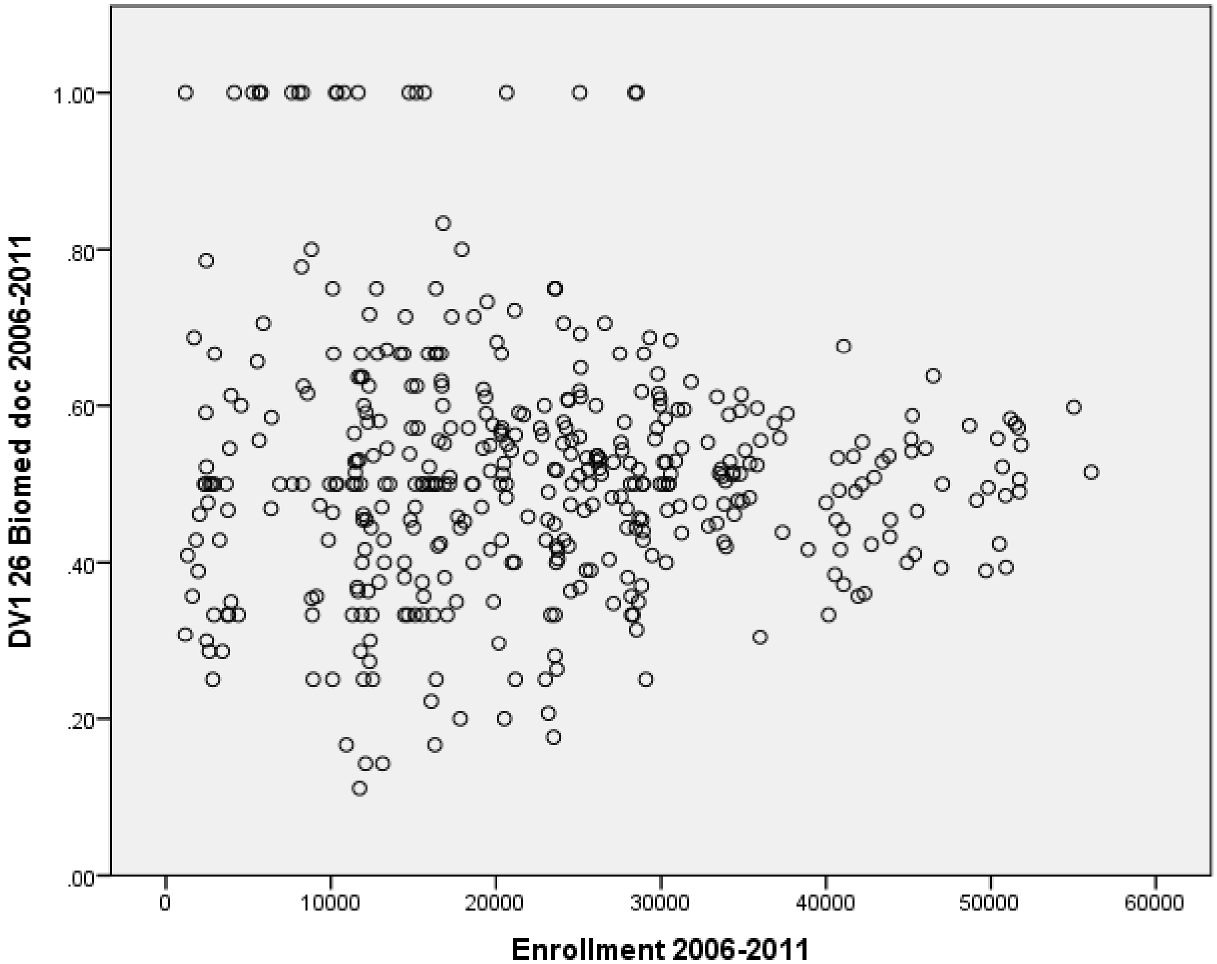


Figure I42. CIP 26 Doctoral by Research Expenditures

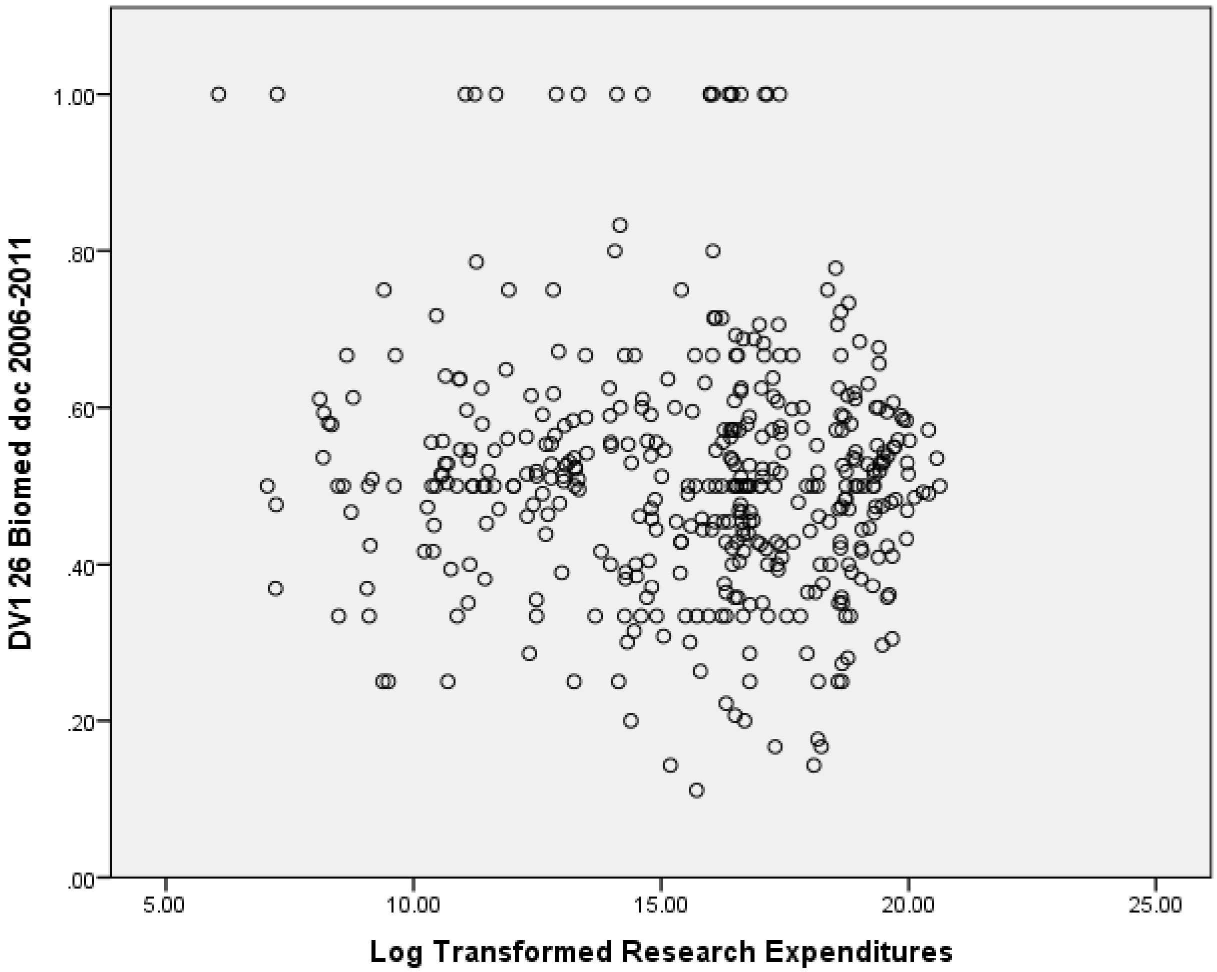


Figure I43. CIP 27 Master by Ratio Female Graduate Students

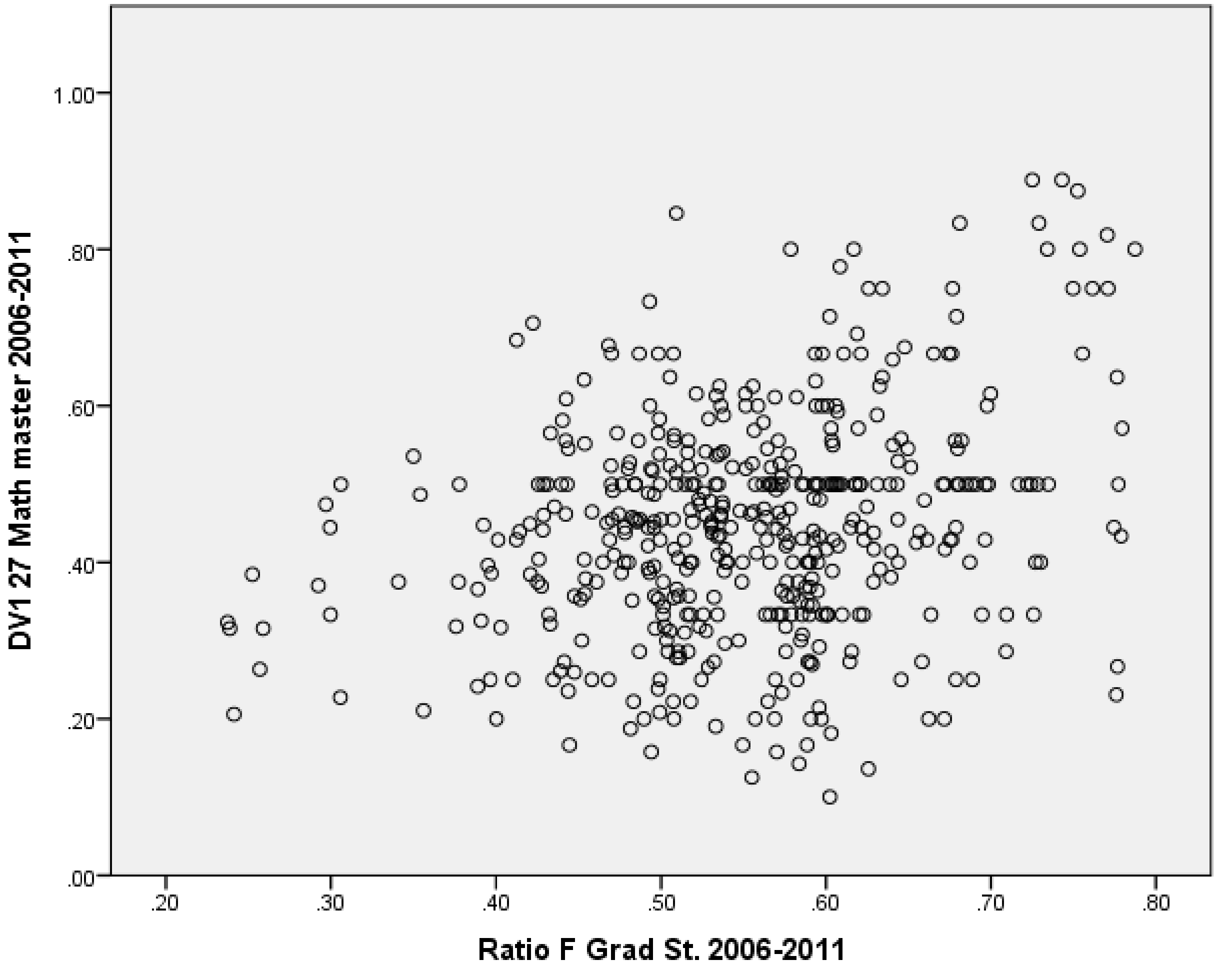


Figure I44. CIP 27 Master by Ratio Female Undergraduate Students

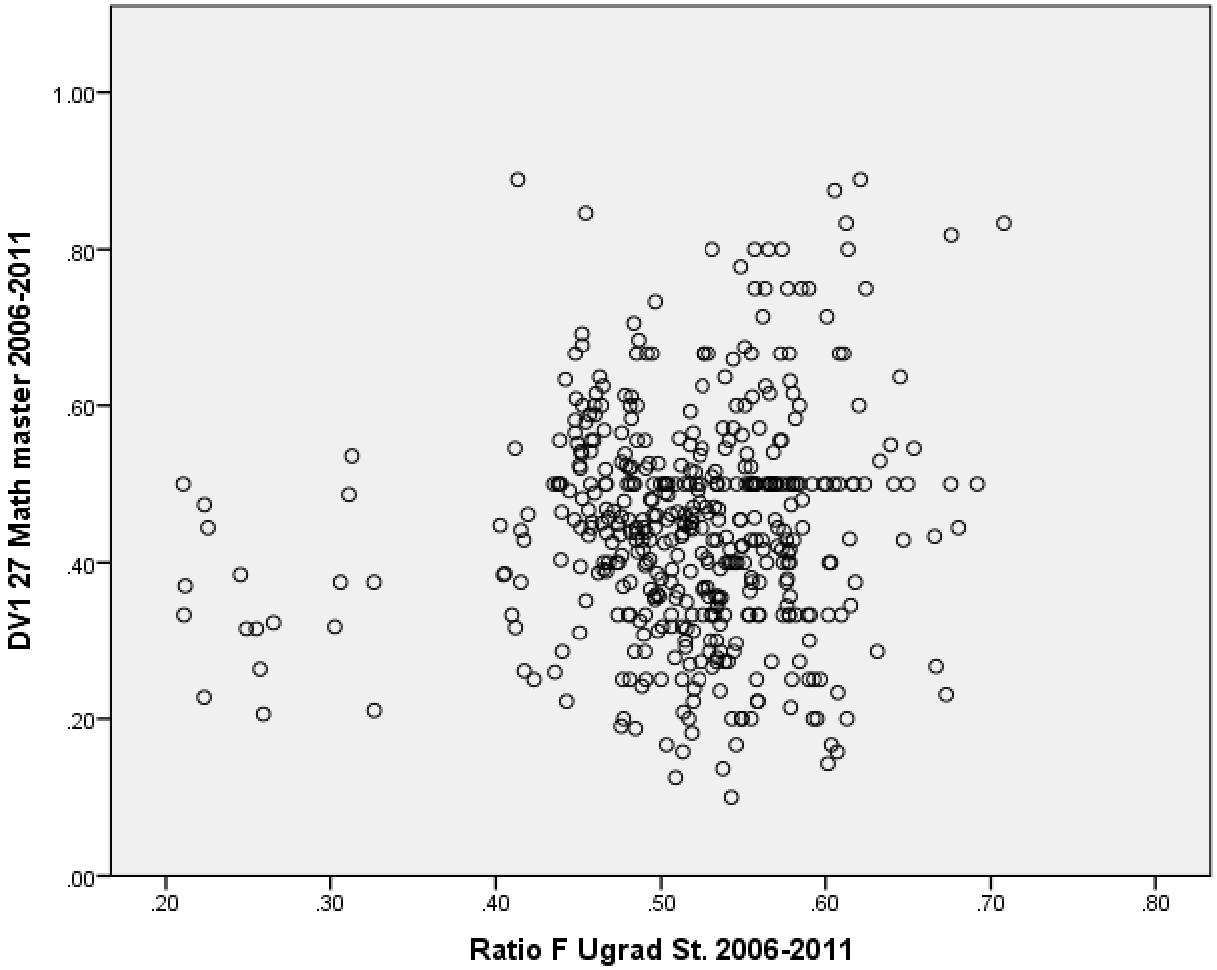


Figure I45. CIP 27 Master by Ratio Female Graduate Assistants

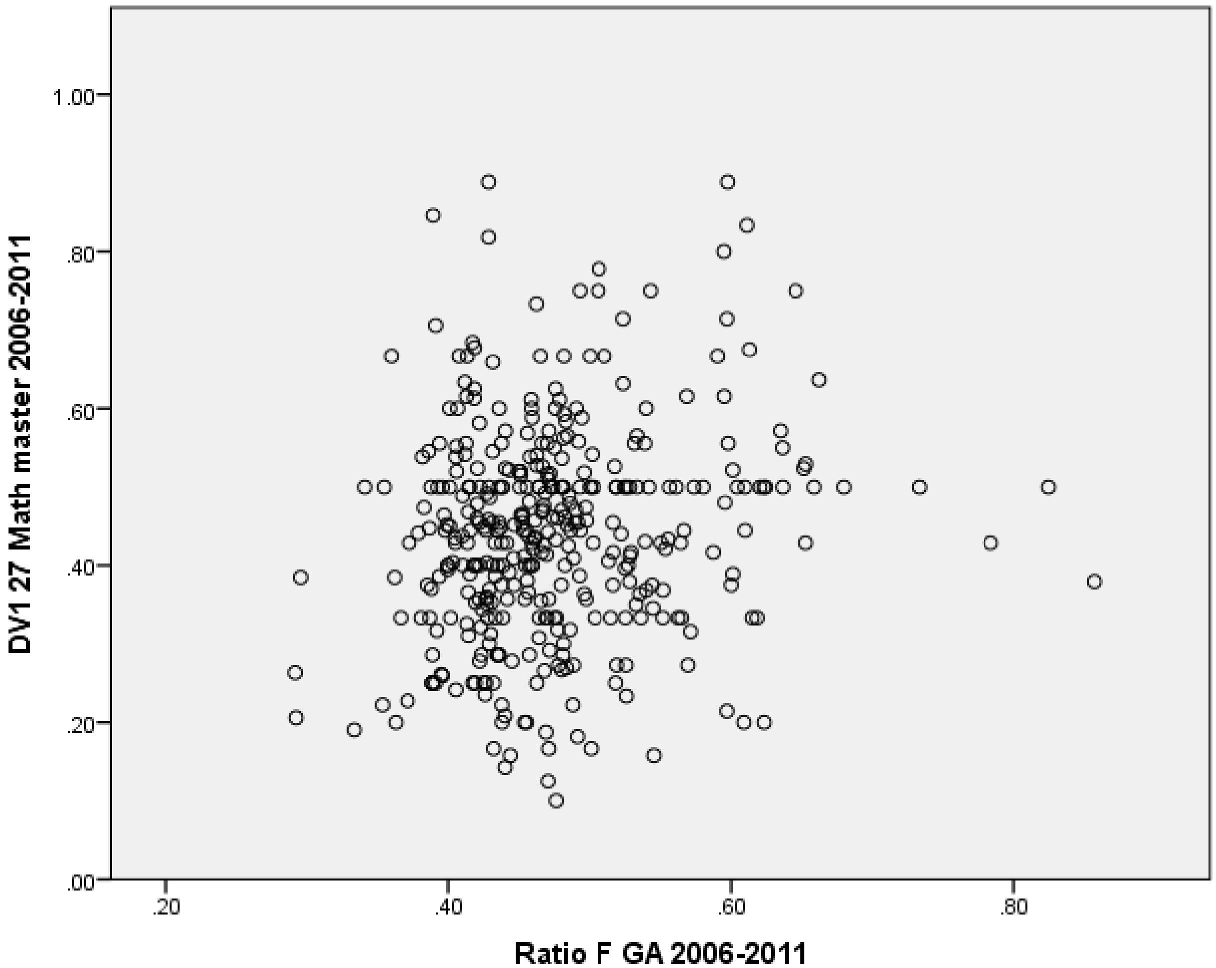


Figure I46. CIP 27 Master by Ratio Female Faculty

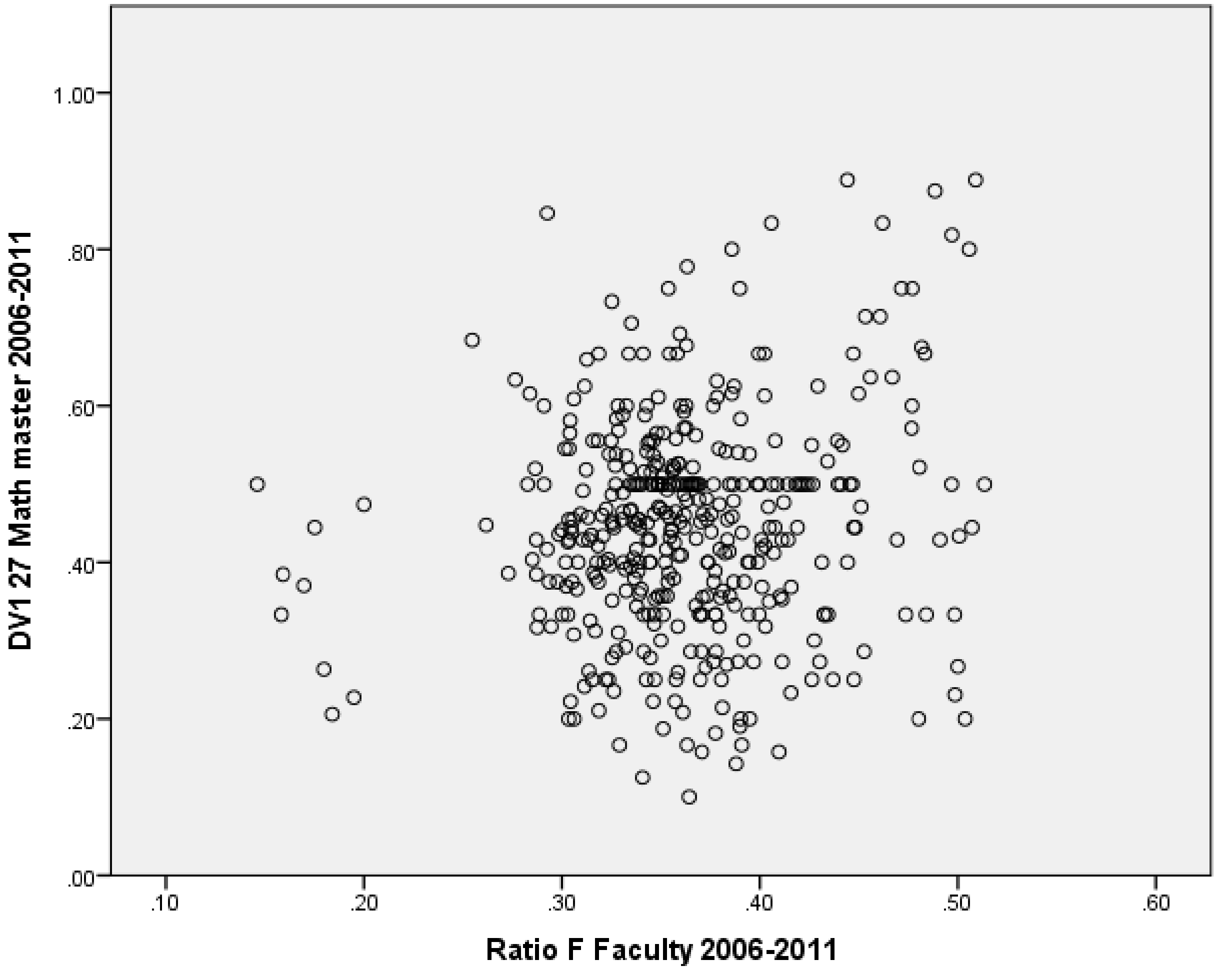


Figure I47. CIP 27 Master by Ratio Female Administrators

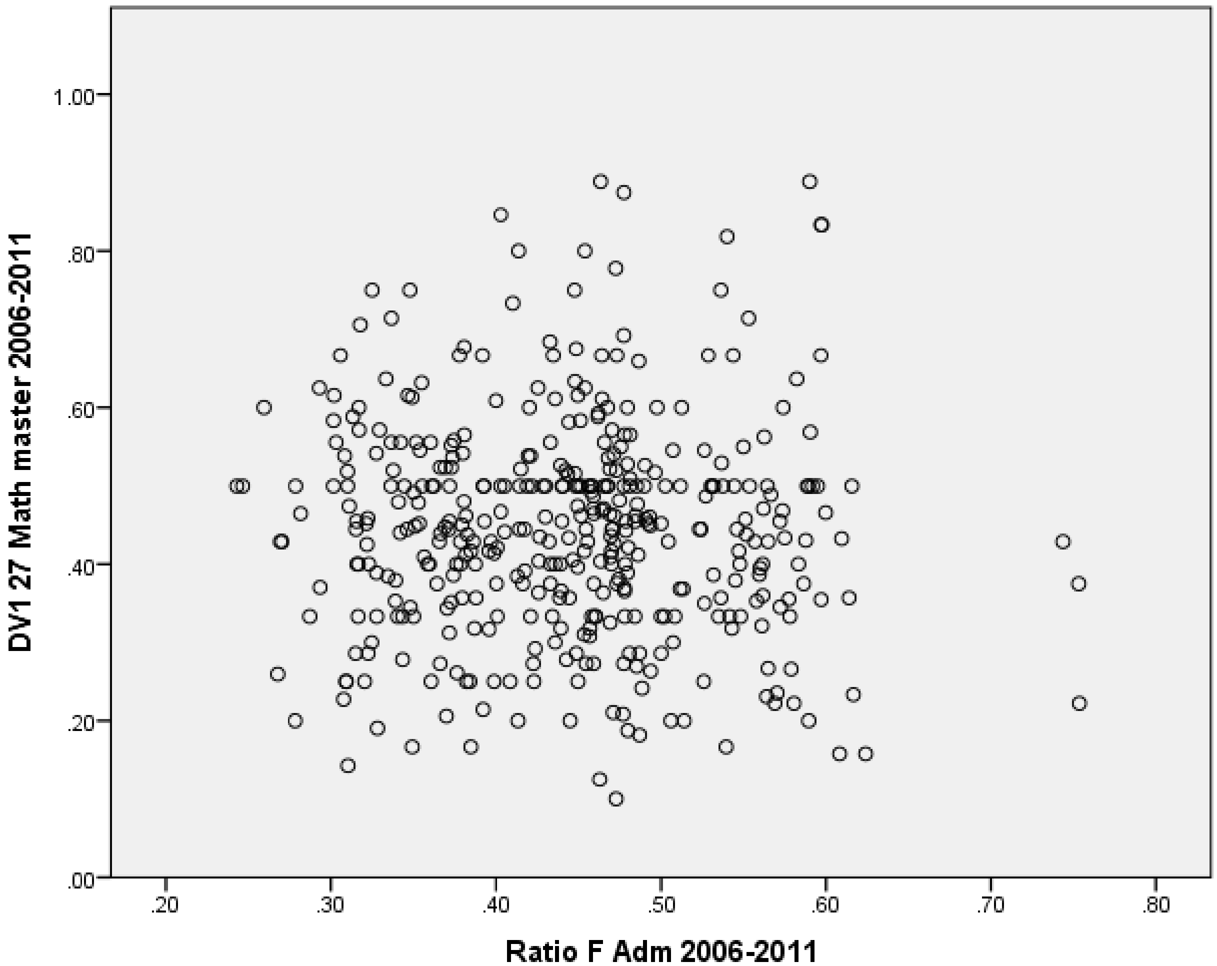


Figure I48. CIP 27 Master by Enrollment

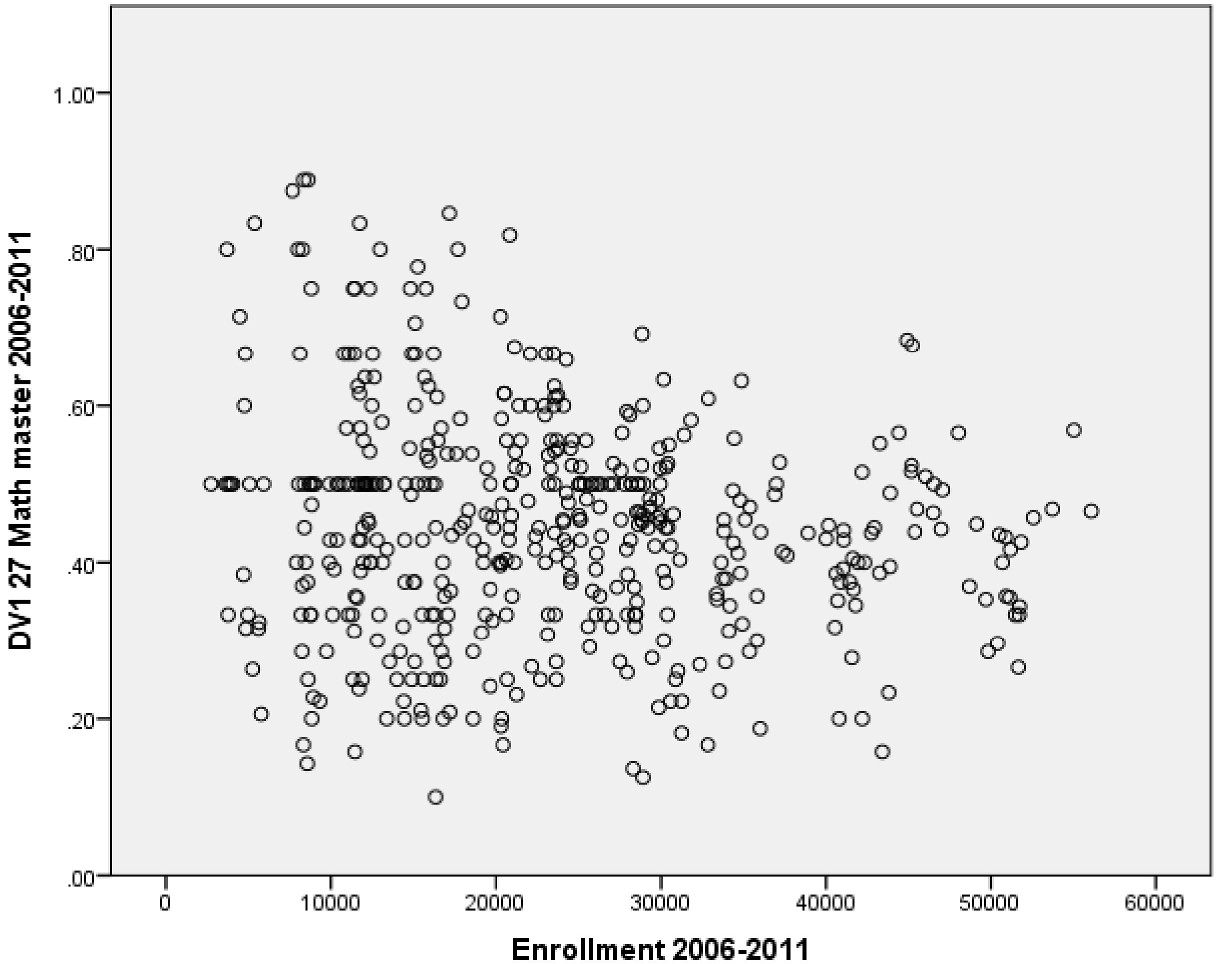


Figure I49. CIP 27 Master by Research Expenditures

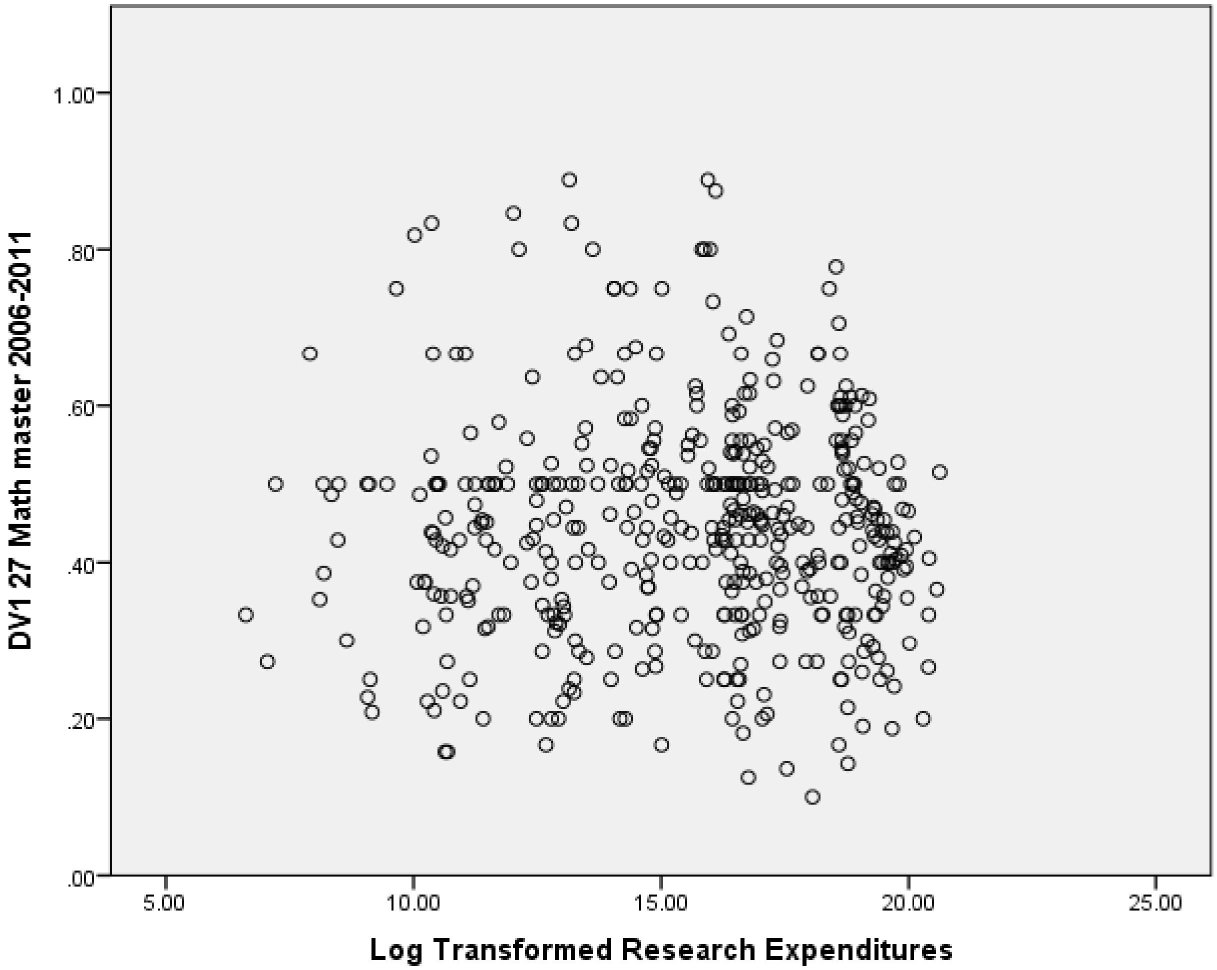


Figure I50. CIP 27 Doctoral by Ratio Female Graduate Students

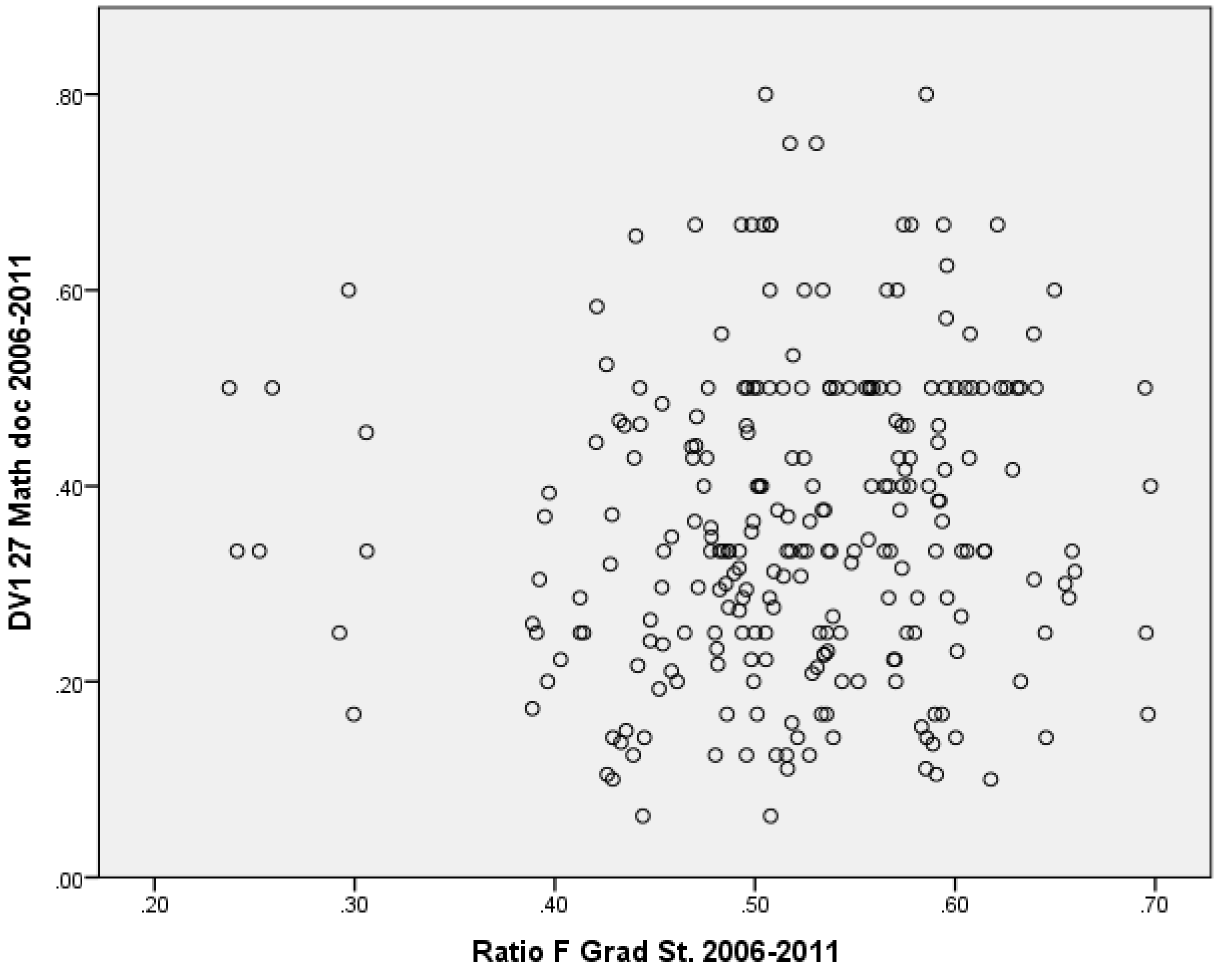


Figure I51. CIP 27 Doctoral by Ratio Female Undergraduate Students

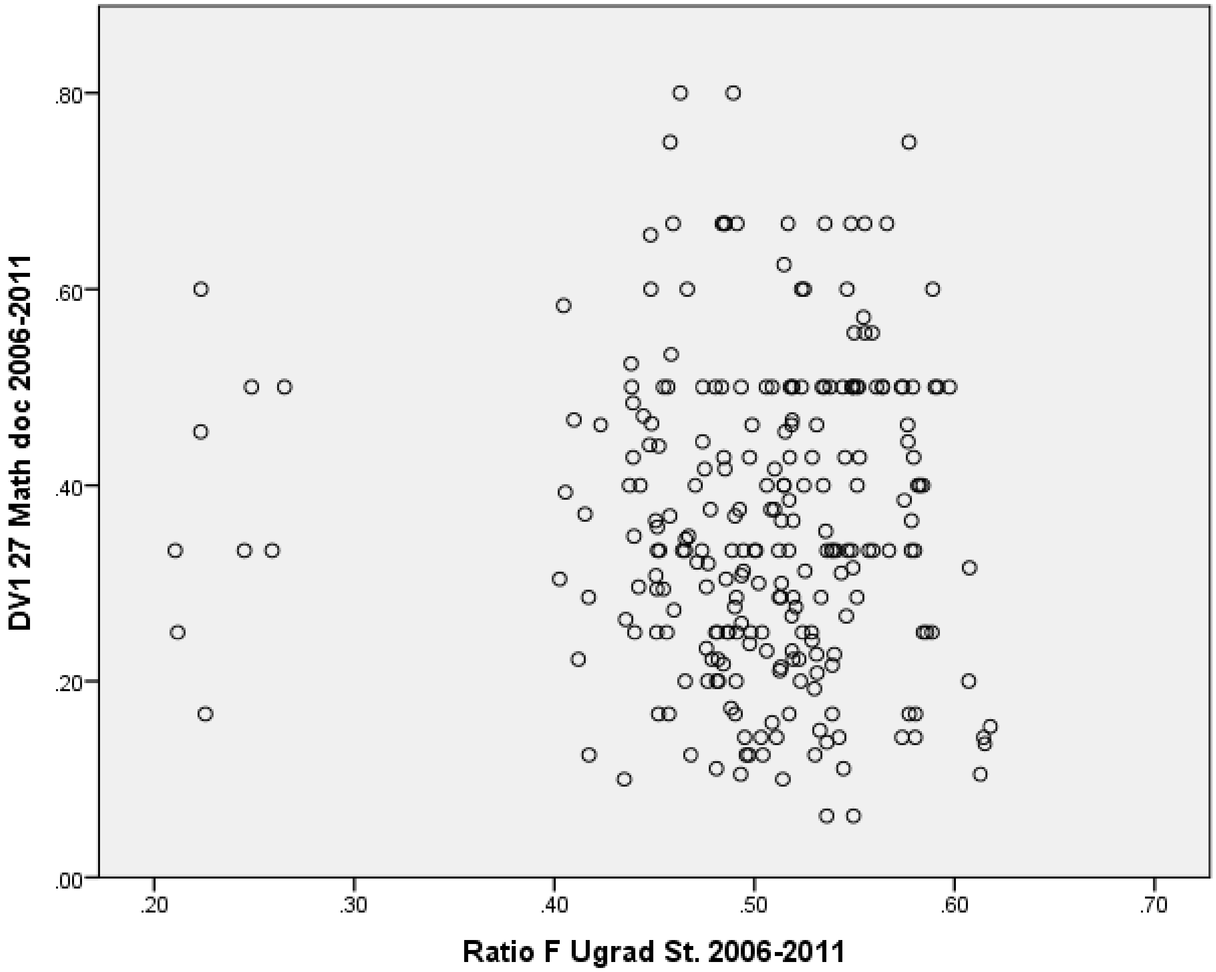


Figure I52. CIP 27 Doctoral by Ratio Female Graduate Assistants

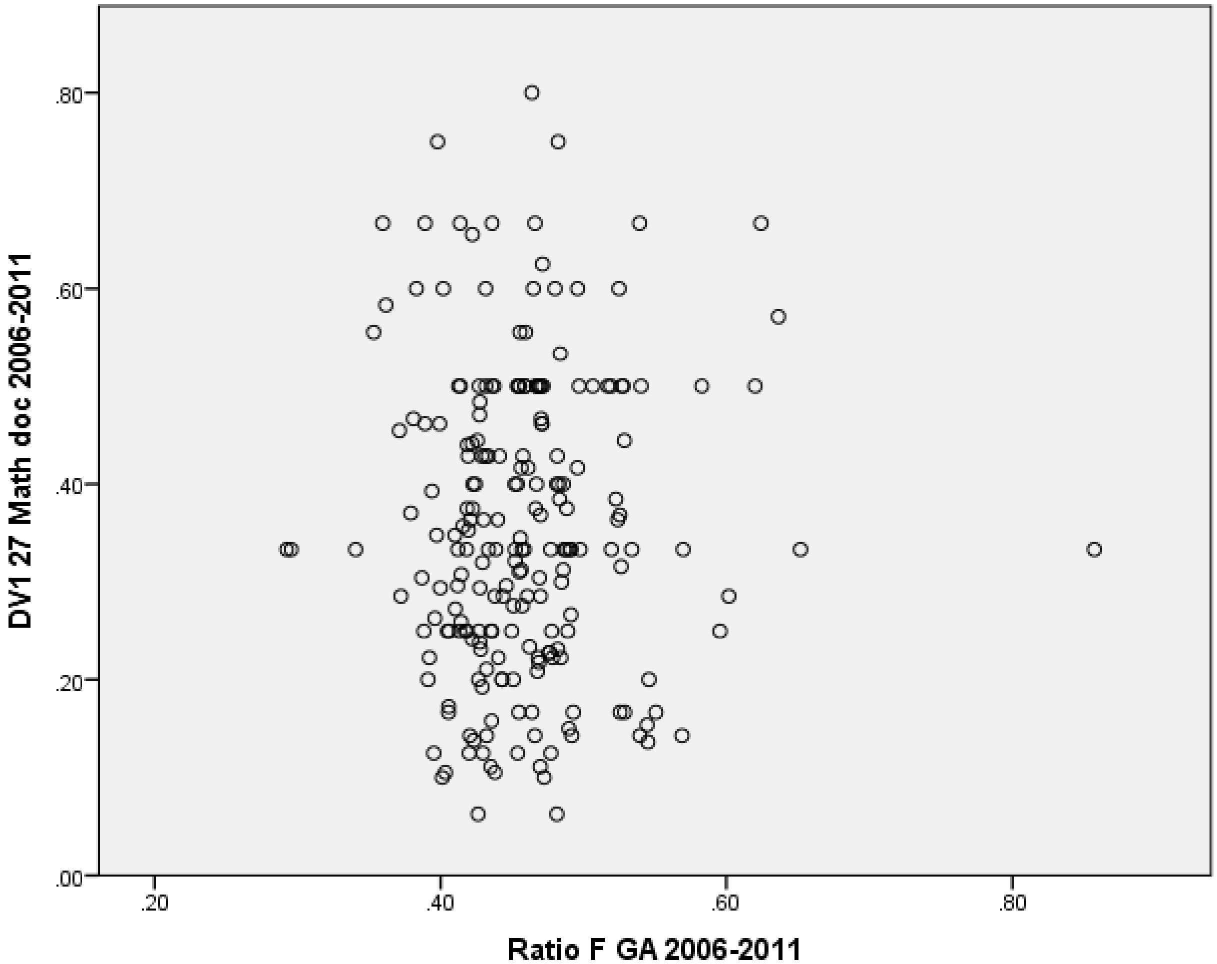


Figure I53. CIP 27 Doctoral by Ratio Female Faculty

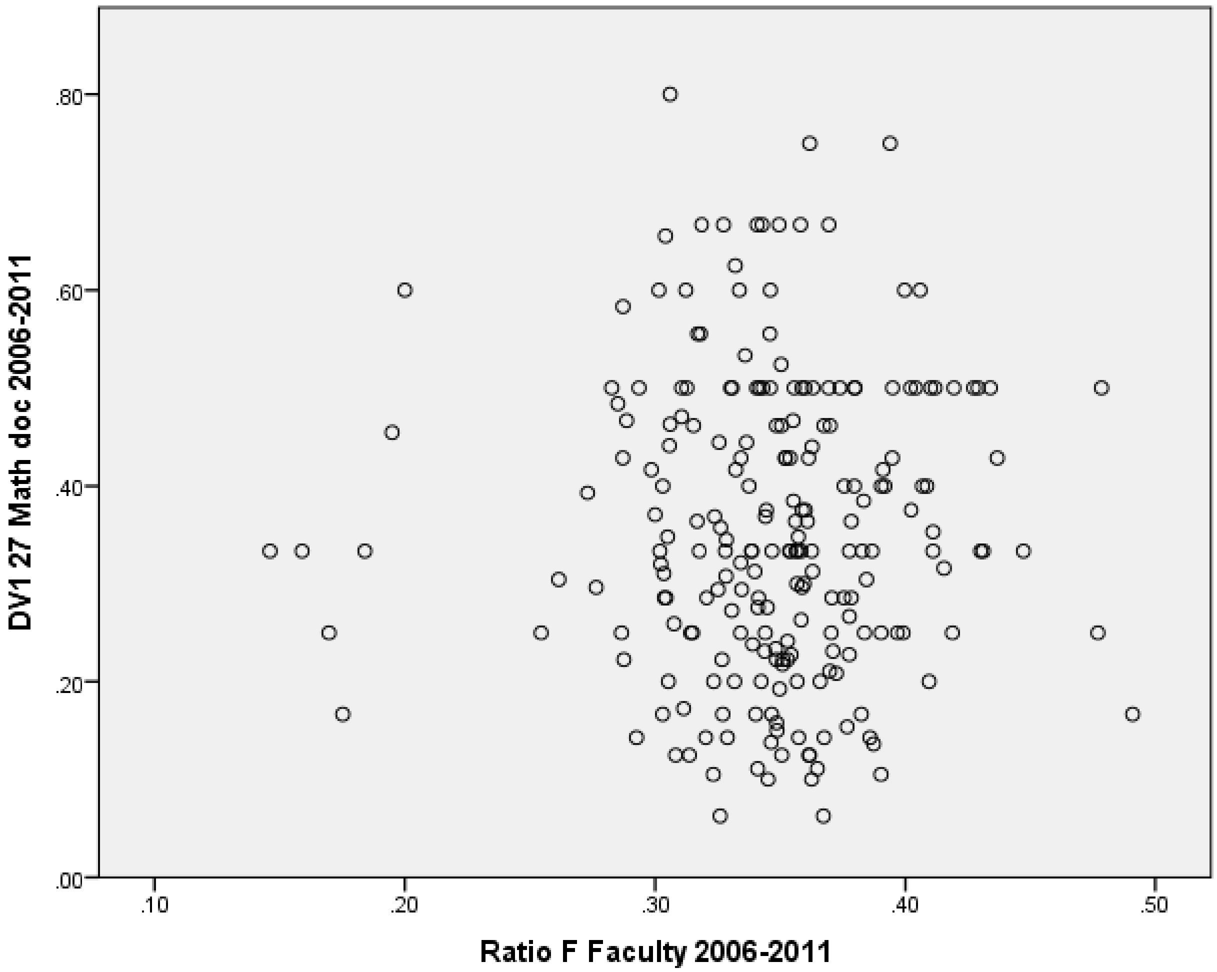


Figure I54. CIP 27 Doctoral by Ratio Female Administrators

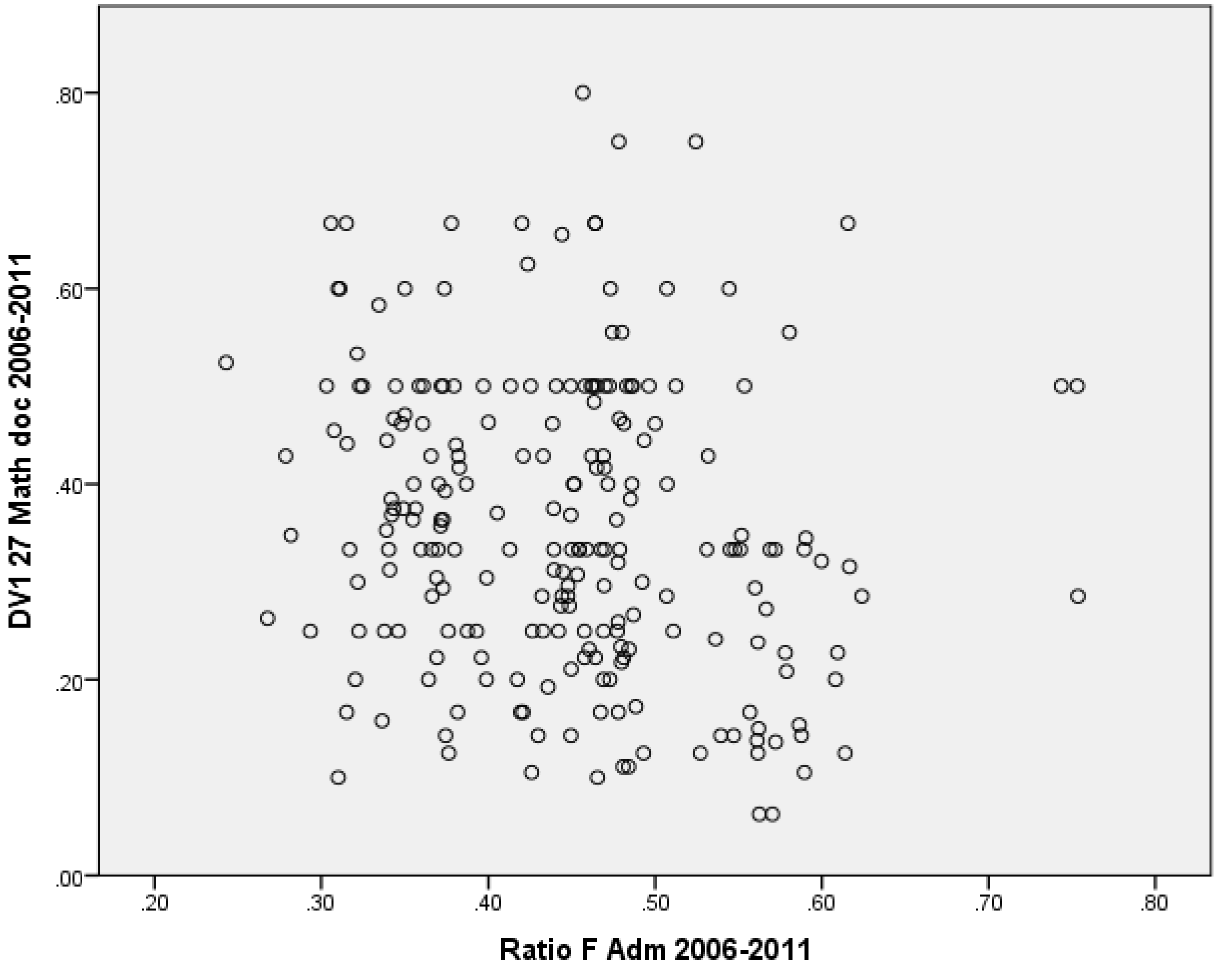


Figure I55. CIP 27 Doctoral by Enrollment

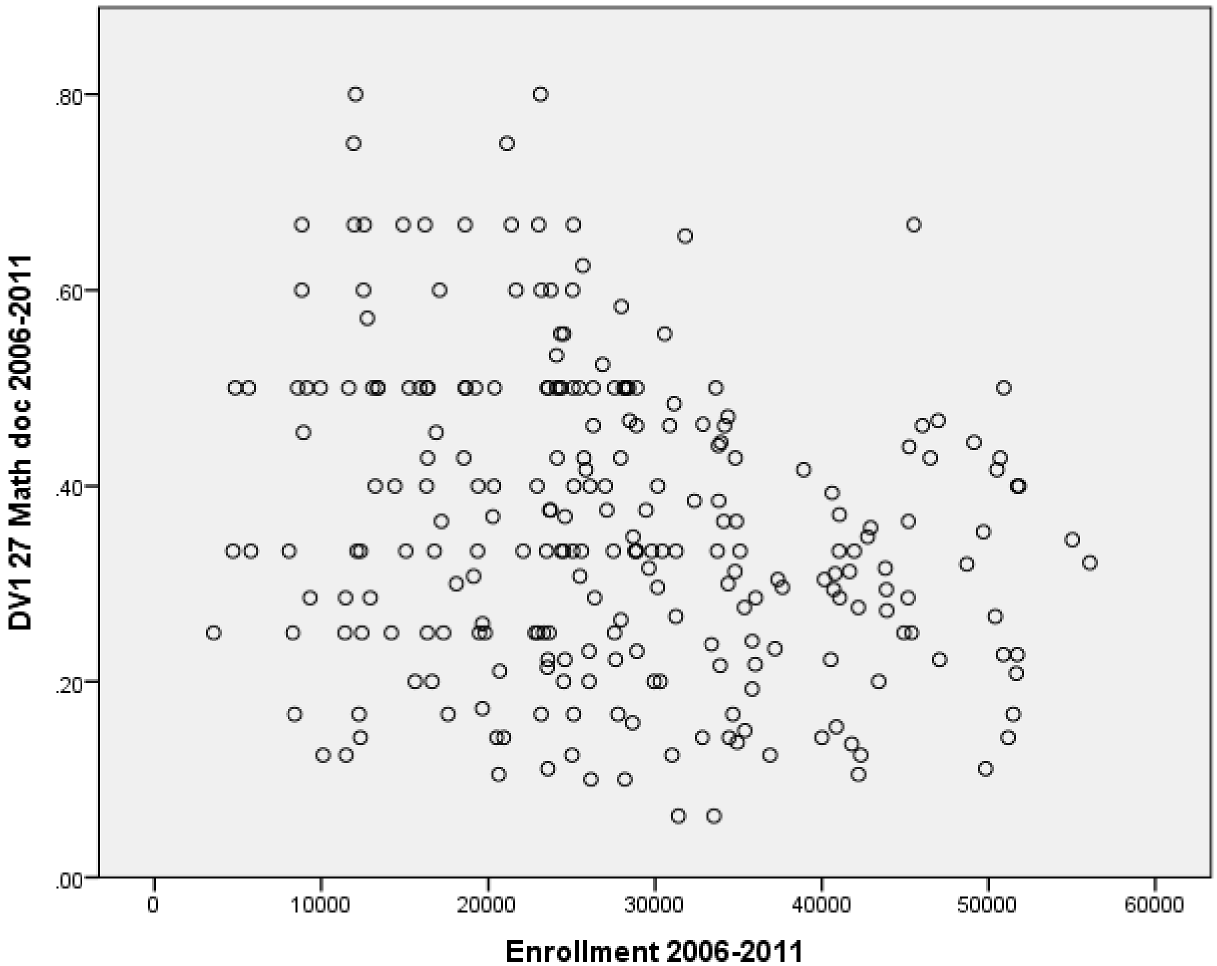


Figure I56. CIP 27 Doctoral by Research Expenditures

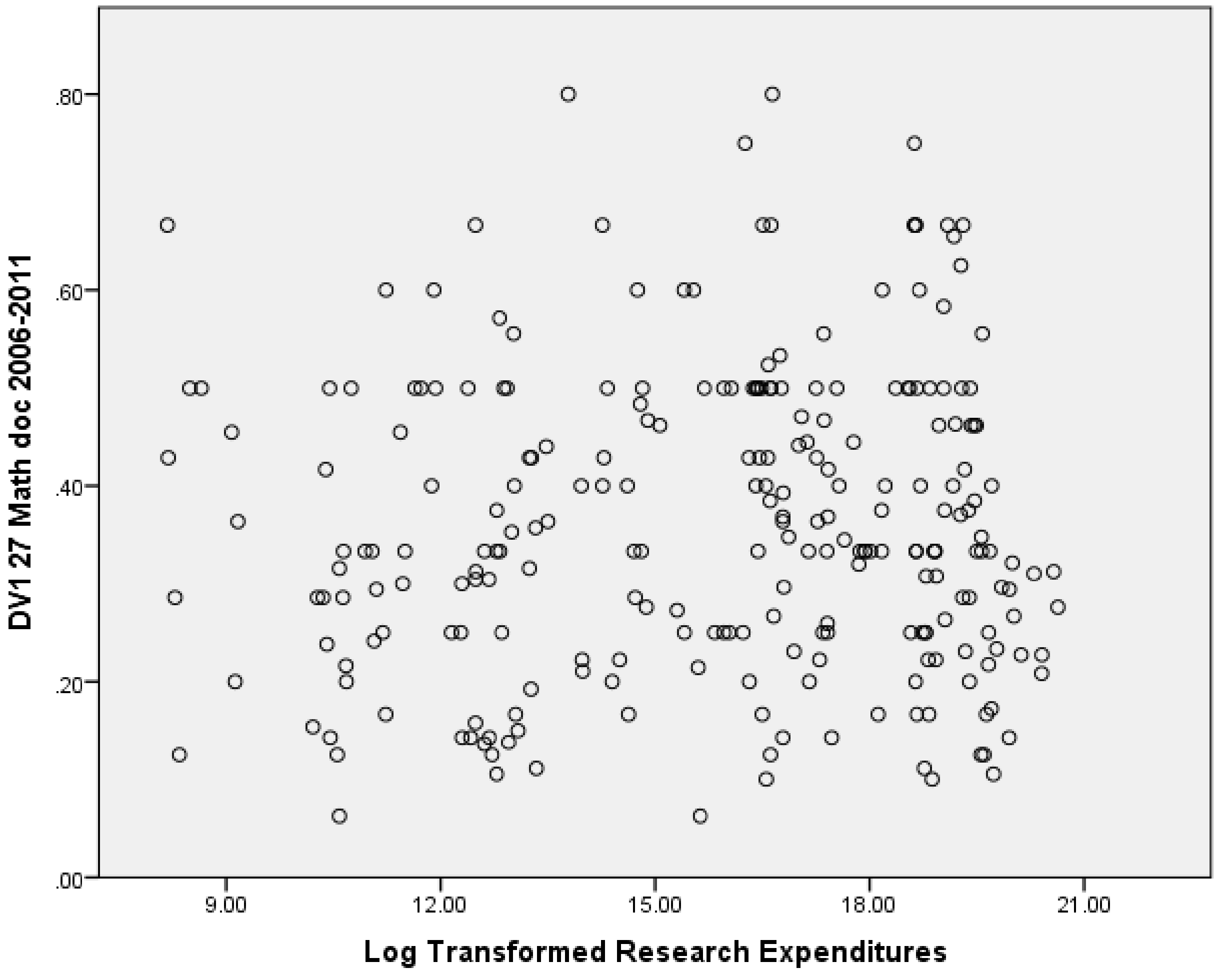


Figure I57. CIP 40 Master by Ratio Female Graduate Students

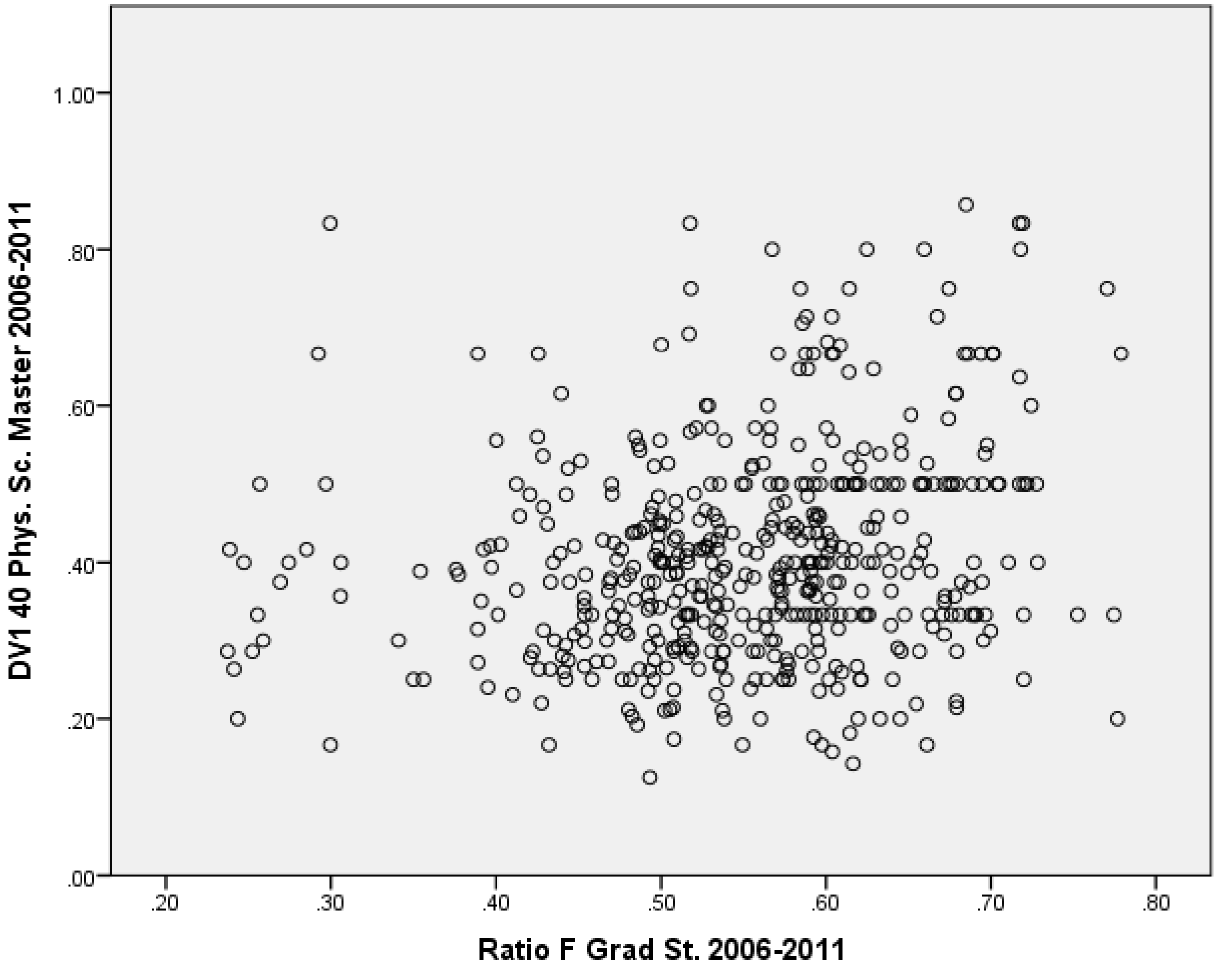


Figure I58. CIP 40 Master by Ratio Female Undergraduate Students

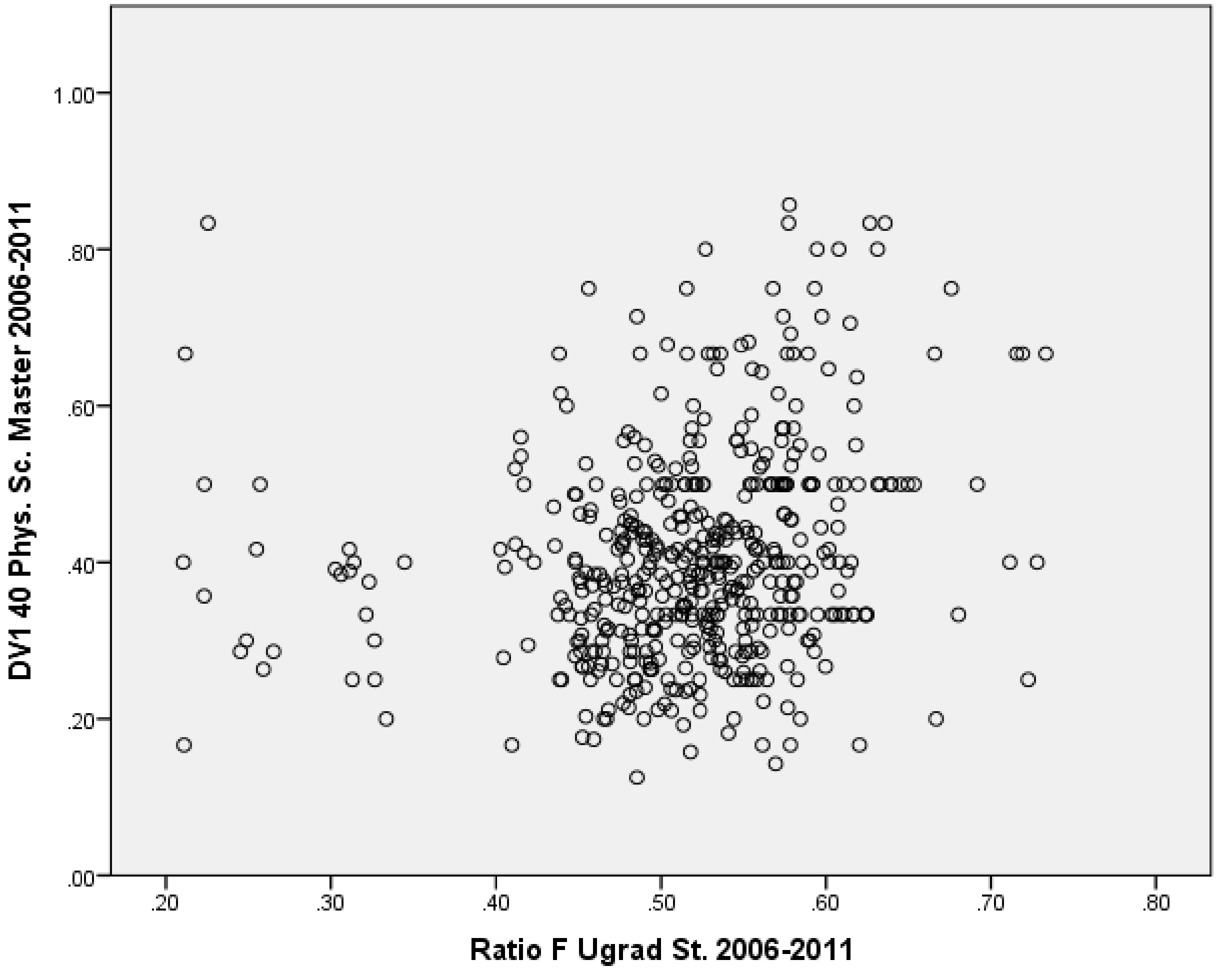


Figure I59. CIP 40 Master by Ratio Female Graduate Assistants

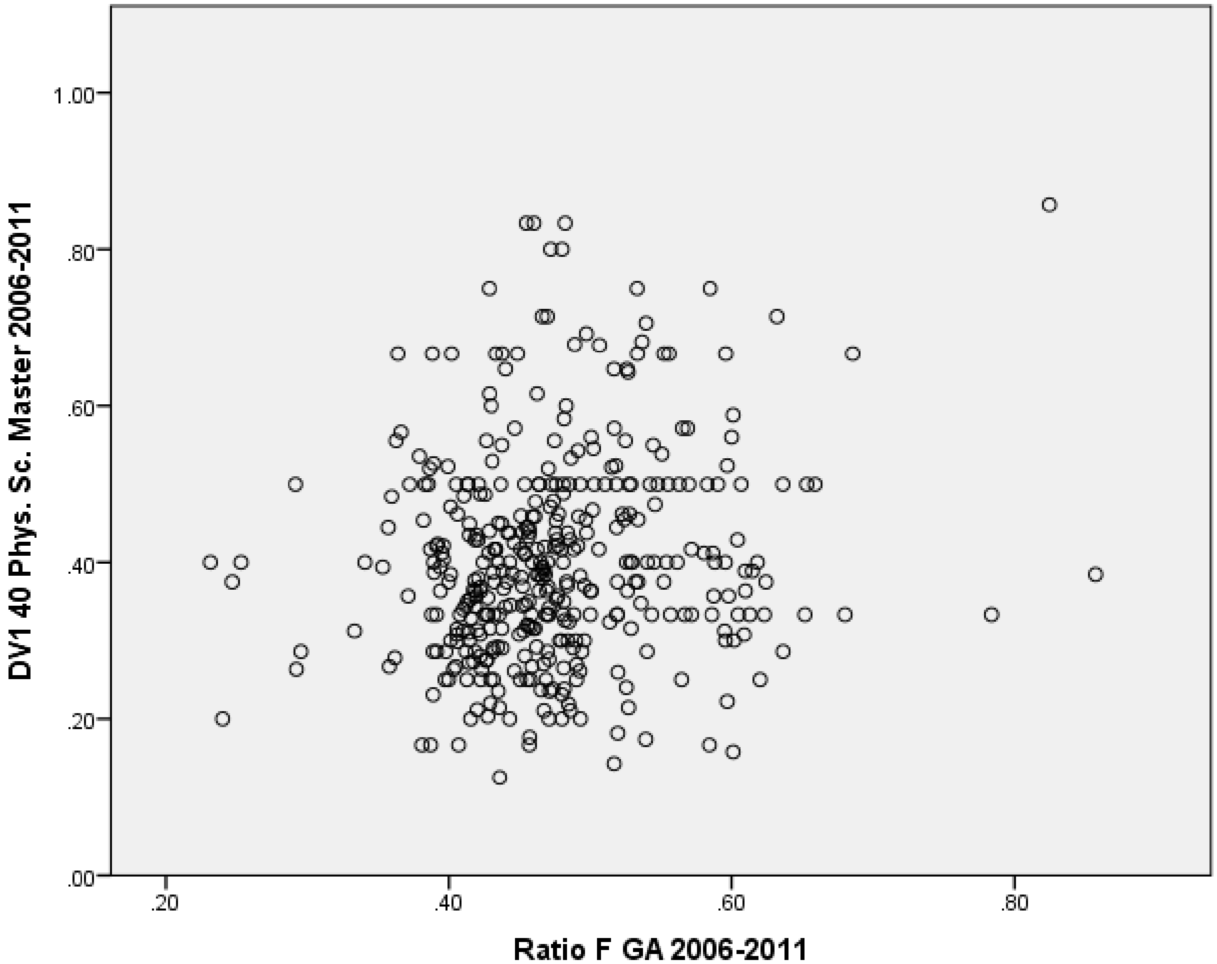


Figure I60. CIP 40 Master by Ratio Female Faculty

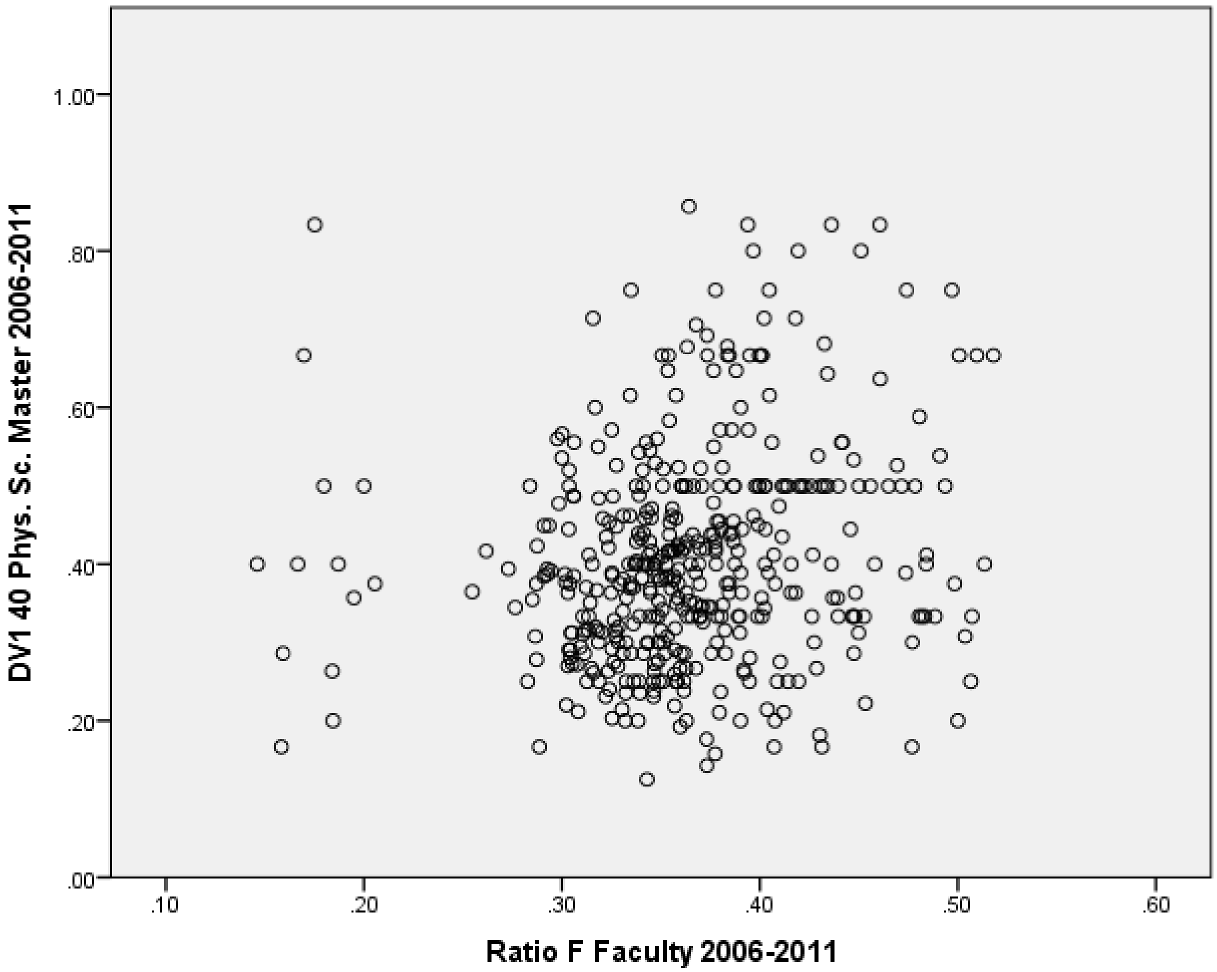


Figure I61. CIP 40 Master by Ratio Female Administrators

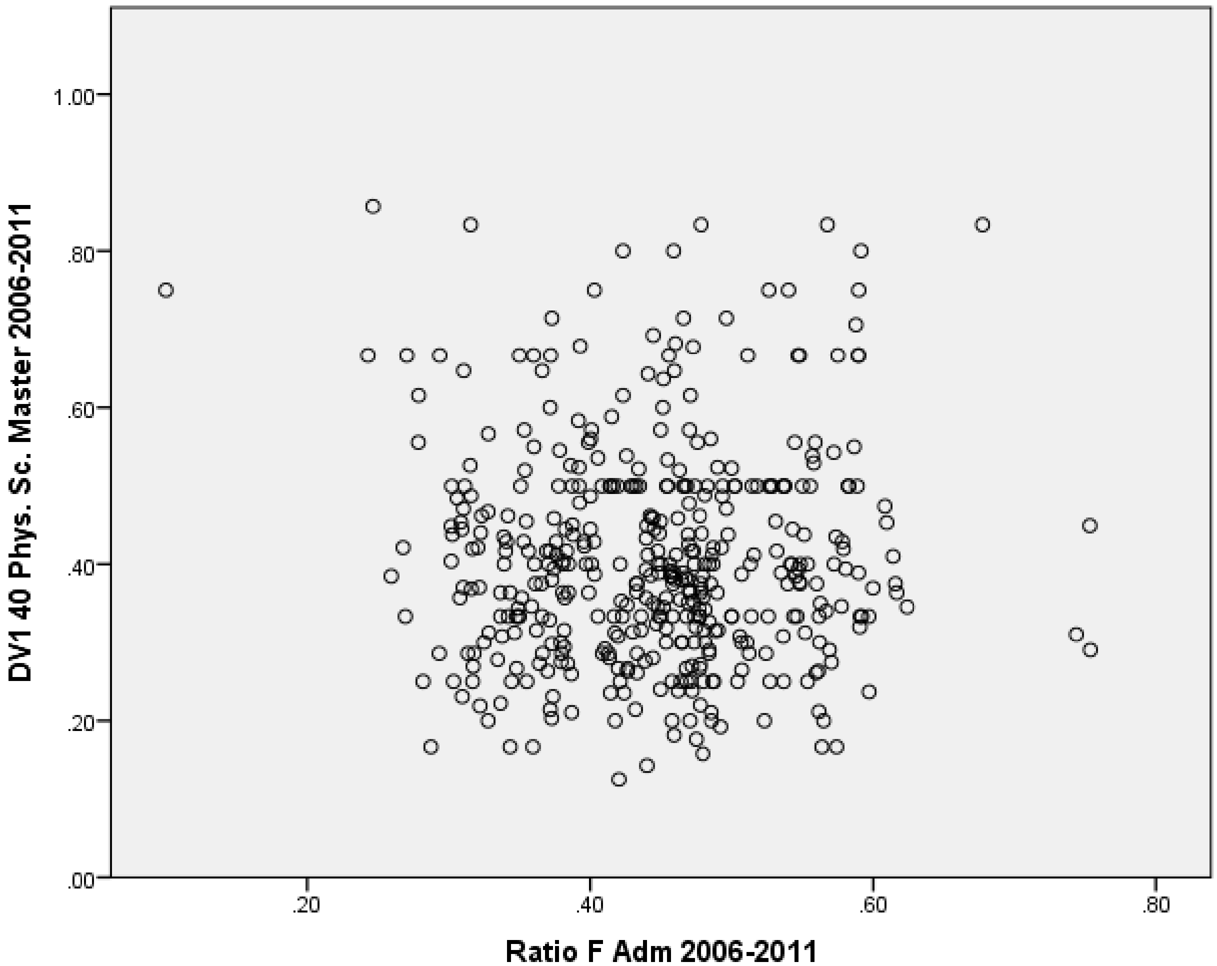


Figure I62. CIP 40 Master by Enrollment

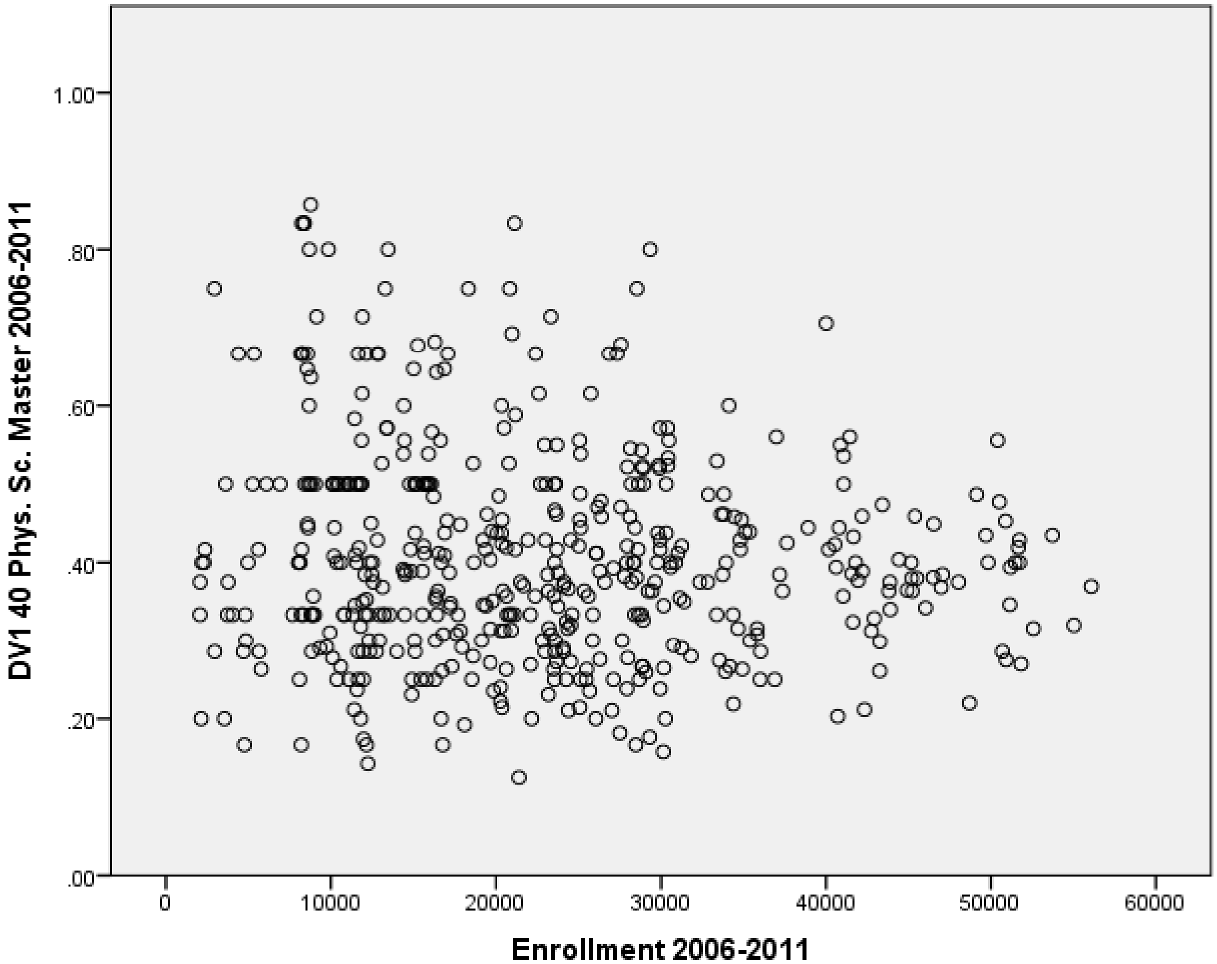


Figure I63. CIP 40 Master by Research Expenditures

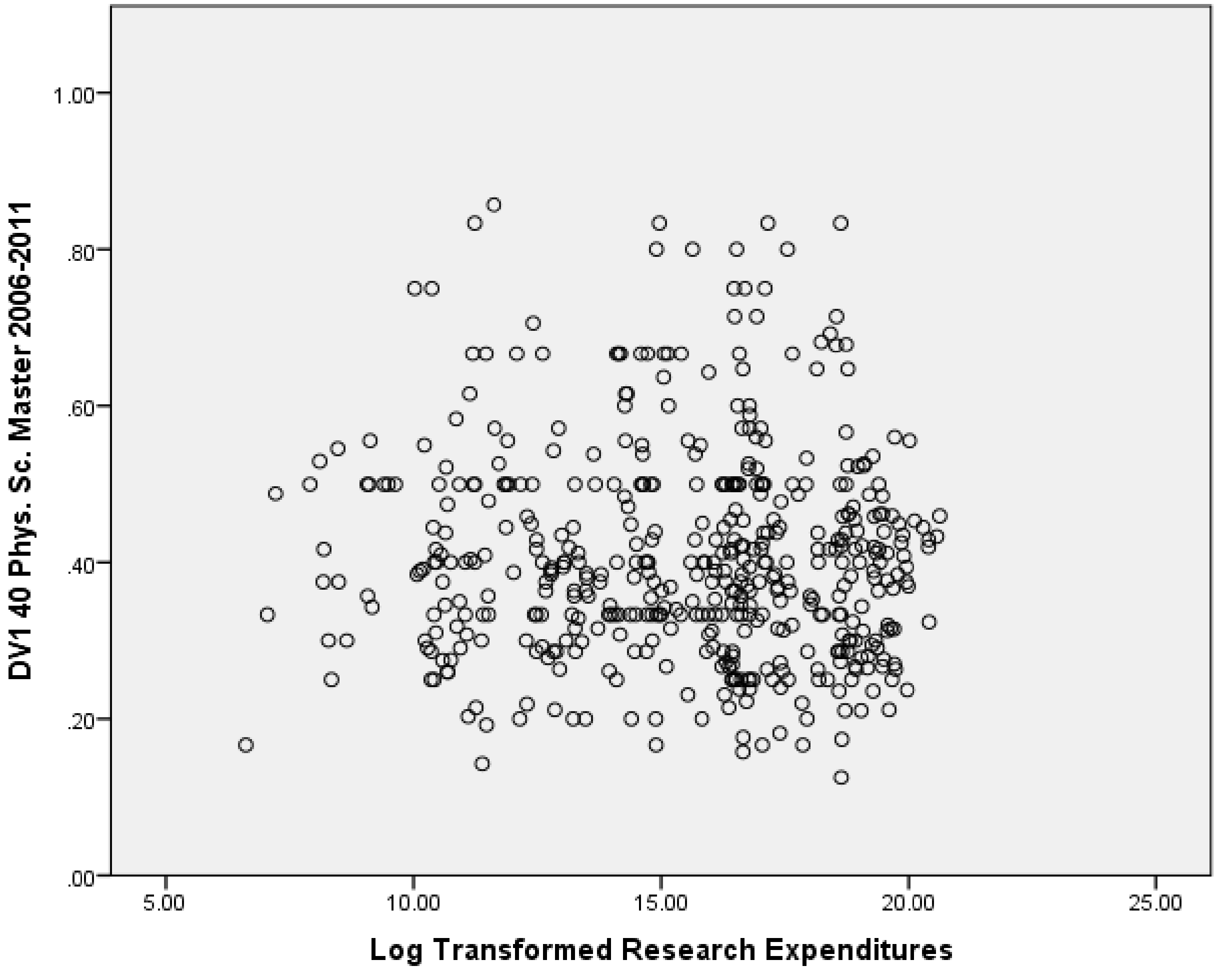


Figure I64. CIP 40 Doctoral by Ratio Female Graduate Students

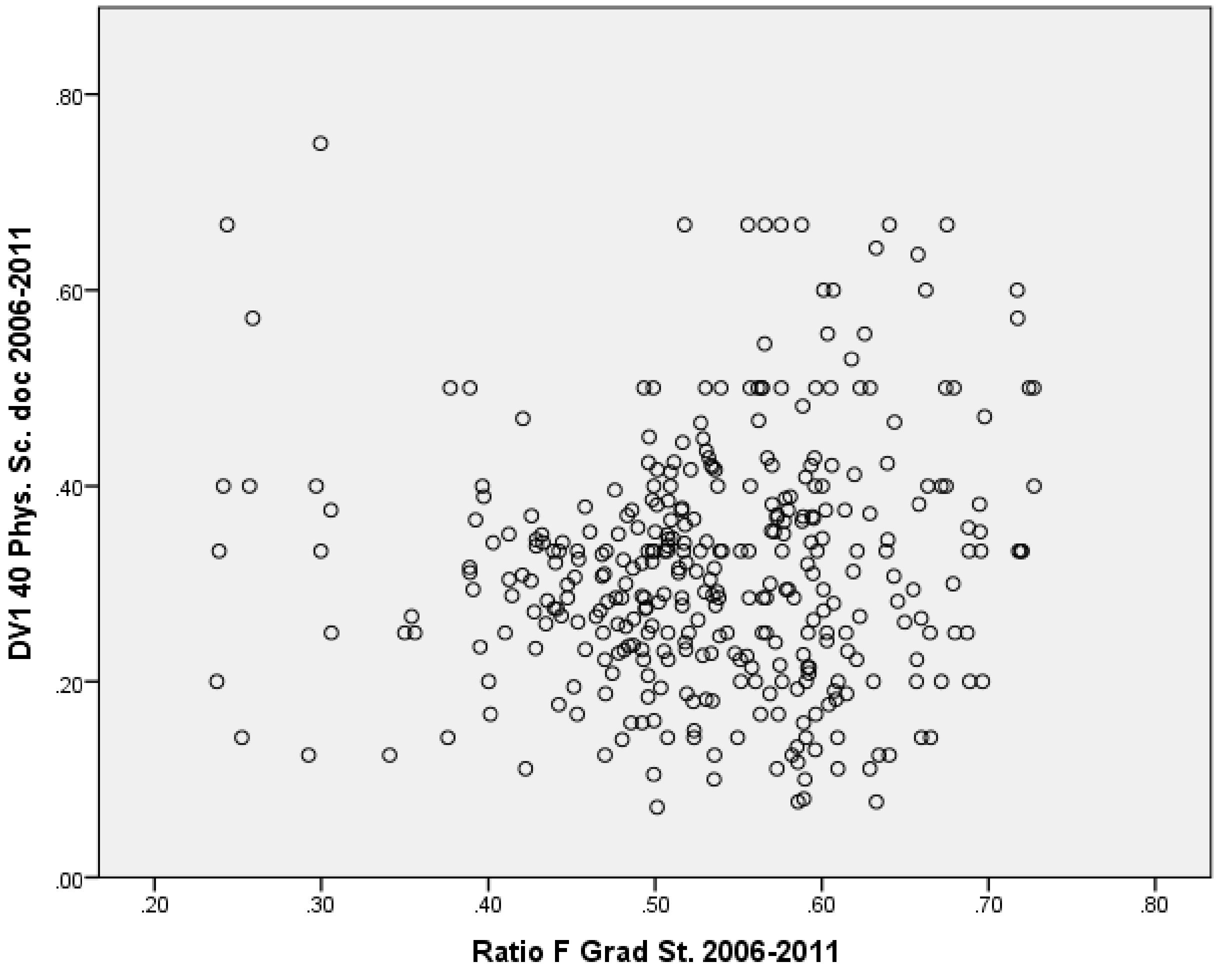


Figure I65. CIP 40 Doctoral by Ratio Female Undergraduate Students

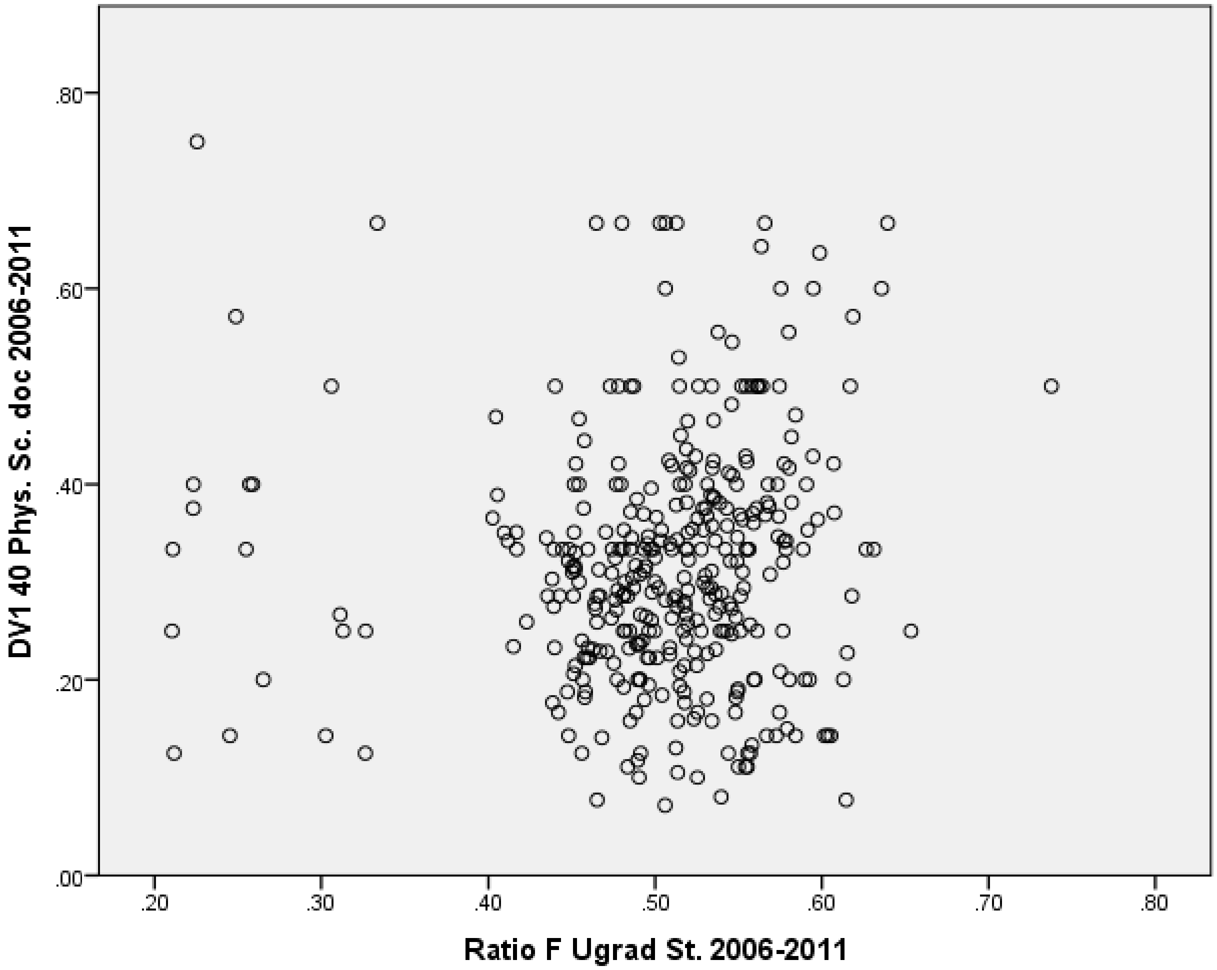


Figure I66. CIP 40 Doctoral by Ratio Female Graduate Assistants

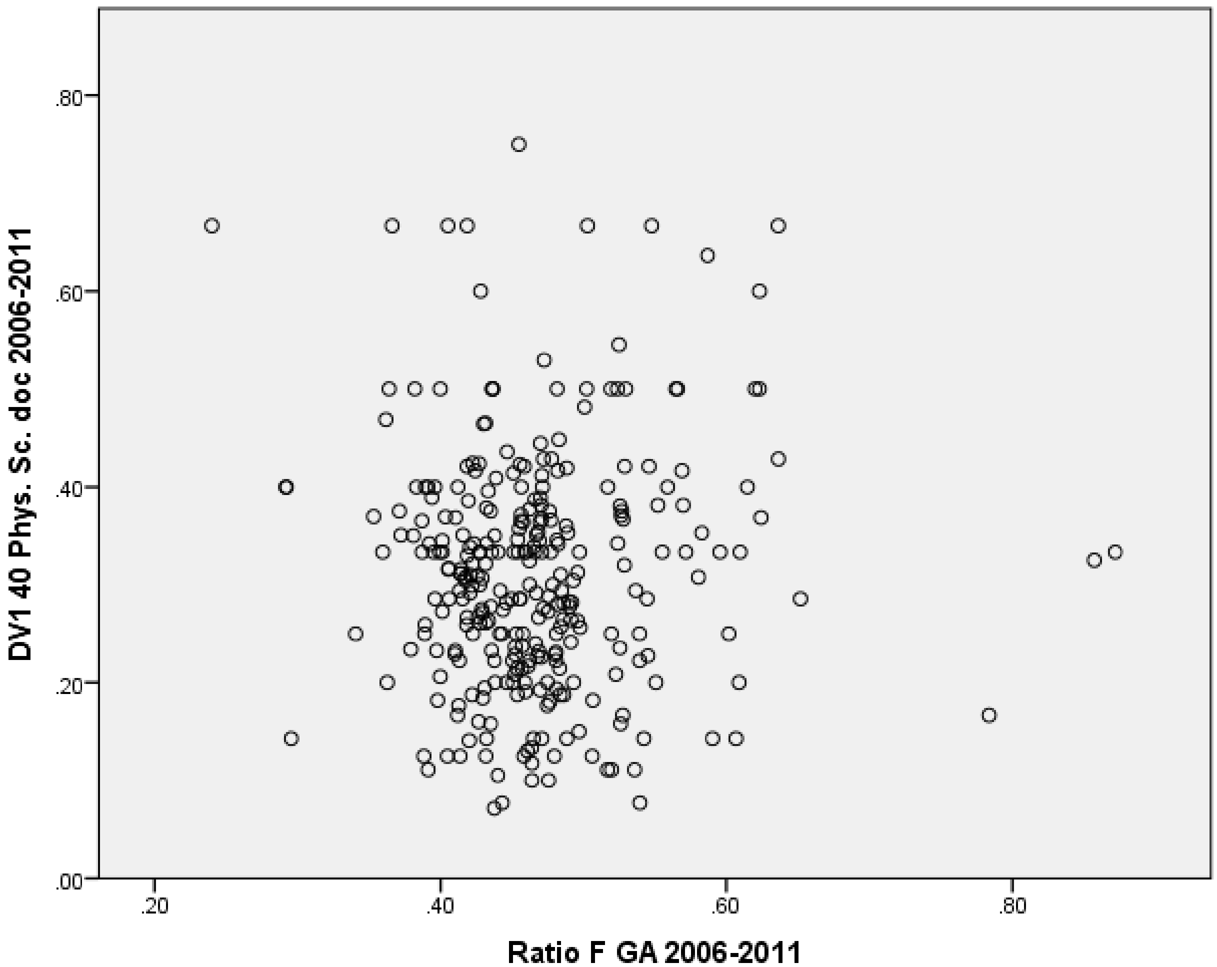


Figure I67. CIP 40 Doctoral by Ratio Female Faculty

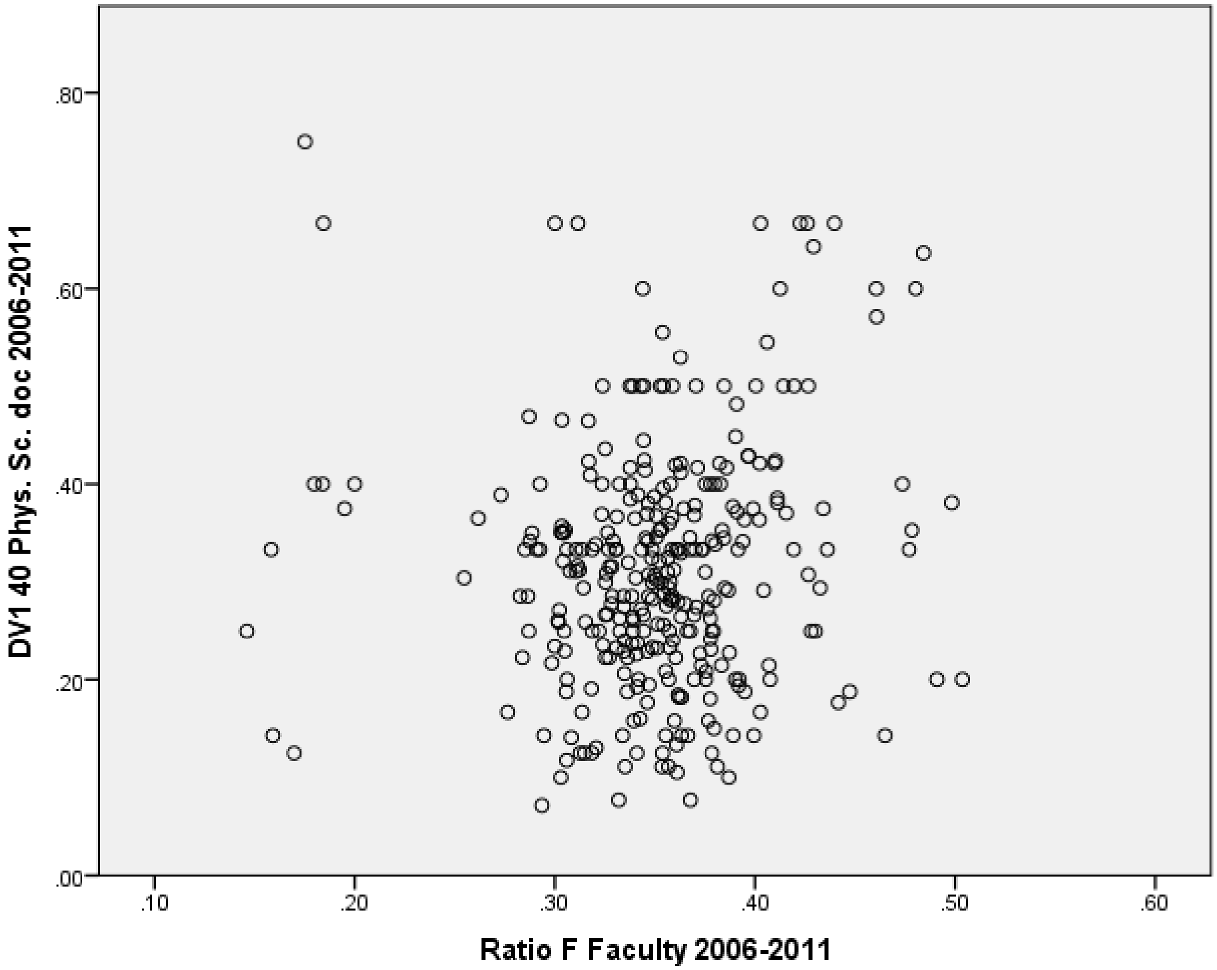


Figure I68. CIP 40 Doctoral by Ratio Female Administrators

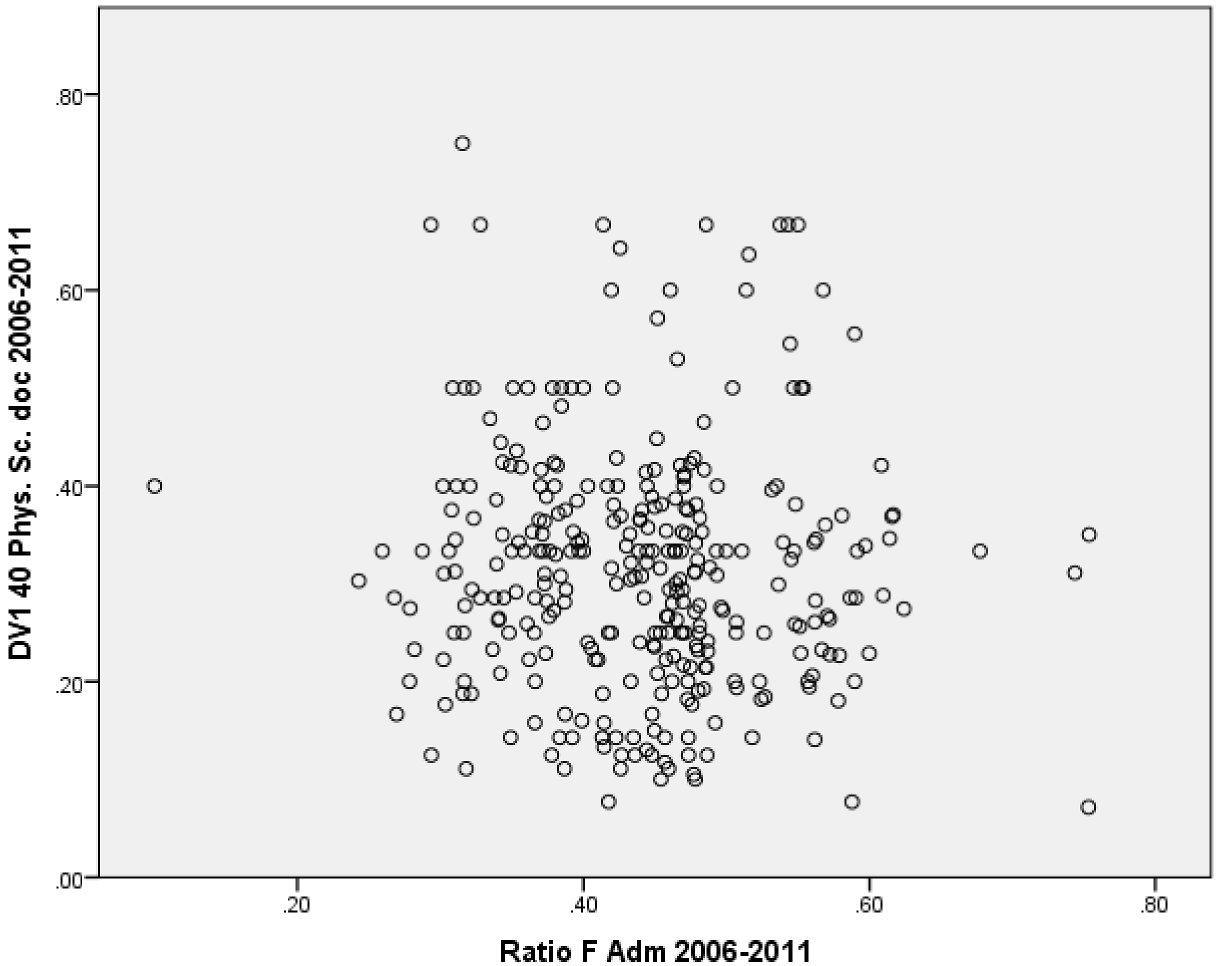


Figure I69. CIP 40 Doctoral by Enrollment

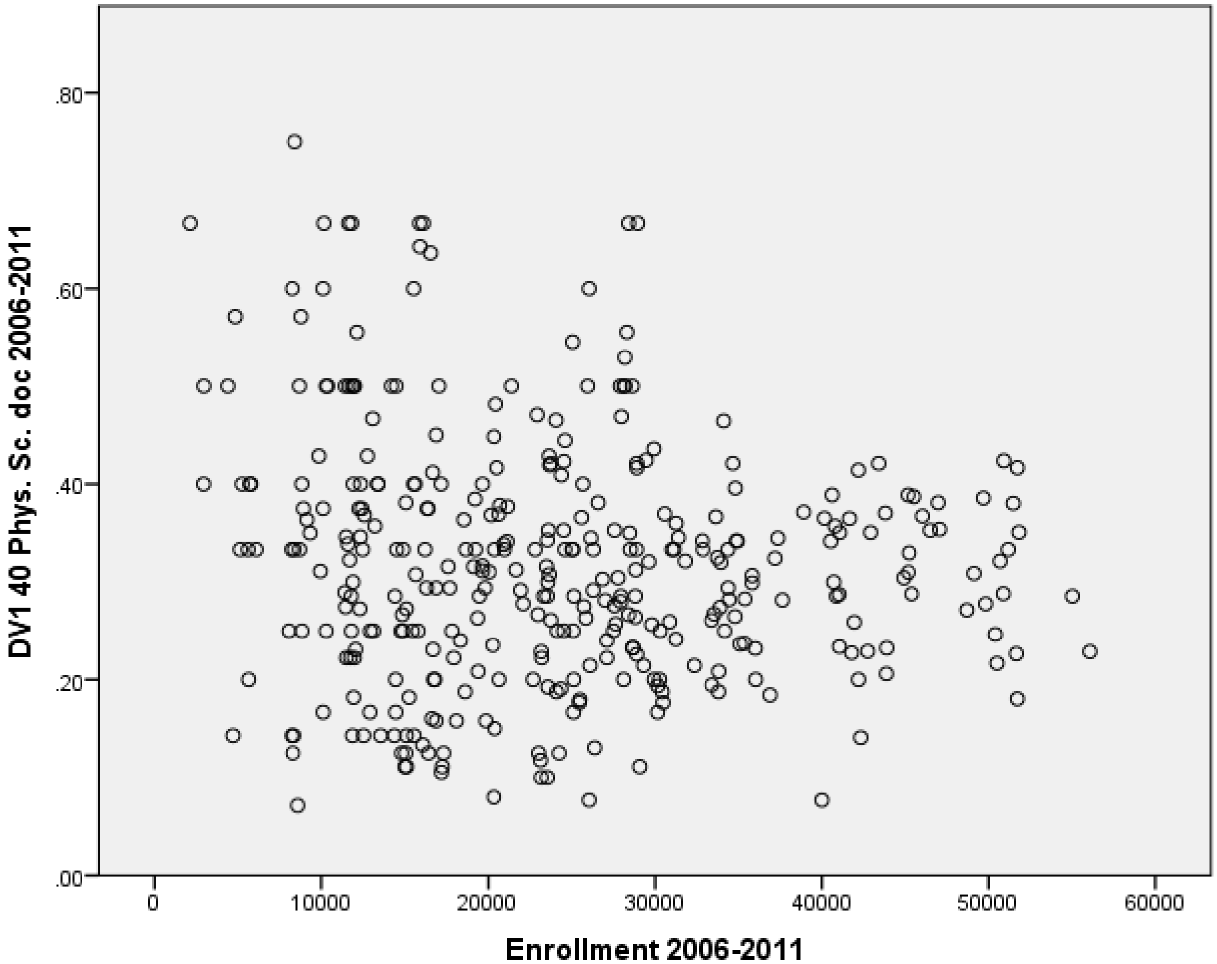


Figure I70. CIP 40 Doctoral by Research Expenditures

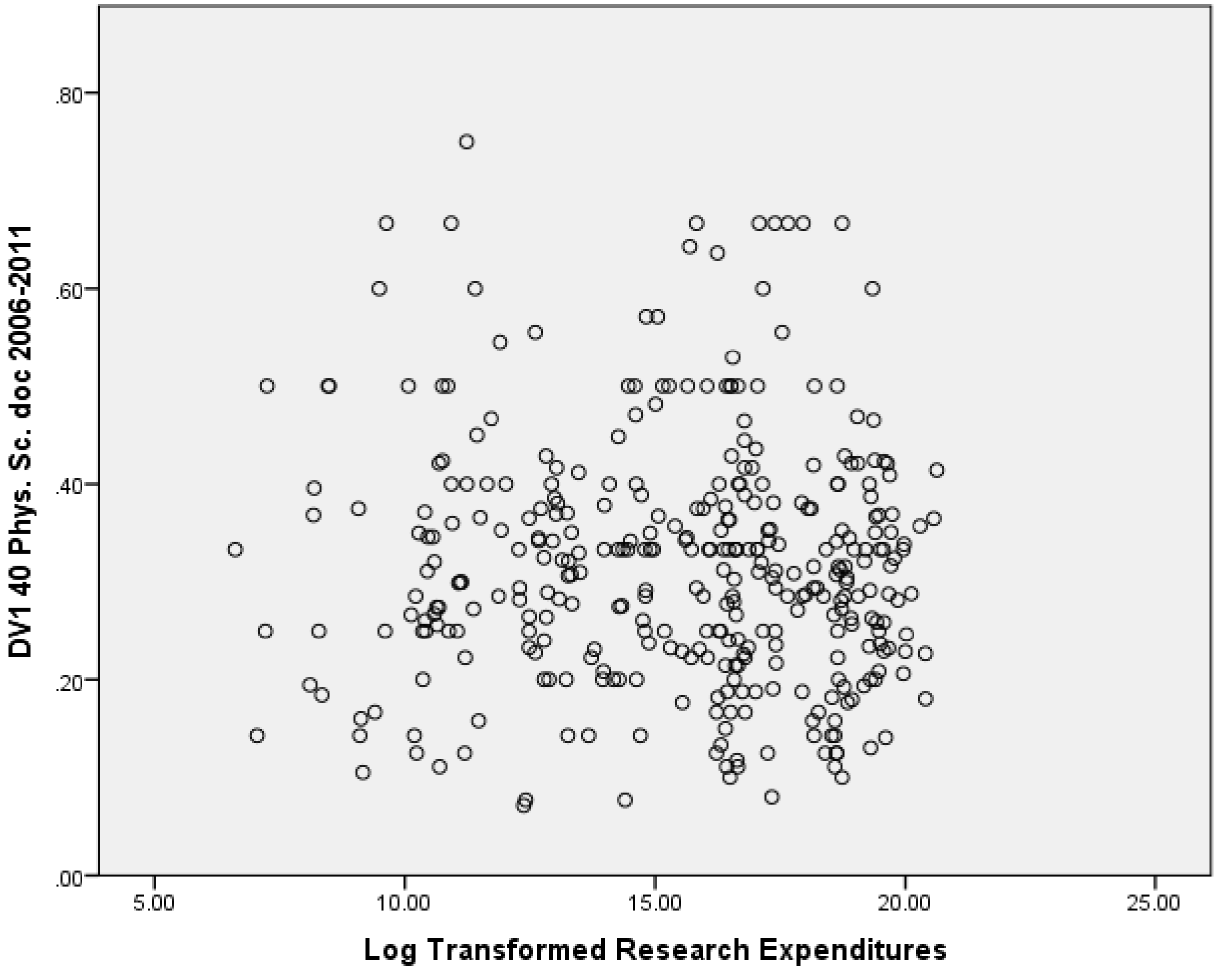


Figure I71. CIP 11 Master Homoscedasticity

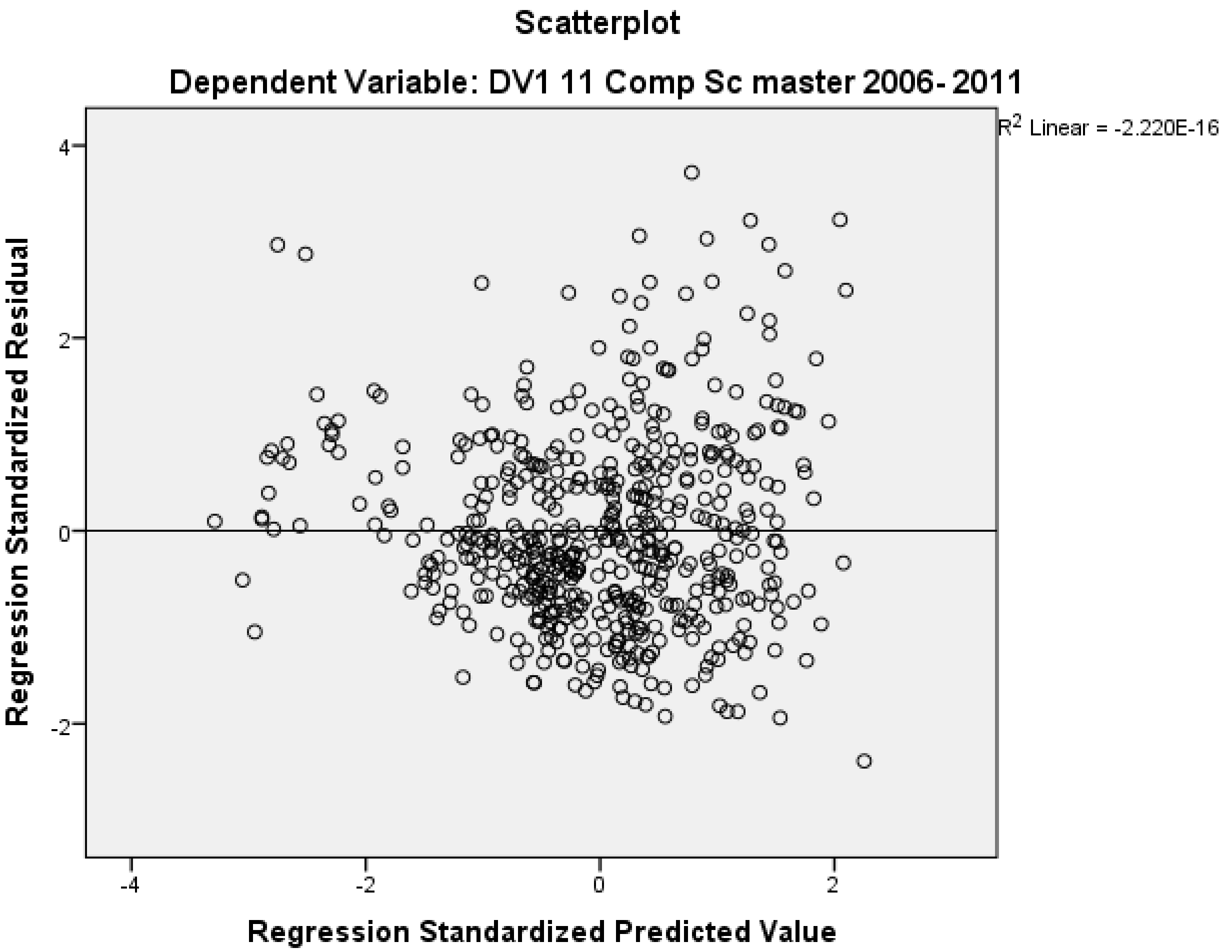


Figure I72. CIP 11 Doctoral Homoscedasticity

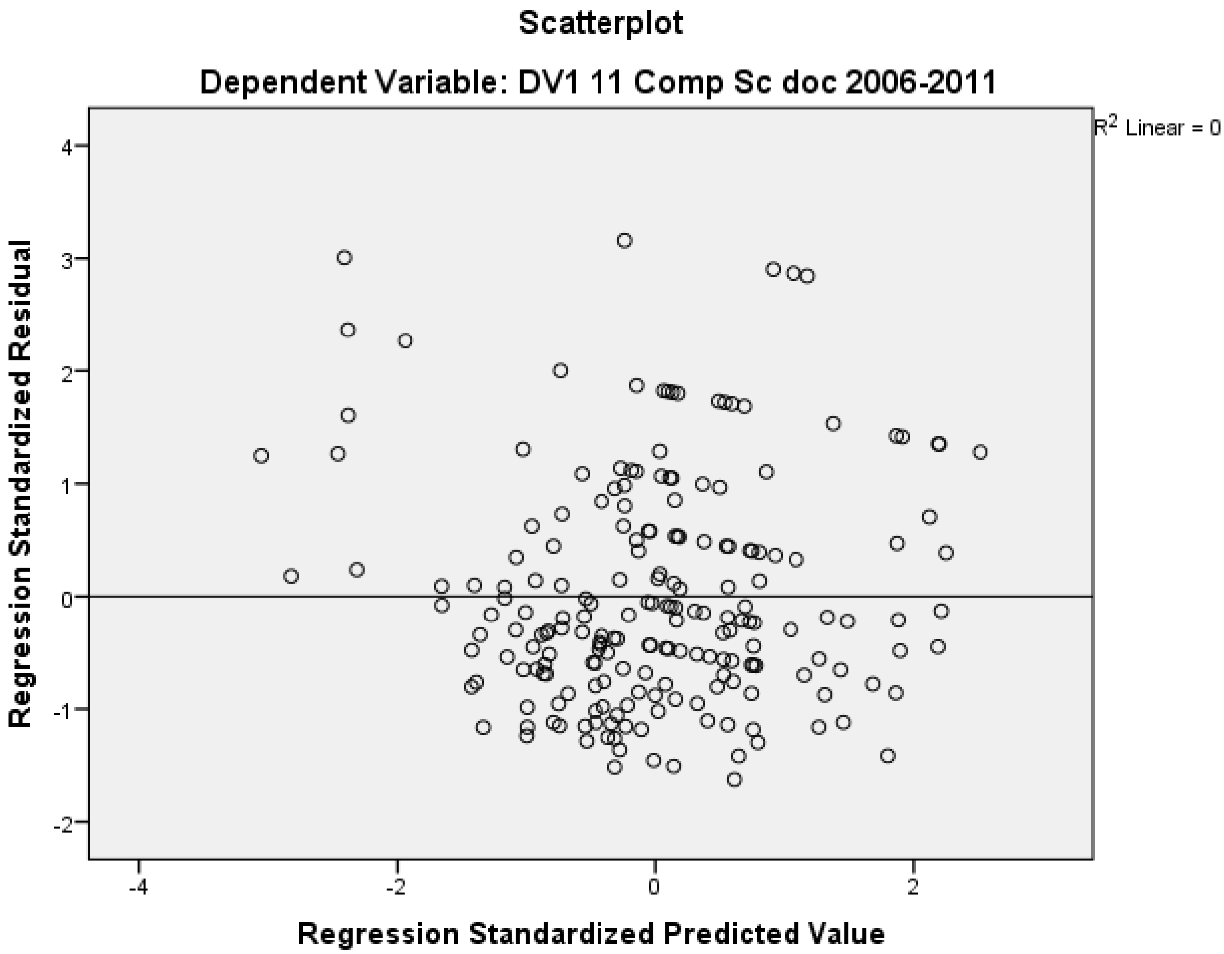


Figure I73. CIP 14 Master
Homoscedasticity

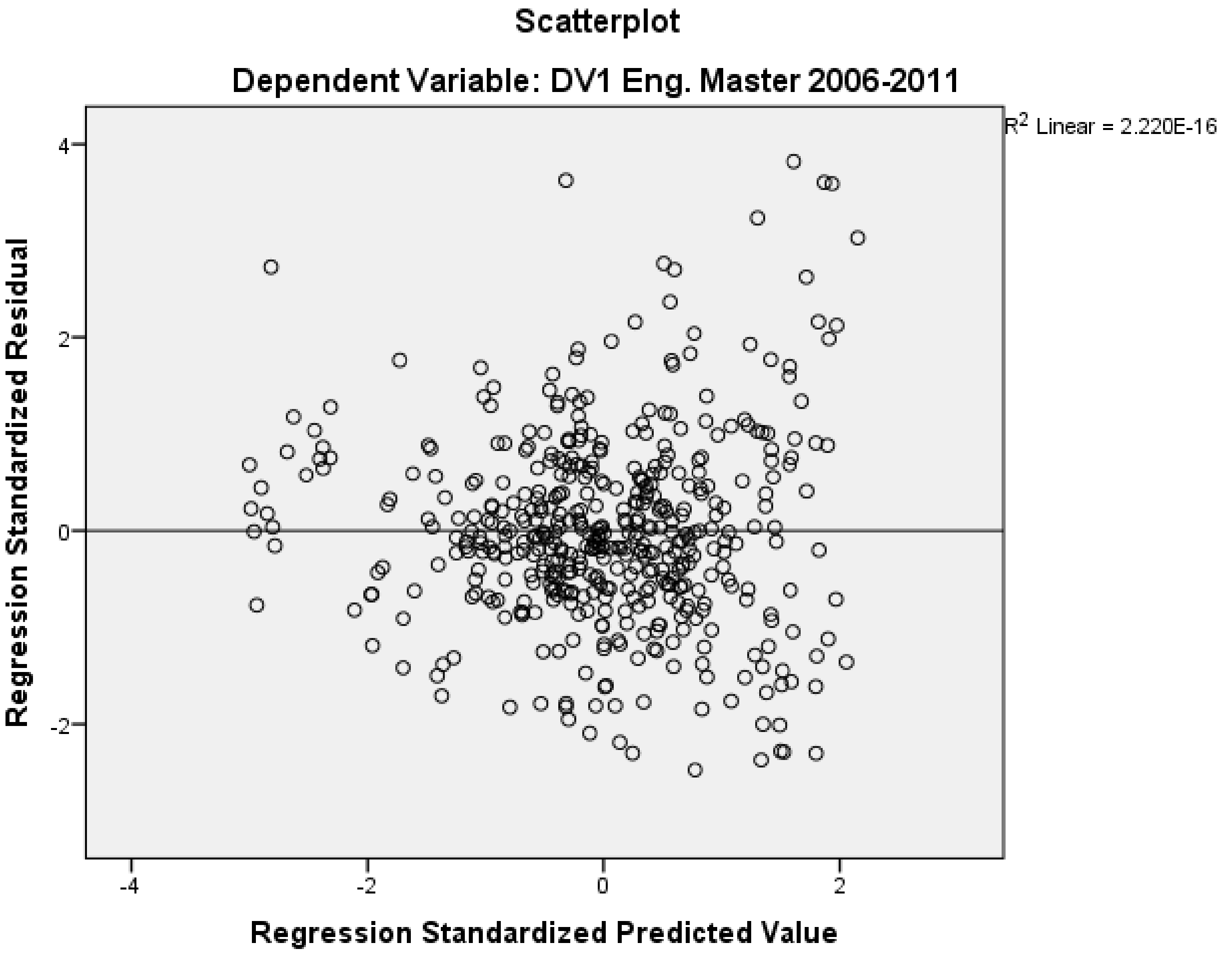


Figure I74. CIP 14 Doctoral Homoscedasticity

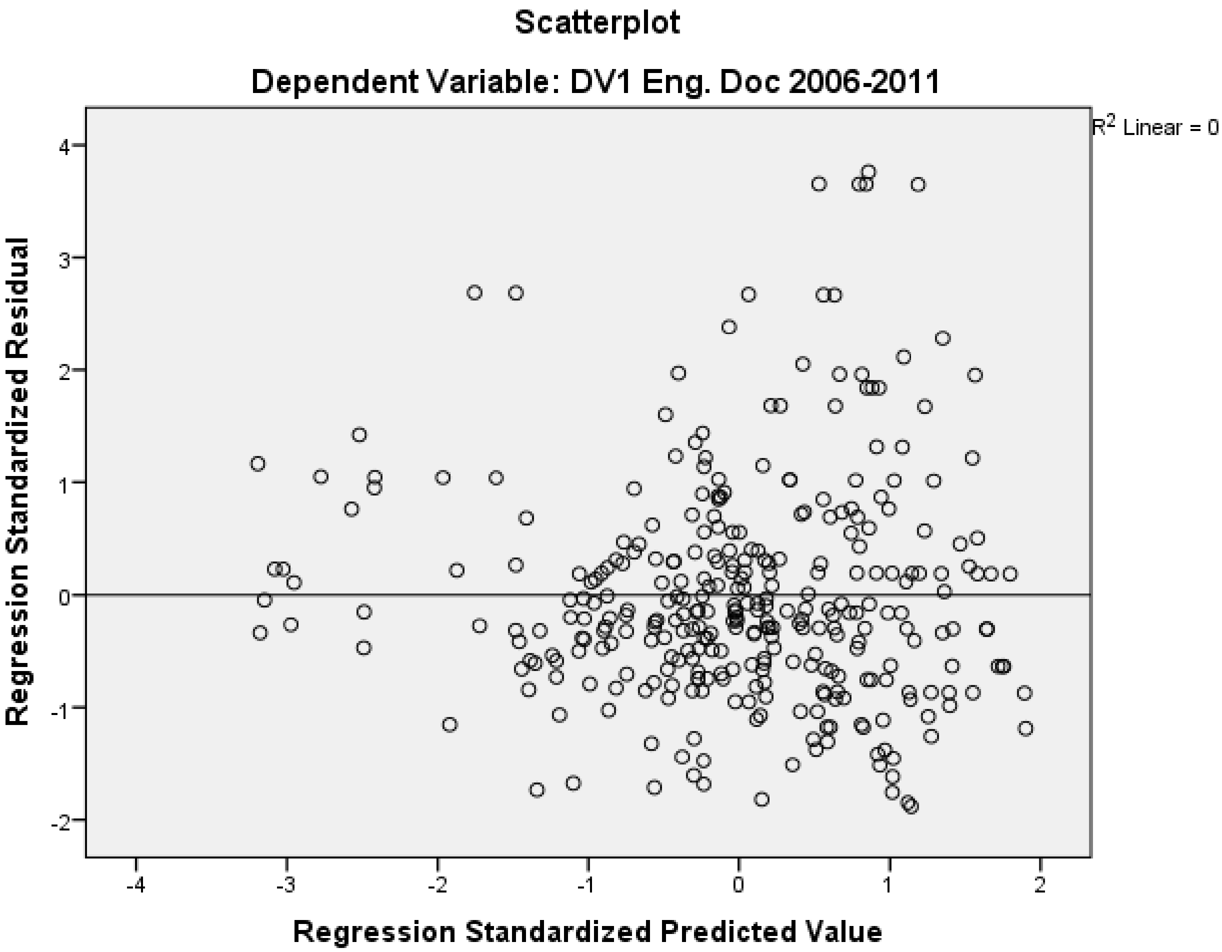


Figure I75. CIP 26 Master Homoscedasticity

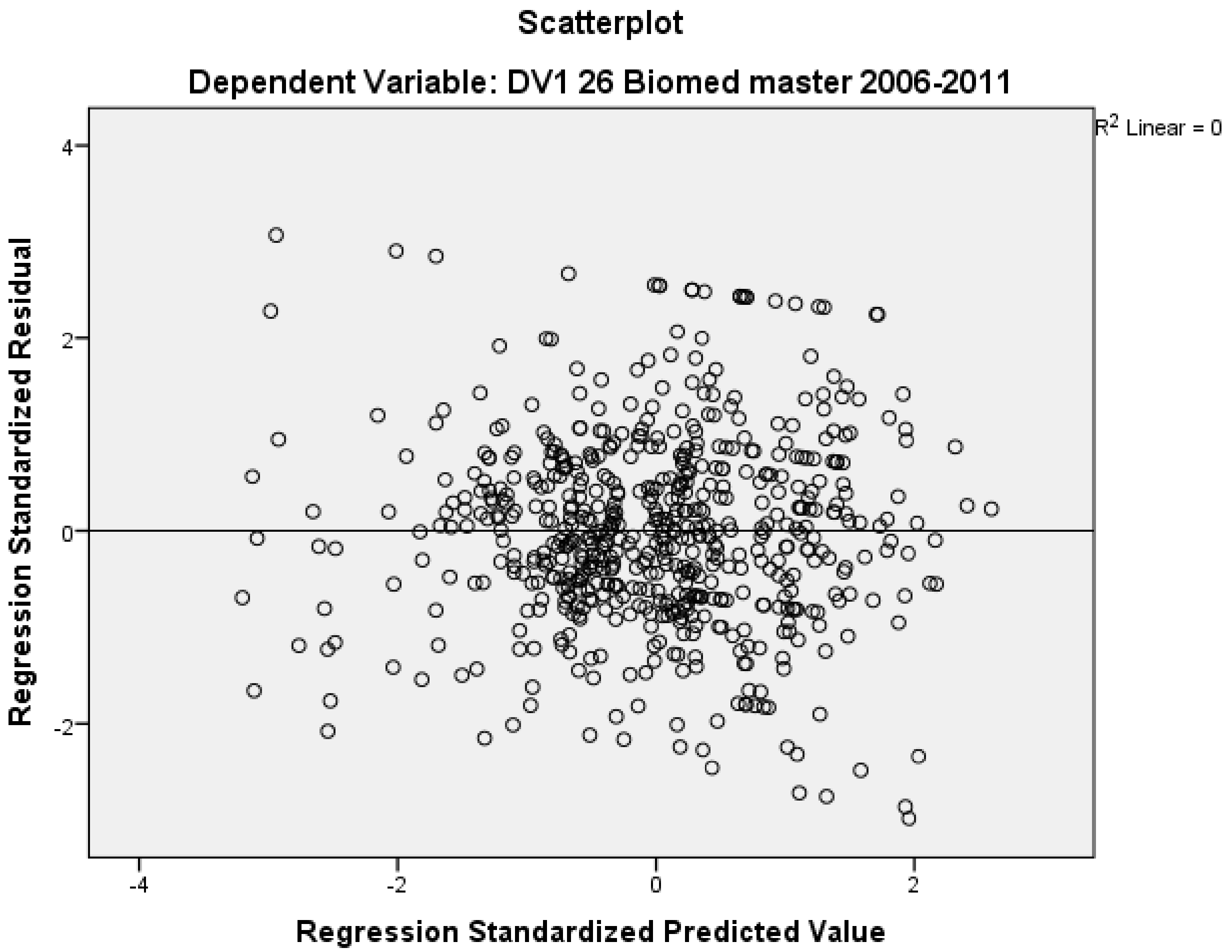


Figure I76. CIP 26 Doctoral Homoscedasticity

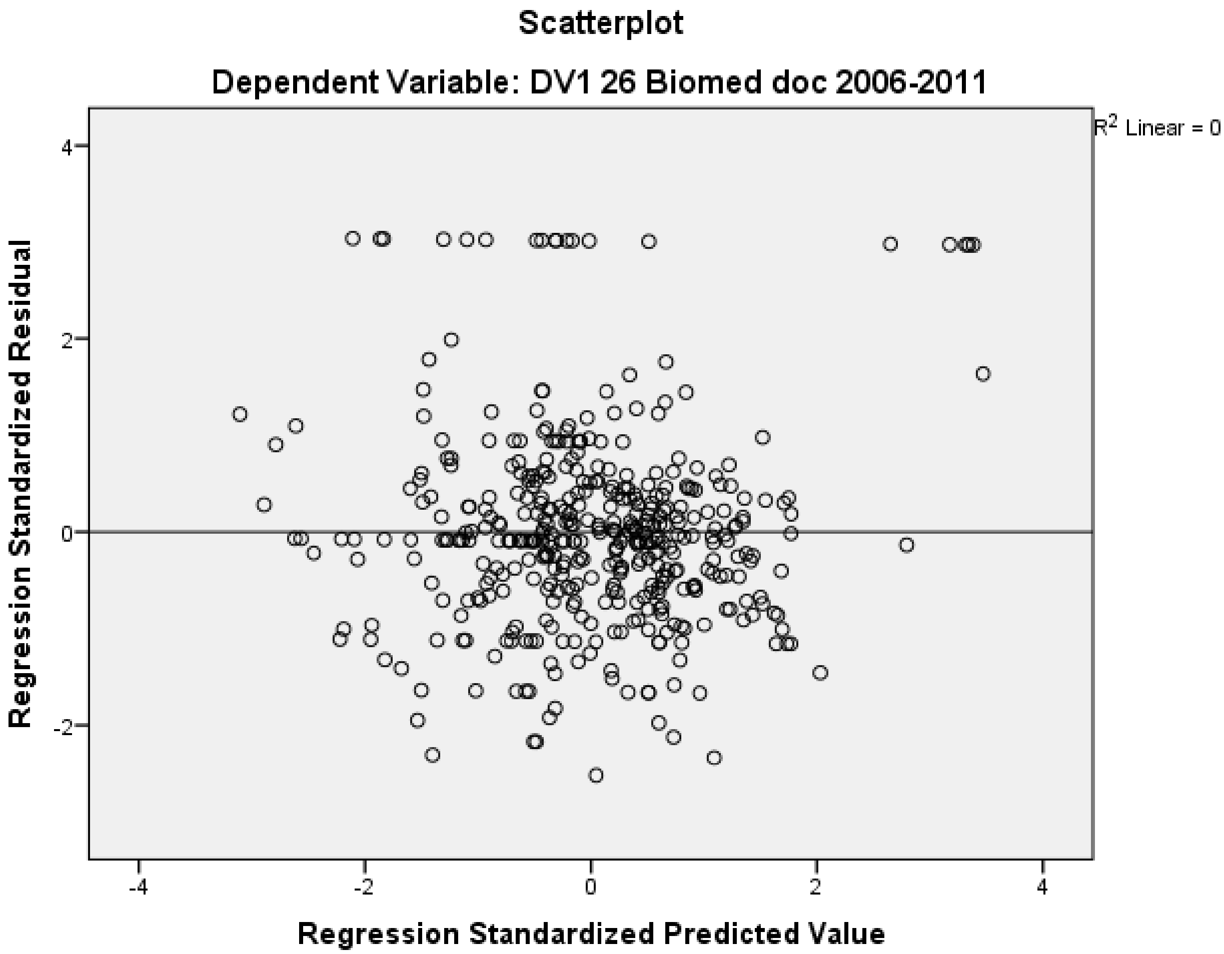


Figure I77. CIP 27 Master
Homoscedasticity

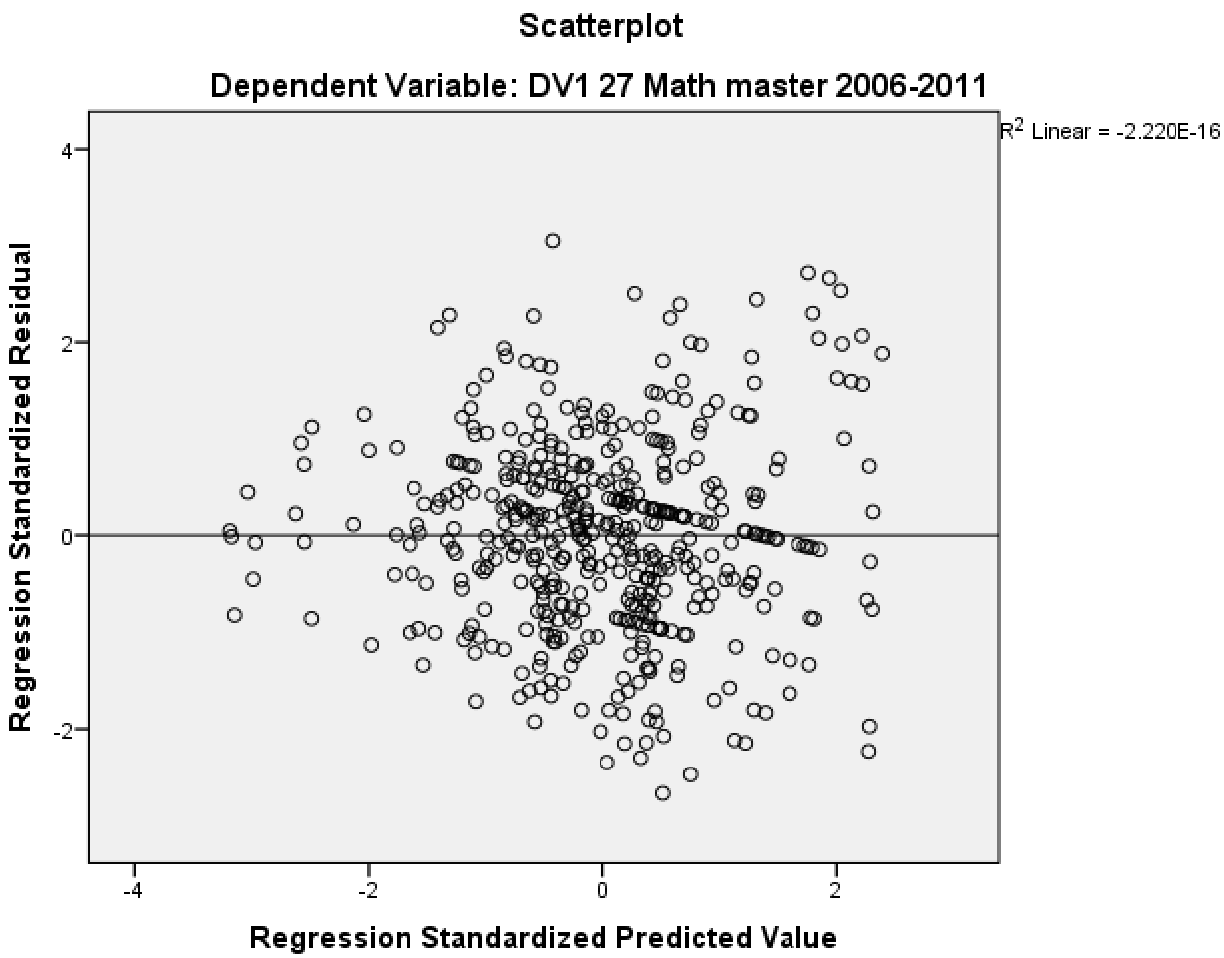


Figure I78. CIP 27 Doctoral Homoscedasticity

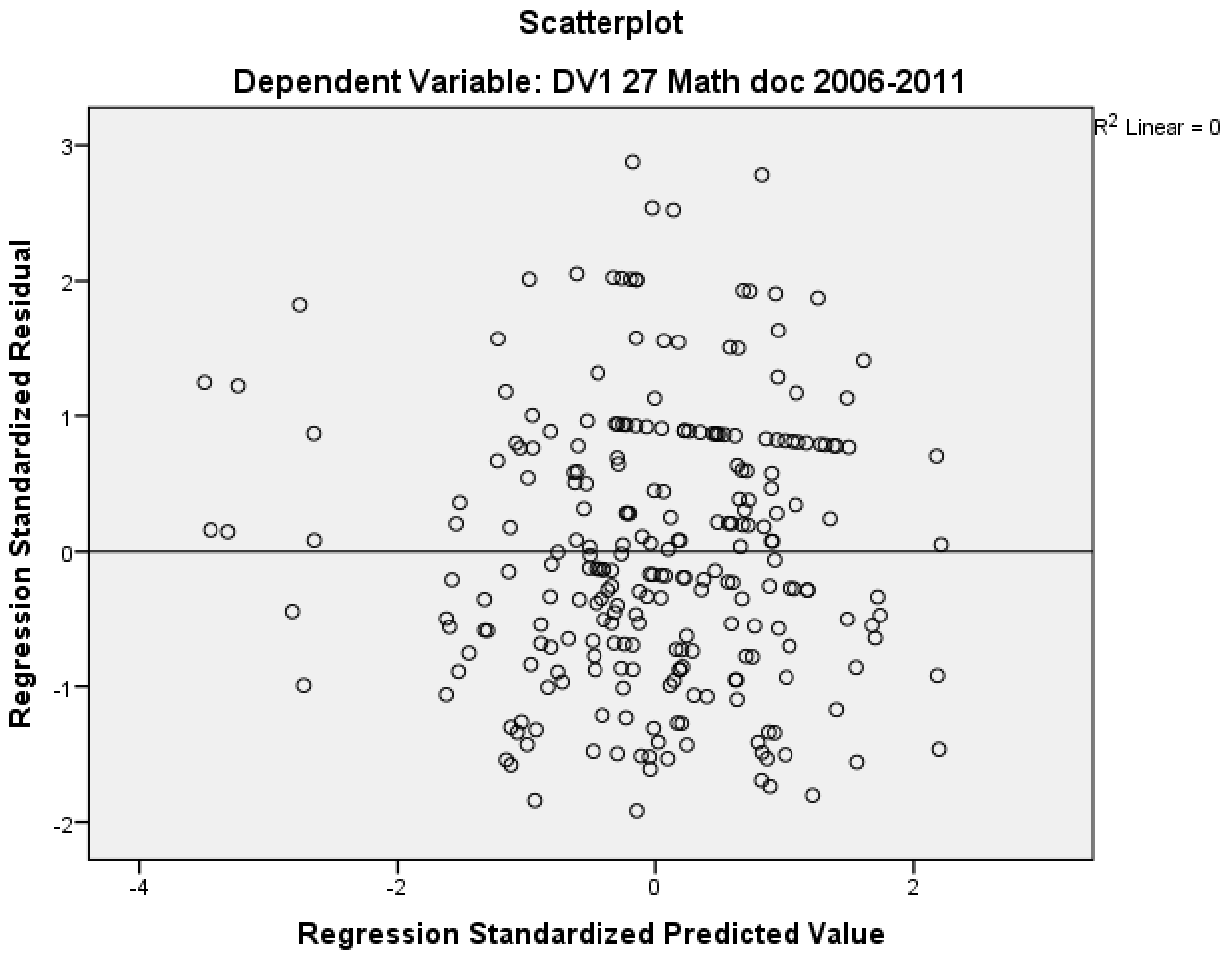


Figure I79. CIP 40 Master by Homoscedasticity

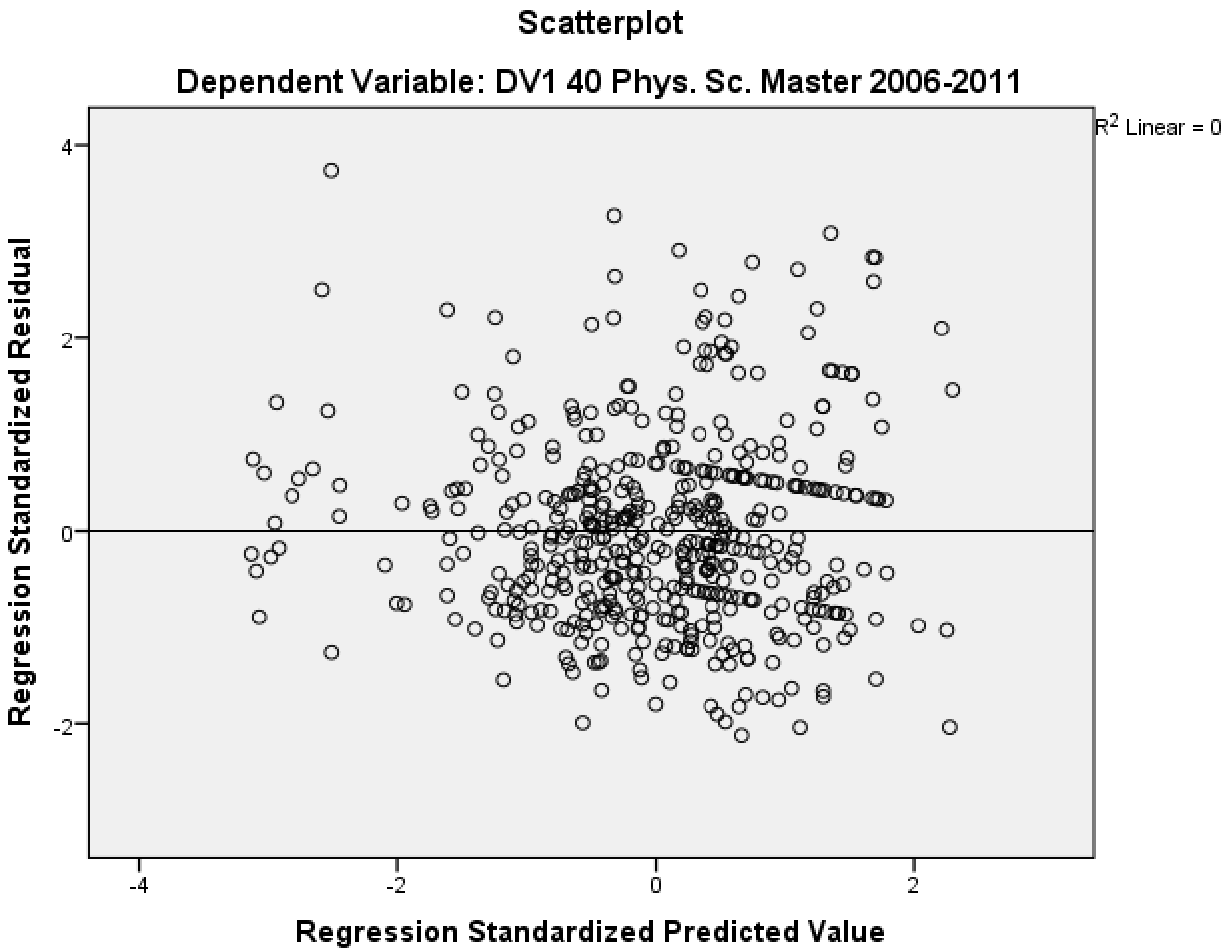


Figure I80. CIP 40 Doctoral Homoscedasticity

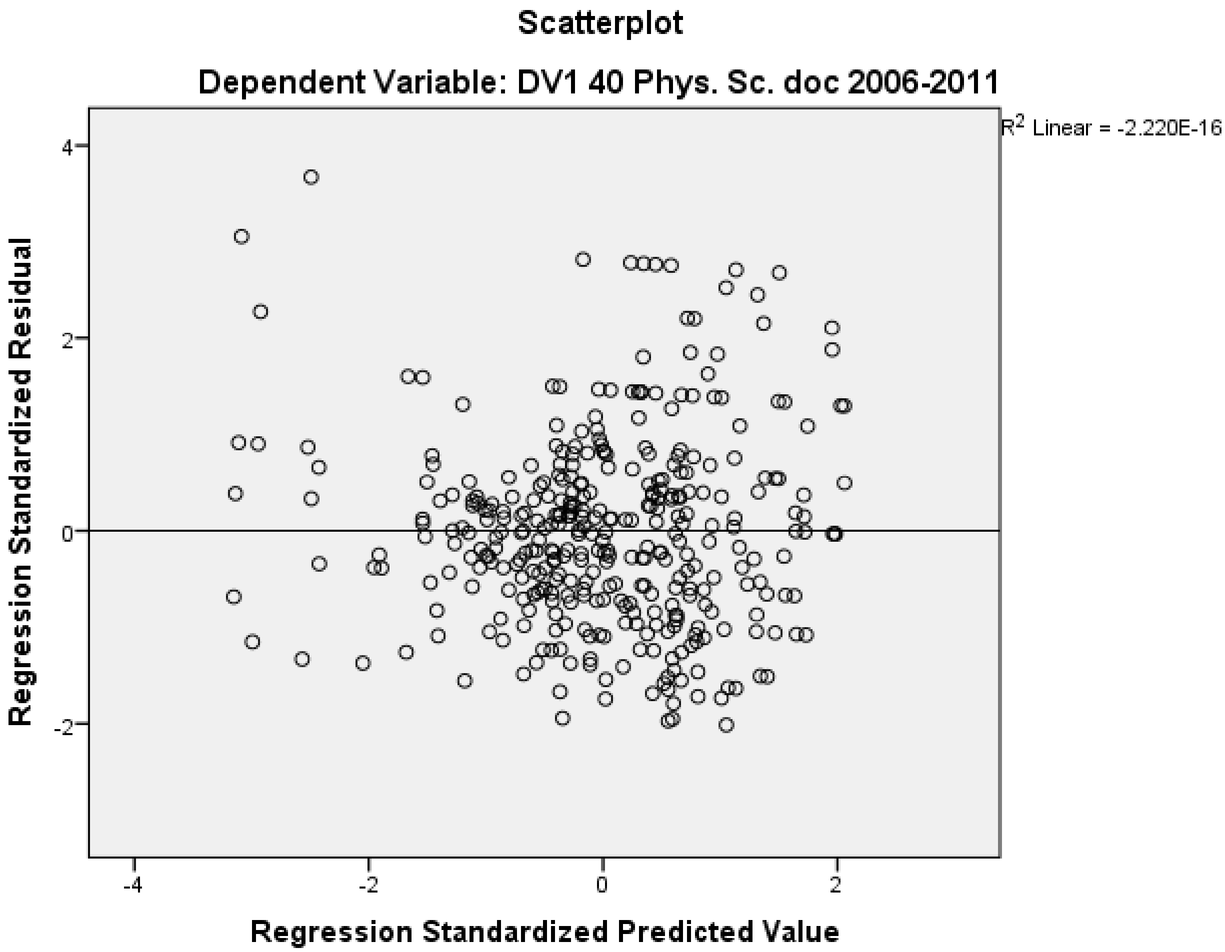


Figure I81. CIP 11 Master Distribution

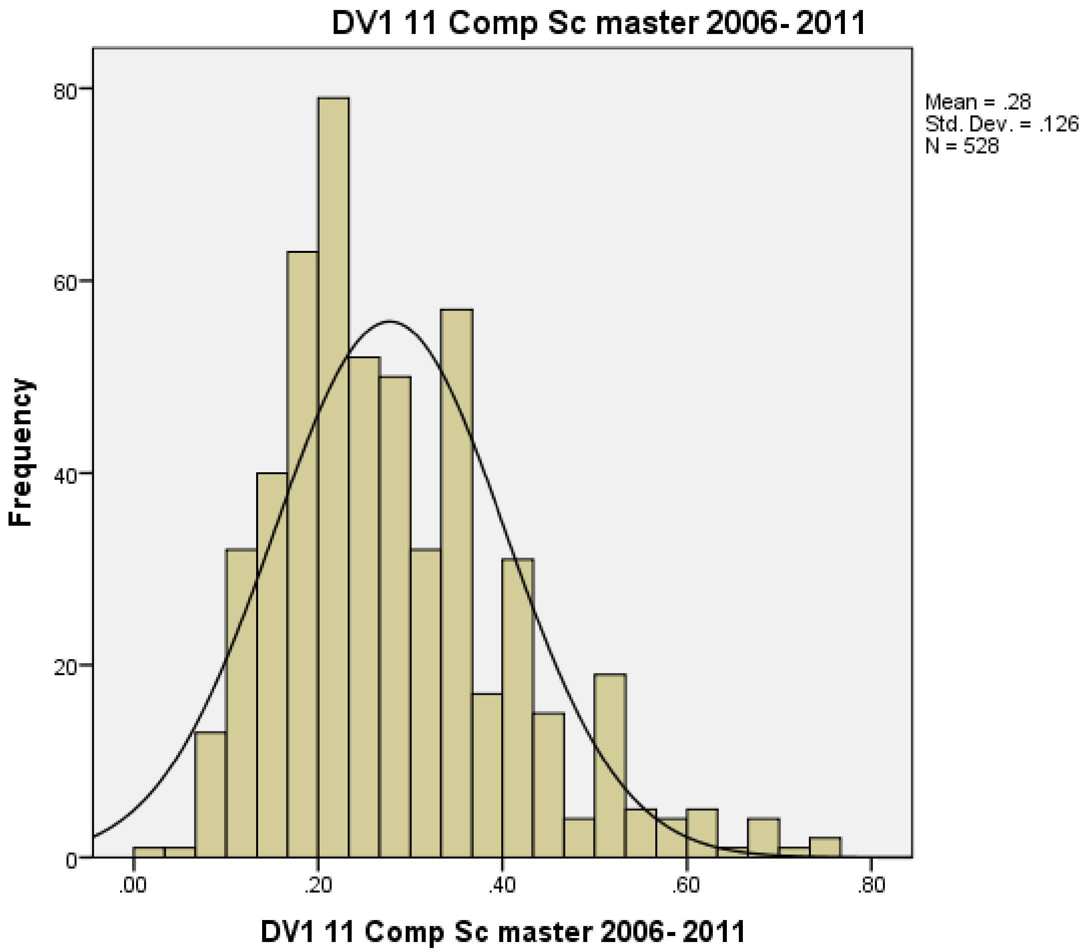


Figure I82. CIP 11 Doctoral Distribution

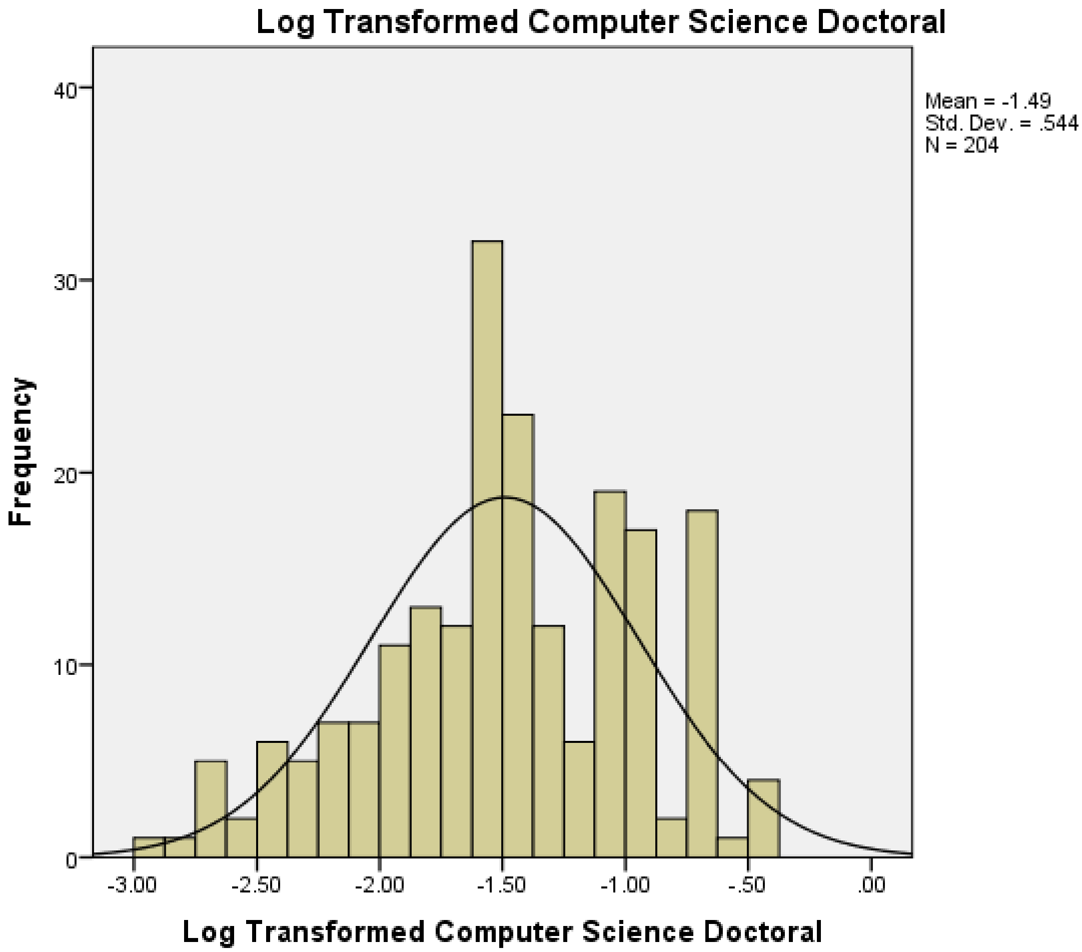


Figure I83. CIP 14 Master Distribution

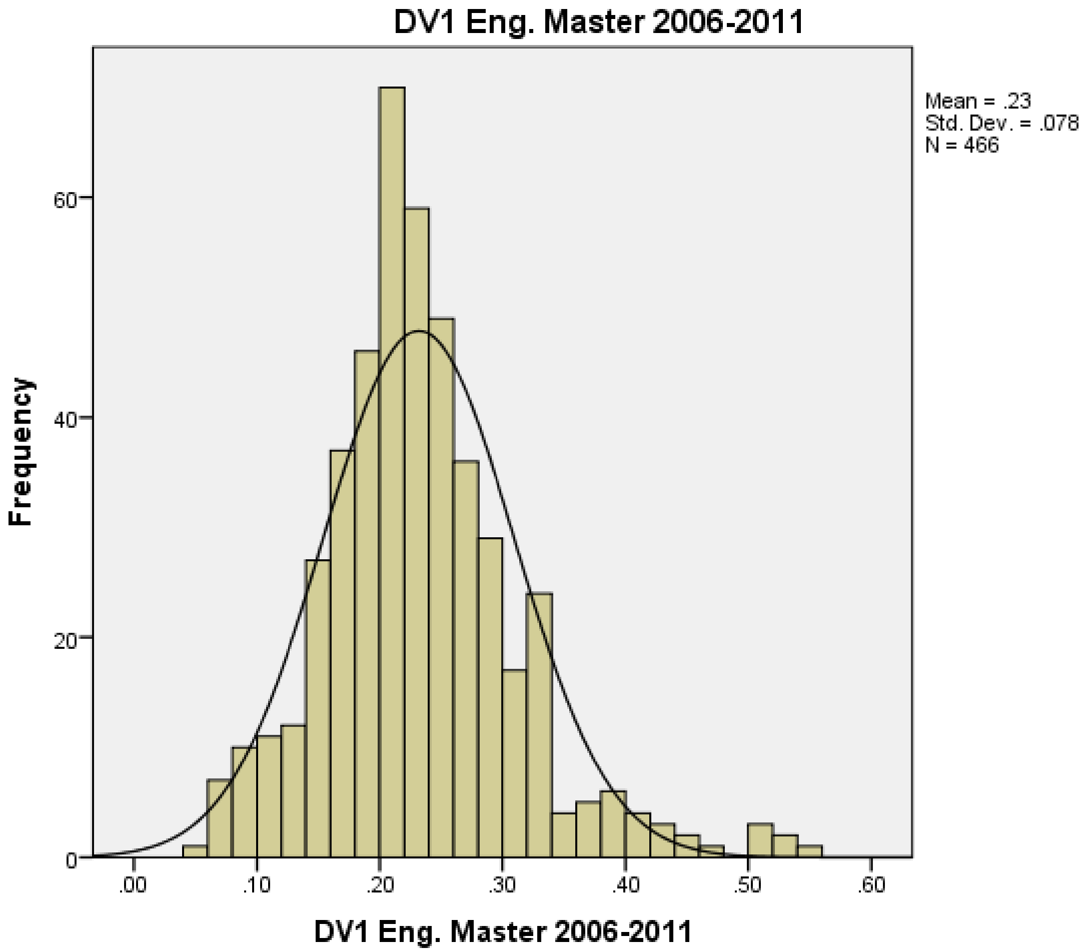


Figure I84. CIP 14 Doctoral Distribution

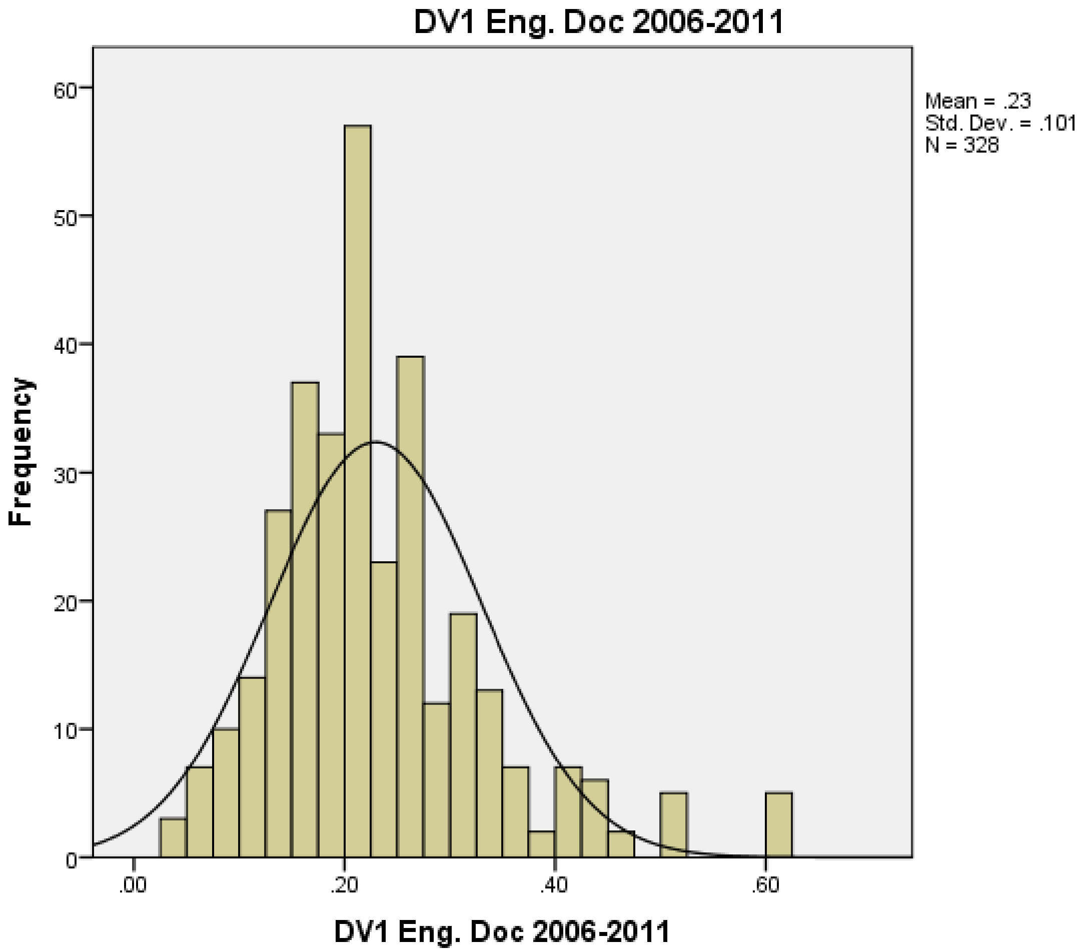


Figure I85. CIP 26 Master Distribution

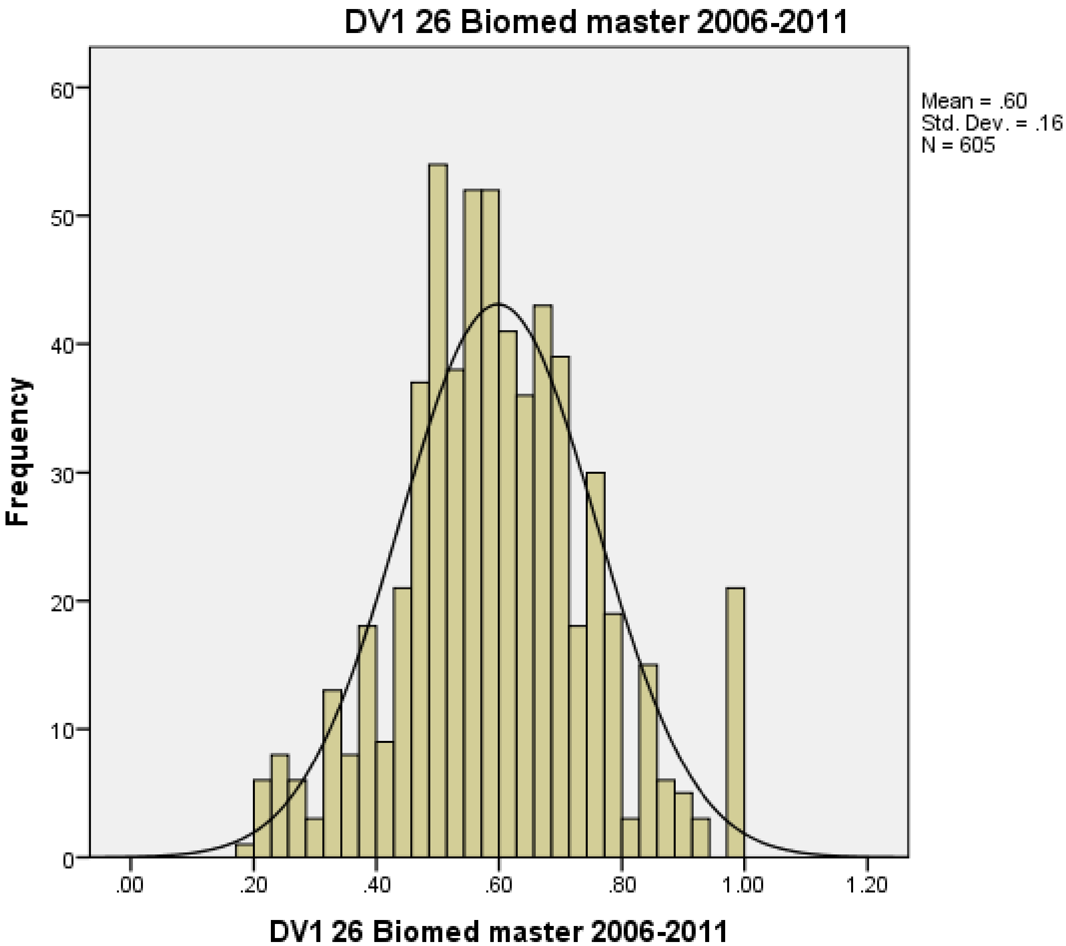


Figure I86. Doctoral Distribution

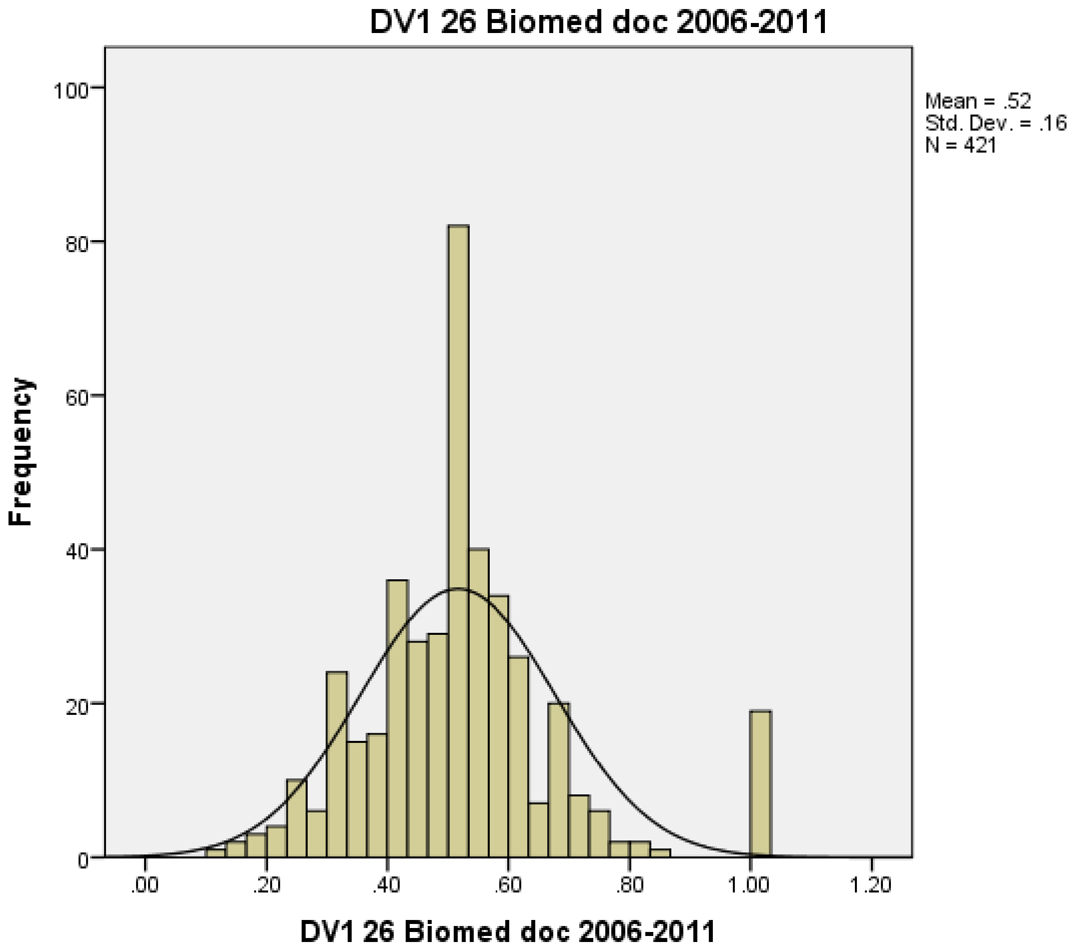


Figure I87. CIP 27 Math Master Distribution

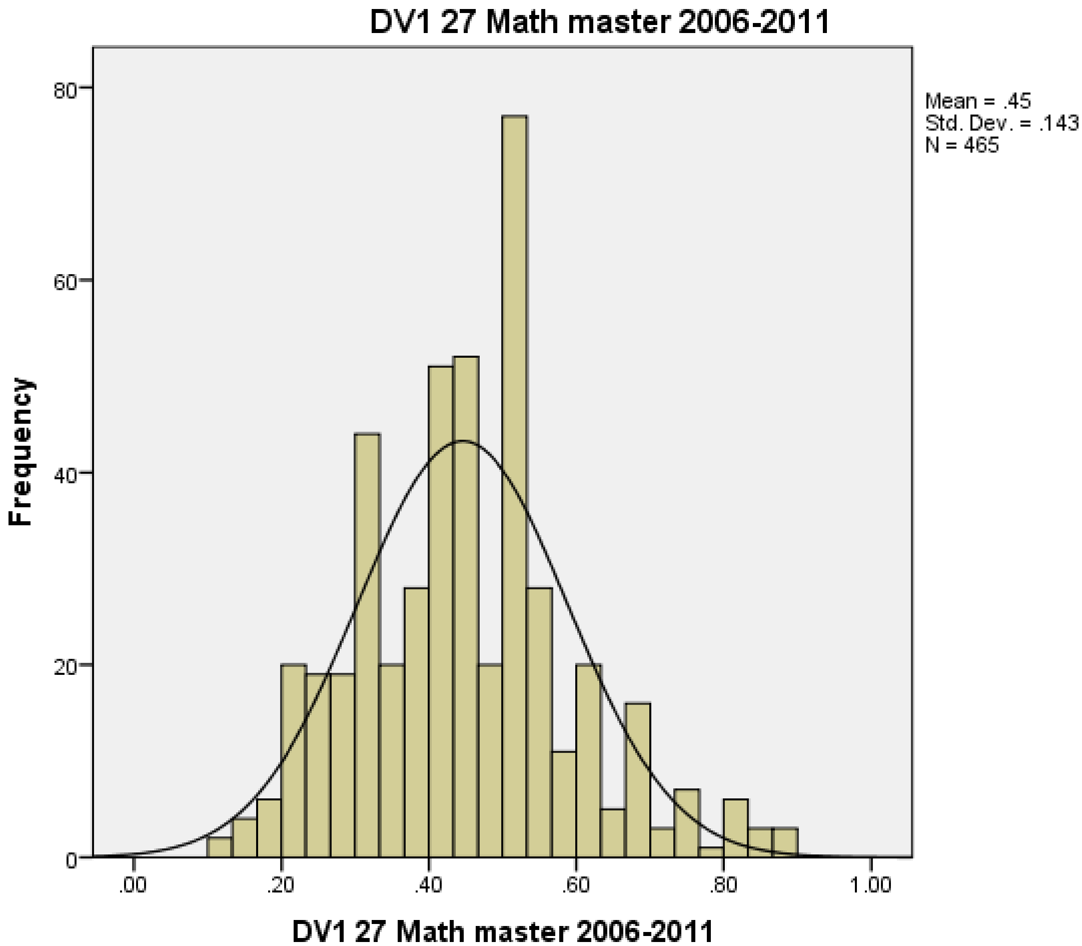


Figure I88. CIP 27 Math Doctoral Distribution

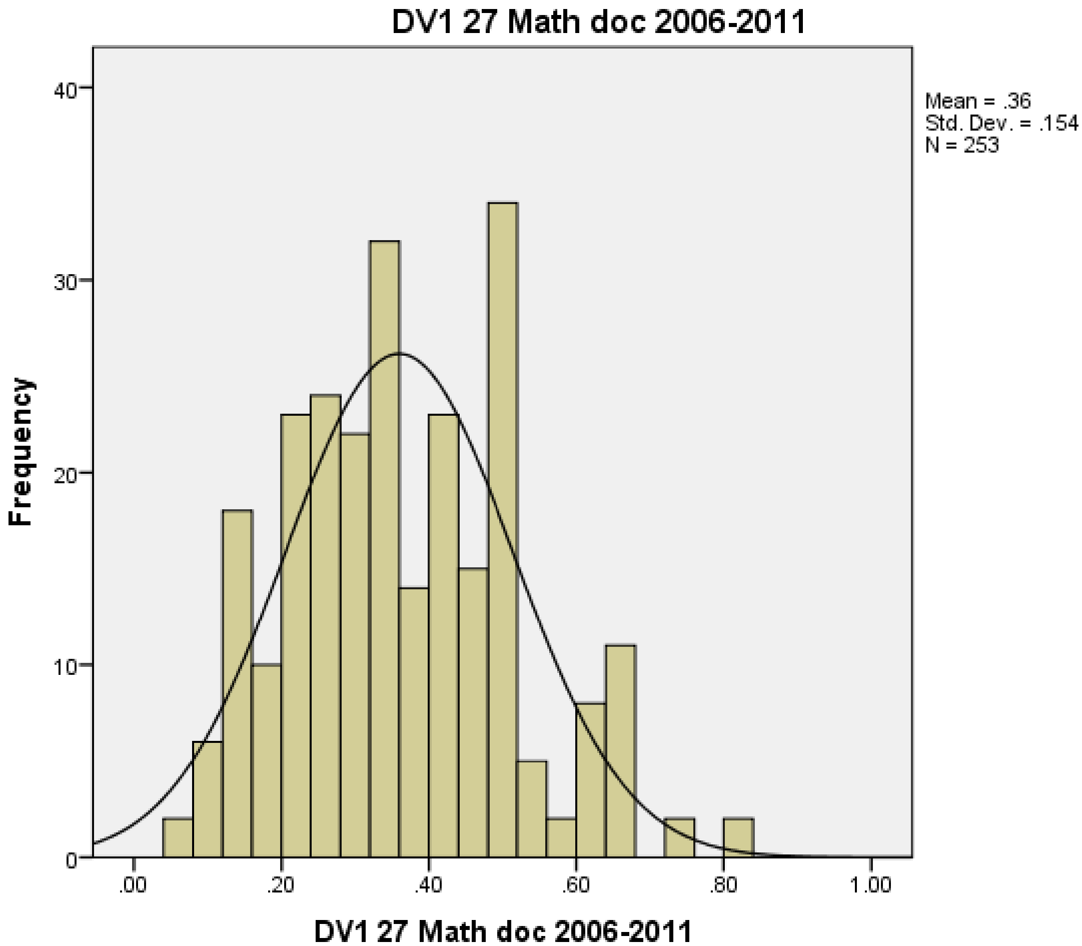


Figure I89. CIP 40 Master Distribution

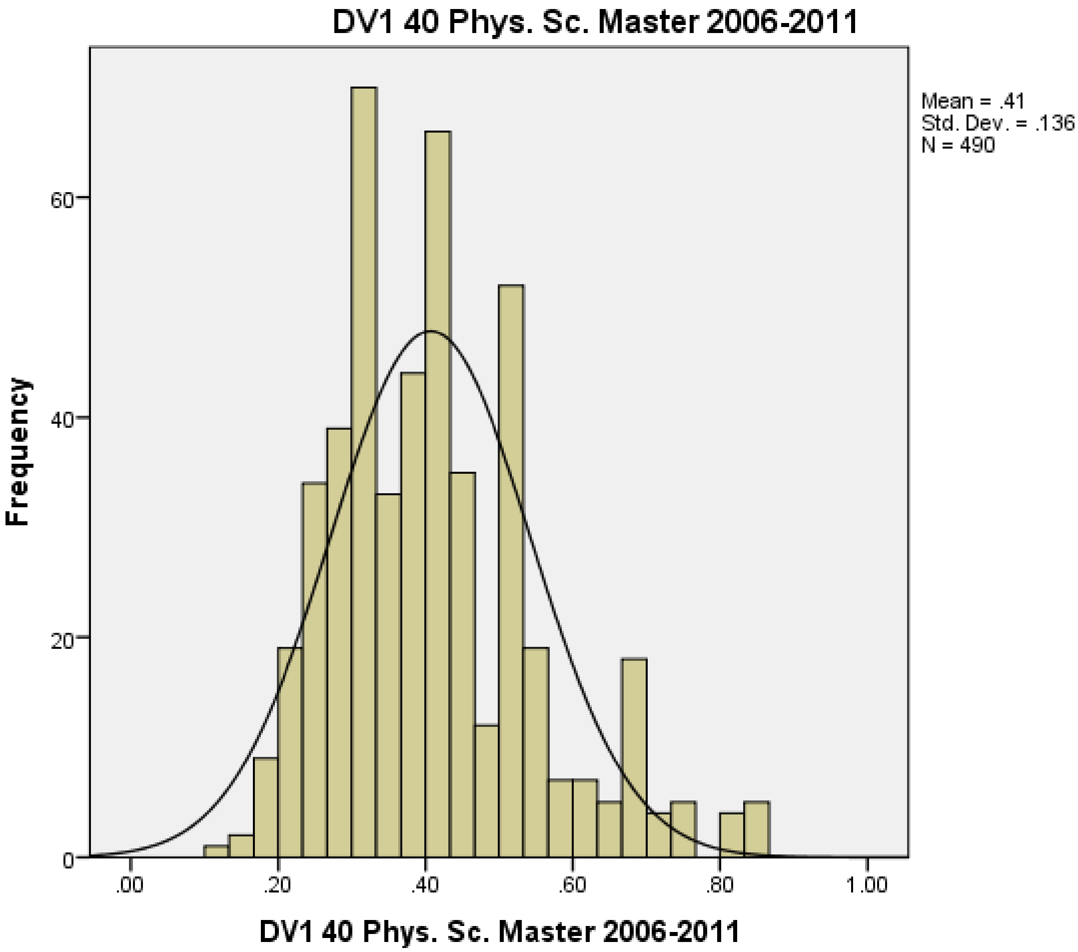


Figure I90. CIP 40 Doctoral Distribution

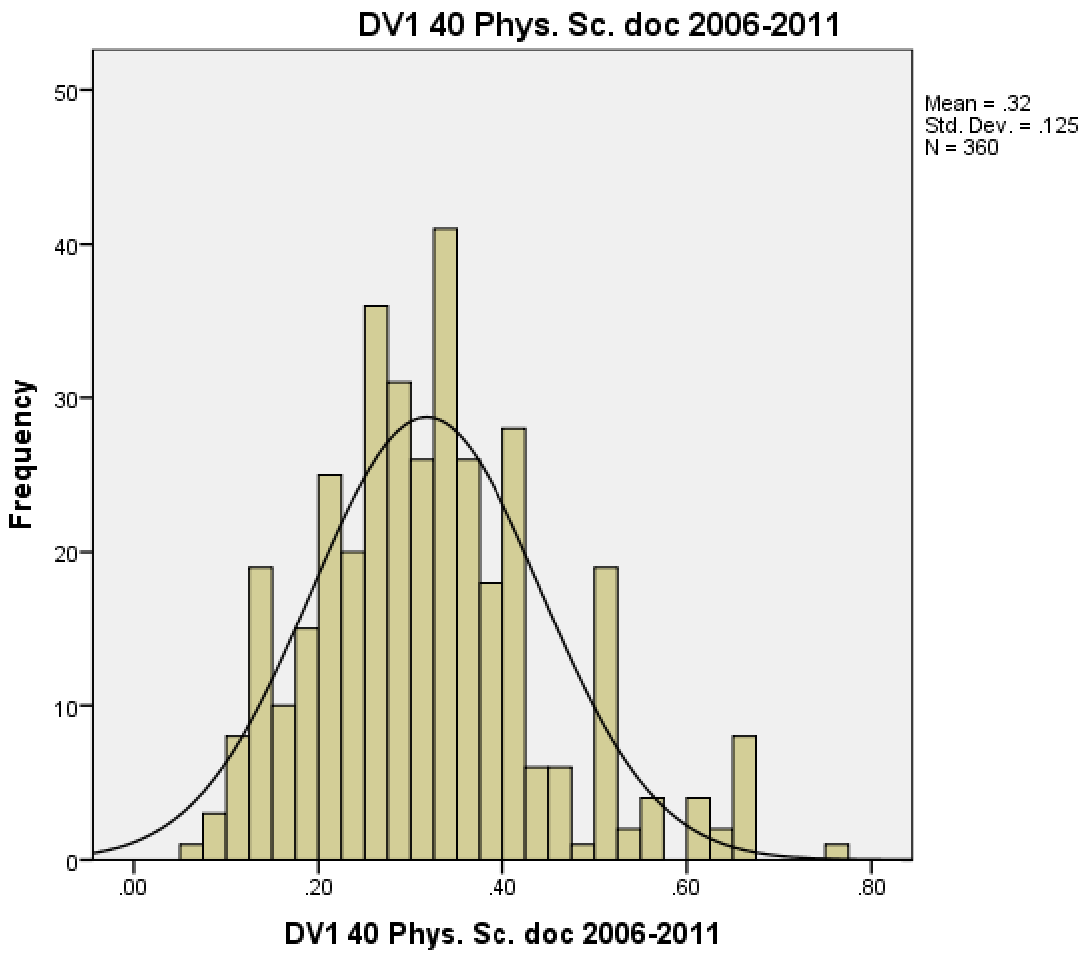


Table I1

Research Question Six OLS Regression Assumptions for Multicollinearity 2006-2011

Independent Variables	Ratio F Grad St.	Ratio F Ugrad. St.	Ratio F GA	Ratio F Faculty	Ratio F Adm.	Enrollment	Log Transformed Research Expenditures
Ratio F Grad St. 2006-2011		1.421	2.781	2.280	3.138	3.148	3.142
Ratio F Ugrad St. 2006-2011	1.794		2.184	2.161	1.941	2.135	2.174
Ratio F GA 2006-2011	1.253	2.261		1.421	1.419	1.419	1.410
Ratio F Faculty 2006-2011	1.651	1.129	2.284		2.266	2.274	2.264
Ratio F Adm. 2006-2011	1.264	1.187	1.268	1.260		1.261	1.249
Enrollment 2006-2011	1.212	1.143	1.212	1.209	1.205		1.109
Log Transformed Research Expenditures	1.143	2.592	1.139	1.137	1.129	1.049	